

The Frigid Golden Age: Experiencing Climate Change in the Dutch Republic, 1560-1720

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Dissertation Abstract

During the nadir of the Little Ice Age between 1565 and 1720, average European temperatures declined by nearly one degree Celsius. While altered weather patterns strained the adaptive abilities of Europe's agricultural societies, the northern Netherlands enjoyed the prosperity of its Golden Age. The economy, culture, and environment of the Dutch Republic yielded a distinct pattern of vulnerability and resilience in the face of early modern climate change. In this dissertation, newly interpreted documents are examined alongside scientific evidence, first to establish relationships between local, short-term environmental conditions and human activity, and ultimately to identify broader connections between long-term climate change and the history of the Dutch Republic. This methodology reveals that the coldest decades of the Little Ice Age presented not only challenges but also opportunities for Dutch citizens.

Central to the increasingly capitalist economy of the Dutch Republic was the development, maintenance, and continued expansion of transportation networks that spanned the globe. Complex relationships between local environments, weather, and climatic trends stimulated new discoveries in Arctic waters, quickened the journeys of outbound United East India Company ships, hampered Baltic commerce, and altered how travellers moved within the borders of the Republic. Weather patterns that accompanied the Little Ice Age also affected how commerce was forcibly expanded and defended. The Anglo-Dutch Wars, fought from 1652 to 1674, were contested in a period of transition between decade-scale climatic regimes. In the first war, meteorological conditions that accompanied a warmer interval in the Little Ice Age granted critical advantages to English fleets, which were usually victorious. By contrast, in the latter wars, weather patterns that now reflected a cooling climate repeatedly helped Dutch fleets prevail over the English and later French armadas.

Finally, climatic fluctuations affected mentalities within the Dutch Republic. Understandings of weather in the Republic may have demonstrated a vague awareness of climate change, and cultural responses to weather reflected the resilience of the Republic by expressing the conviction that weather could be confronted and endured. Ultimately, the influence of the Little Ice Age was ambiguous for the resilient society of the Dutch Republic in its Golden Age.

Dedicated to my father, Bas Degroot

Beste Vriend

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Introduction

Climate Change and Human History

In 2013 and 2014, the Intergovernmental Panel on Climate Change (IPCC), a scientific body established under the auspices of the United Nations, published two assessments that summarized the expected environmental manifestations and human impacts of future global warming. Informed by thousands of interdisciplinary scholars, these synthesis reports reflected compromises that ultimately favoured conservative conclusions. Nevertheless, the IPCC projected that average global temperatures would likely rise by 0.4 degrees Celsius in the coming two decades, particularly over land in the high northern latitudes. Although further predictions were subject to different emissions scenarios, models featured in the first report forecasted a total increase of between 1.5 and 4 degrees Celsius by the end of the century. While acknowledging that regional changes in prevailing weather stimulated by a global increase in temperatures might initially benefit some wealthy communities, the second assessment concluded by describing the severe water shortages, ecosystem degradation, health challenges, and economic upheaval that will likely trouble life on a warmer planet.¹

Global warming is inconceivable without an understanding of the past, for temperatures cannot rise without having once been lower. The outlines of that past have grown increasingly clear to historical climatologists and climate historians, the interdisciplinary scholars of historical climates. However, the history of climate remains a battleground in the tortured public debate about anthropogenic warming. Even those willing to believe academics over lobbyists frequently

¹ Lisa Alexander et al. *Climate Change 2013: The Physical Science Basis*. (IPCC WGI AR5, 2013), 953. Virginia Burkett et al., *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. (IPCC WG II AR5, 2014), 13. These conclusions were not much changed from the IPCC's fourth assessment report, published in 2007. The IPCC's fifth assessment report is expected later this year. Lenny Bernstein et al., *Climate Change 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change*. Valencia, Spain, 12-17 November 2007, 48.

hold to teleological narratives in which civilizations, now in peril, emerged and matured in stable and relatively benign climates. In fact, equilibrium in natural systems is typically an illusion born from the brevity of human experience.²

The Holocene, the climatic regime stretching from the thawing of the last great Ice Age to the present, dawned in a world that remained between one and three degrees Celsius warmer than twentieth-century averages until as late as 2000 BCE. Relatively moist conditions and high sea levels segregated populations that earlier migrated by land to North America or Australia.³ After 2000 BCE a gradual – if uneven – cooling of global temperatures likely resulted in the drying of the Sahara, yet in Europe at least temperatures rose again at the height of the classical era.⁴ This “Roman Optimum,” with its drier, warmer climate, faltered in a period of volcanism beginning around 180 CE, and the globe’s atmosphere subsequently cooled during the so-called “Vandal Minimum.”⁵ An unusually wet and stormy climatic regime endured for several decades in the sixth century, and again from 750 CE until as late as 900 CE. However, by the eleventh century the climate of the so-called Medieval Climatic Anomaly prevailed across much of the world, and in many regions temperatures were generally warmer than twentieth-century averages. Colder, stormier, wetter weather increasingly troubled the thirteenth century in swaths

² Paul Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. (Cambridge: The MIT Press, 2010), 4.

³ In this context “twentieth-century averages” refers to global temperatures between 1900-1960. During this period global temperatures rose until 1950 before experiencing a brief reduction; the current regime of accelerating global warming had not yet emerged in full. Hubert H. Lamb, *Climate, History and the Modern World, 2nd Ed.* (Rutledge: New York, 1995), 260.

⁴ Significantly more detailed evidence exists regarding the history of European climate. Reasons include: significant government funding for pan-European databases and research, the continent’s status as home for many of the major figures of historical climatology past and present, and the particularly intense, thoroughly recorded impact of relatively recent climatic change in Europe given, among other variables, its high latitude, and historically complex cultures with high rates of elite literacy. John F. Richards, *The Unending Frontier*. (Berkeley: University of California Press, 2003), 69.

⁵ J. D. Gunn, “A.D. 536 and its 300-year Aftermath,” in *The Years Without Summer: Tracing AD 536 and its Aftermath*, ed. J.D. Gunn. (Oxford: Archaeopress, 2000), 10. Tina Wang, Donna Surge and Karen Jo Walker, “Isotopic evidence for climate change during the Vandal Minimum from *Ariopsis felis* otoliths and *Mercenaria campechiensis* shells, southwest Florida, USA,” *The Holocene* 21:7 (2011): 1089.

of the Northern Atlantic; a global “Little Ice Age,” often marked by those conditions and accompanying glacial advances, lingered with warmer respites until deep into the nineteenth century. With the exception of slight cooling between 1950 and 1970, temperatures have been on the rise ever since.⁶

Before the onset of modern warming, the Little Ice Age was the most significant climatic anomaly of the last 8,000 years. Cooler temperatures, and, with them, altered patterns of precipitation and enhanced cyclonic activity, strained the adaptive capabilities of Western Europe’s agricultural societies. Between 1565 and 1720, the coldest phase of the Little Ice Age in Europe coincided with a so-called “general crisis” of violence, starvation, higher commodity prices, and demographic stagnation. However, between approximately 1590 and 1714 the northern Low Countries experienced the remarkable commercial expansion, cultural dynamism, and population growth of its Golden Age.⁷

Interdisciplinary climate reconstructions and diverse documentary sources reveal that the climatic fluctuations of the Little Ice Age presented both challenges and opportunities for Dutch citizens. Distinct economic structures, social relations, and cultural attitudes within the Dutch Republic allowed Dutch citizens to consciously exploit, or unwittingly benefit from, some of the weather patterns that became more common during the coldest phases of the Little Ice Age. Not all Dutch citizens shared in this resilience, and indeed some meteorological conditions could be disastrous in a low-lying region that depended on trade. Still, in the commercial acquisition and

⁶ M.J. Ingram, G. Farmer and T.M.L. Wigley, “Past Climates and their Impact on Man: a Review,” in *Climate and History: Studies on Past Climates and their Impact on Man*, ed. M.J. Ingram, G. Farmer and T.M.L. Wigley. (Cambridge: Cambridge University Press, 1981), 17. Hubert Lamb, *Climate, History and the Modern World*, 260. Jean M. Grove, “The Century Time-scale.” In *Time-scales and Environmental Change*, ed. Thackwray S. Driver and Graham P. Chapman. (Oxford: Routledge, 1996), 40.

⁷ Sam White, “The Real Little Ice Age.” *The Journal of Interdisciplinary History* 44:3 (Winter, 2014): 327. Shaun A. Marcott et al., “A Reconstruction of Regional and Global Temperature for the Past 11,300 Years,” *Science*, CCCIX (2013), 1198. Geoffrey Parker and Lesley M. Smith, ed., *The General Crisis of the Seventeenth Century*. (Oxford: Routledge, 2005), 7.

military defence of wealth, and the cultural reception of weather, the influence of Little Ice Age climatic oscillations was profoundly ambiguous within the Dutch trading empire.

Historical climatologists exploring relationships between human and climatic histories during the Little Ice Age have traditionally considered how cooler temperatures, coupled with shifts in prevailing patterns of precipitation, hampered early modern European agriculture in the wake of relative medieval warmth. Since the hesitant ambiguity of Le Roy Ladurie's *Times of Feast, Times of Famine*, historical climatologists have sought links between the climate typical of Little Ice Age minima and, for example, the failure of Atlantic Norse agriculture, the Great Famine of the early fourteenth century, food shortages during the chaos of the Reformation, agricultural decline in Scotland culminating in union with England, and the potato blight in Ireland.⁸ In recent years, studies in historical climatology have explored a broadening variety of interactions between human and climatic histories, using a continually expanding selection of sources from a widening array of geographic regions. New books and articles, both popular and academic, have examined topics ranging from the difficulty of colonizing Australia towards the end of the Little Ice Age, to music during the cold seventeenth century; from the rising popularity of "reason" among early modern European intellectuals during years of extreme

⁸ With good reason; in England, for example, the growing season could be reduced by as much as two months in years marked by particularly severe winters during the Maunder Minimum. Emmanuel Le Roy Ladurie, *Times of Feast, Times of Famine: A History of Climate Since the Year 1000*. (Garden City, NY: Doubleday & Company, Inc., 1971), 293. Lamb, *Climate, History and the Modern World*, 232. Fred Pearce, *Climate and Man: From the Ice Ages to the Global Greenhouse*. (London: Vision Books, 1989), 31. Neville Brown, *History and Climate Change: A Eurocentric perspective*. (London: Routledge, 2001), 262. Bauernfeind and Woitek, "The Influence of Climatic Change on Price Fluctuations in Germany during the 16th Century Price Revolution," *Climatic Change* 43:1 (1999): 307. Christian Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth and Early Seventeenth Centuries," *The Medieval History Journal* 10: 1&2 (2007): 39.

weather, to the spread of smallpox on the great plains in the frigid final decades of the eighteenth century.⁹

Accordingly, recent studies in historical climatology have increasingly moved beyond the idea that climatic fluctuations limit or expand the energy available to agricultural economies. However, declensionist assumptions continue to inform many recent historical accounts of the Little Ice Age in Europe and beyond. Even some of the most nuanced narratives that examine the most unlikely connections between climate, weather, environment, and humanity continue to support the notion that a decline in temperatures, a shift in prevailing patterns of precipitation, and a general rise in meteorological extremes rendered life more difficult for nearly everyone in early modern Europe. In many cases this was undoubtedly true, but, in general, uncomplicated assumptions regarding the detrimental effects of the Little Ice Age in Europe are possible only because they ignore, among other events, the rise of the Dutch Republic during the coldest decades of the period. A sliver of land, with environmental characteristics that ought to have rendered it particularly vulnerable to the meteorological extremes of the Little Ice Age, nevertheless developed the most dynamic economy in the early modern world. How can historical climatologists make sense of the success of the Dutch Republic during the Little Ice Age; what might it say about the likely connections between climatic and human histories? This dissertation explores that question, revealing that the Republic's distinct environmental, cultural, and economic structures yielded distinct patterns of both vulnerability and resilience in the face of climatic fluctuation.¹⁰

⁹ Joëlle Gergis et al., "The Influence of Climate on the First European Settlement of Australia: A Comparison of Weather Journals, Documentary Data and Palaeoclimate Records, 1788–1793." *Environmental History* (2010) 15(3): 485. Wolfgang Behringer, *A Cultural History of Climate*. (Cambridge: Polity Press, 2010), 141. Adam R. Hodge, "In Want of Nourishment for to Keep Them Alive: Climatic Fluctuations, Bison Scarcity, and the Smallpox Epidemic of 1780–82 on the Northern Great Plains." *Environmental History* (2012) 17(2): 400.

¹⁰ The concepts of "vulnerability" and "resilience" here conform to definitions laid out by Georgina Endfield. Vulnerability refers to the potential for loss, while resilience can be defined as adaptive capacity that mitigates loss.

Typical surveys of Dutch history frequently, if briefly, describe the importance of weather conditions for the Republic's economic or military activity. Moreover, interdisciplinary reconstructions of the early modern climate have incorporated references to weather in surviving documentary evidence written in the Republic. However, very few published works devote more than passing attention to relationships between the oscillations of the Little Ice Age and the Republic's history in the sixteenth, seventeenth, and eighteenth centuries. For example, in a series of books and articles, military historian Geoffrey Parker acknowledged the military significance of weather but not climate for Spanish and Dutch troops during the Eighty Years' War.¹¹ Parker's interests have recently turned to climate history, and in 2013 he published a major volume that attempts to link climatic cooling to global crisis in the seventeenth century. Remarkably, this book generally ignores developments within the Dutch Republic, despite Parker's eminence as a historian of the Low Countries. Parker's omission is not unusual. Most climate historians have excluded the Dutch from their narratives, while most historians of the Republic have described weather events without mentioning climatic trends.¹²

There are some exceptions, but even these are problematic. Among historians whose interests do not primarily concern environmental issues, Jan de Vries has written perhaps the fullest treatment of climate change in the Republic. In 1978, De Vries briefly yet perceptively examined how cold winter weather influenced travel by horse-drawn barges through the Dutch canal system. Two years later, he published an article that considered the importance of climatic variability in Dutch history, yet he was constrained by the limitations of contemporary climate

Georgina H. Endfield, "Exploring Particularity: Vulnerability, Resilience, and Memory in Climate Change Discourses." *Environmental History* 19 (2014): 305.

¹¹ Already in 1971, Parker described how weather events, like repeated storms or particularly cold winters, influenced some military operations during the Eighty Years' War. Geoffrey Parker, *The Dutch Revolt*. (London: Penguin Books, 1985), 57. Geoffrey Parker, *The Army of Flanders and the Spanish Road, 1567-1659*. (Cambridge, 1971), 169.

¹² Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century*. (London: Yale University Press, 2013), xix. See also: Parker and Smith, *The General Crisis of the Seventeenth Century*.

reconstructions. Strangely, when Jan de Vries and Ad van der Woude published a provocative survey of Dutch economic history in 1997, the historical influence of Little Ice Age weather was largely consigned to the ostensibly “unfathomable capriciousness of nature.”¹³ Slightly more detailed was the analysis of climate and meteorological conditions given by J.R. Jones in 1996. In the introduction to his survey of the Anglo-Dutch Wars, he very briefly described how easterlies and storms during the Little Ice Age facilitated Dutch attempts to leave port while disrupting English blockades. On the other hand, he seemed unaware that the European climate was not universally cool during the Anglo-Dutch Wars, and his history subsequently made no further reference to climatic fluctuation.¹⁴

Climate historians have fared no better. In 1995 climatologist Hubert Lamb devoted only a few vague sentences to links between early climatic fluctuations, the migration of herring shoals, and the prosperity of the Republic in the seventeenth century. Five years later, anthropologist Brian Fagan, in his popularizing survey of the Little Ice Age in Europe, briefly mentioned ice off the Dutch coast during the winter of 1683/84. While describing the rise of a European “merchant class” during the sixteenth and seventeenth centuries, Wolfgang Behringer in 2010 wrote that “not by chance did the Netherlands experience its Golden Age at this time,

¹³ De Vries and Van der Woude did allude, briefly, to the possible economic influence of the Little Ice Age, and wrote that “it is possible that the longer-term manifestations of the LIA offered, on balance, more benefits to the Dutch than they imposed costs.” That claim is tested in this dissertation. Jan de Vries and Ad van der Woude, *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500-1815*. (Cambridge: Cambridge University Press, 1997), 23.

¹⁴ J.R. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*. (London: Longman, 1996), 18. De Vries and Van der Woude, *The First Modern Economy*, 249. Jan de Vries, “Measuring the Impact of Climate on History: The Search for Appropriate Methodologies.” *Journal of Interdisciplinary History*, x:4 (Spring 1980): 626. Jan De Vries, *Barges and Capitalism. Passenger Transportation in the Dutch Economy, 1632-1839*. (Utrecht: HES Publishers, 1978): 295.

when the rest of the continent suffered periodic famines.” However, the Republic received no further mention in Behringer’s *A Cultural History of Climate*.¹⁵

On the other hand, Dutch winter landscapes painted in the sixteenth, seventeenth, and eighteenth centuries have long received special attention from historical climatologists (chapter 7). Most recently, Ingrid D. Sager and Alexis Metzger completed Masters theses that reinterpreted such paintings in light of the climatic fluctuations of the Little Ice Age. Now a PhD candidate, Metzger and fellow doctoral student Adam Sundberg have also studied the broader social and cultural influence of the Little Ice Age in the Dutch Republic. Metzger is investigating descriptions of cold weather in diary entries, while Sundberg has extensively examined the perception and material consequences of environmental disasters at the conclusion of the Dutch Golden Age. However, the only major published works to address the Little Ice Age in the Low Countries at any length are the massive volumes of J. Buisman’s and A.F.V. van Engelen’s *Duizend jaar weer, wind en water in de Lage Landen* (“A millennium of weather, wind and water in the Low Countries”). Still unfinished, the volumes do not present coherent historical analyses. Instead, they serve as important reference works that feature interdisciplinary climate reconstructions, primary sources recording severe weather events, and brief definitions or contextual explanations. Ultimately, this dissertation synthesizes several historiographical traditions by exploring how the Little Ice Age at its nadir influenced some of the most important material and cultural expressions of the Dutch Republic at its height.¹⁶

¹⁵ Lamb, *Climate, History, and the Modern World*. 2nd Ed., 228. Brian M. Fagan, *The Little Ice Age: how climate made history, 1300-1850*. (Boulder: Basic Books, 2000), 113. Behringer, *A Cultural History of Climate*, 111.

¹⁶ These dissertations, while not yet complete, were brought to my attention by Sundberg and Metzger. Adam Sundberg, “Weathering the Little Ice Age - Wealth and Climate Adaptation during the Dutch Golden Age.” (PhD diss., University of Kansas, 2015). Alexis Metzger, “Le froid en Hollande au Siècle d’or. Essai de climatologie culturelle.” (PhD diss., University of Paris, 2016). Ingrid D. Sager, *The Little Ice Age and 17th Century Dutch Landscape Painting, a Study on the Impact of Climate on Art*. Dominguez Hills: California State University, 2006. Alexis Metzger, *Plaisirs de Glace: Essai sur la peinture hollandaise hivernale du Siècle d’or*. Editions Hermann,

Reconstructing Past Climates

Climate can be defined as the sum of weather events – both extreme and ordinary – during a particular time, typically a decade or longer, in a particular place, on a scale that can range from local to global.¹⁷ Many early attempts to identify links between human history and climate were grounded in the assumption of climatic stability,¹⁸ and typically served to naturalize societal inequalities. In the nineteenth century the popular European notion that immutable differences in the world's climate were responsible for the geographical distribution of human achievement was largely supplanted in popular discourse by racism motivated by imagined biological differences.¹⁹ However, even as climatic determinism was largely discarded, and European colonists were encouraged to settle in the tropics, the notion of climatic stability appeared to have been confirmed by the first century-long records of weather observations compiled with relatively accurate meteorological instruments. By coincidence, this hundred-year temperature series began in the eighteenth century, and ended in the nineteenth century, during years in which average Atlantic temperatures were similar. Despite the recent experience of the

2012. J. Buisman and A. F. V. van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575-1675*. (Franeker: Uitgeverij Van Wijnen, 2000), 703.

¹⁷ Hubert Lamb, *Climate, History and the Modern World*, 260. Bernstein et al., *Climate Change 2007: Synthesis Report*, 30.

¹⁸ In fact, climate in the ancient world referred to region, not long-term weather. Lawrence Culver, "Seeing Climate through Culture." *Environmental History* 19 (2014): 312.

¹⁹ Clarence Glacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century*. (Berkeley: University of California Press, 1967), 552. Nonetheless, climatic determinism has remained troublingly persistent in popular culture. In the pages of his most recent book controversial German author Thilo Sarrazin has recently argued for Germany's departure from the Eurozone, blaming the hot Mediterranean climate for the supposed sloth and, in turn, financial dependence of southern Europe. Thilo Sarazin, *Europa Braucht den Euro Nicht: Wie uns politisches Wunschdenken in die Krise geführt hat*. (München: DVA Dt. Verlags-Anstalt, 2012), 9.

last cool phase of the Little Ice Age in the early nineteenth century, it was easier to plan future agro-industrial development based on the assumption of a stable climate.²⁰

The notion of past climatic instability was therefore foreign to the relevant disciplines of history and climatology when both were professionalized in the nineteenth century. Even in the 1930s, pioneering attempts by Swedish meteorologist Tor Bergeron and American glaciologist François Matthes to explore climatic variability over time found little echo within scholarly writing before extreme winters in the following decade reflected the disruption of the relatively benign climatic regime of the early twentieth century. Renewed climatic variability stressed agricultural monocultures that supported unprecedented human populations, spurring the formation of new scientific institutions dedicated to the study of climatic fluctuation.²¹ In the humanities Gustaf Utterström in 1955 nuanced earlier climatically deterministic narratives by proposing climatic fluctuation as a possible explanation for both the medieval Viking expansion and Scandinavia's subsequent decline in the sixteenth and seventeenth centuries.²² Just nine years later meteorologist Hubert Lamb published a historical analysis of English climatic fluctuations and their consequences from the context of a very different discipline. French historian Emmanuel Le Roy Ladurie, a leading figure in the influential *Annales* School, challenged some of Utterström's conclusions, and in 1967 published his own seminal study of the early modern climate in Europe.²³

Coupled with building scientific awareness of anthropogenic climate change, these early studies provided an important catalyst for research into past climates. In subsequent decades

²⁰ Hubert H. Lamb, *Climate, History and the Modern World*, 11.

²¹ Wolfgang Behringer, *A Cultural History of Climate*, 106. Lamb, *Climate, History and the Modern World*, 14.

²² Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 38.

²³ Hubert Lamb, *The English Climate*. (London: English Universities Press, 1964), 12. Emmanuel Le Roy Ladurie, *Times of Feast, Times of Famine*, 10. Gustaf Utterström, "Climatic fluctuations and population problems in early modern history," *Scandinavian History Review* 3:1 (1955): 3.

scientists and historians including Christian Pfister, Rudolf Bradzil, and Rüdiger Glaser, encouraged by the development of environmental history in the 1970s, have painstakingly reconstructed climatic fluctuation in the Holocene with the precision necessary to uncover convincing relationships between human and climatic histories.²⁴ In the process they have developed the modern interdisciplinary sub-field of historical climatology, which bridges historical and scientific methodology to reconstruct weather records prior to the establishment of national meteorological networks, to explore societal vulnerability to climatic fluctuation, and to uncover cultural representations or responses to climate.²⁵

Essential to reliable climatic reconstruction is the use of diverse palaeoclimatic evidence originating from material structures that respond to climatic fluctuation and can substitute for direct instrumental measurements. Such “proxy” data include records from ice cores, tree rings, lake sediments, planktonic debris, peat bogs, and other evidence taken from the “natural archives” of the cryosphere, hydrosphere, and biosphere. It also incorporates scientific evidence of changes in the advance or retreat of tree lines, glaciers, and animal ranges, which predictably respond to climatic trends and, when amalgamated with other proxy data, contribute to the development of models that reconstruct past climatic variability. Archaeological and, for more recent periods, historical evidence derived from written descriptions of weather can help test these models while unearthing possible relationships between climatic shifts, weather events, ecological networks, and human populations. Surviving written or visual accounts of weather both mundane and, more typically, extreme are so plentiful from the medieval period on that the reconstruction of climatic fluctuation beyond the eleventh century is necessarily an

²⁴ Behringer, *A Cultural History of Climate*, 86. Donald Worster, “Appendix: Doing Environmental History,” in *The Ends of the Earth: Perspectives on Modern Environmental History*, ed. Donald Worster. (Cambridge: Cambridge University Press, 1989), 291.

²⁵ Rudolf Brazdil et al. “Historical Climatology in Europe - the State of the Art” *Climatic Change* 70 (2005): 365.

interdisciplinary pursuit. Consequently the Medieval Climatic Anomaly and, in particular, the Little Ice Age are the most studied climatic regimes predating the onset of anthropogenic warming, particularly for environmental historians who, notwithstanding their scientific literacy, usually operate from the humanities.²⁶

In general, scientific sources provide information relevant to weather and, in turn, climate at a different “resolution” than most documentary evidence. Low-resolution climate reconstructions involve weather patterns over long time-frames, or across large geographic locations. Ice cores, for example, can be interpreted to record no better than seasonal temperature variations stretching back hundreds of thousands of years. On the other hand, high-resolution climate reconstructions can incorporate hourly meteorological data that are relevant for very local environments. Continuous diary entries, for instance, can include extremely precise observations of changes in weather. However, such documentary evidence typically does not record meteorological conditions for more than several decades, and it must be carefully interpreted to test its reliability. For example, in documentary evidence weather events can be used as metaphors, or they can be exaggerated in order to prompt, or excuse, human activities.

The need for precision in climatic reconstruction was not always recognized by historians. In 1970, Robert Claiborne, a noted populariser of science, admitted that in order to link climatic fluctuations to events in human history he had “guessed – and with a shamelessness that would give a professional historian or climatologist the green fits.”²⁷ Born from the inadequacy of existing scientific sources and the difficulty of interpreting meteorological observations provided in documentary evidence, such guesswork, still ubiquitous in modern

²⁶ Brazdil et al. "Historical Climatology in Europe - the State of the Art," 364. Gergis, "The Influence of Climate on the First European Settlement of Australia," 504. Brown, *History and Climate Change*, 315. Lamb, *Climate, History and the Modern World*, 148.

²⁷ Robert Claiborne, *Climate, Man and History*. (London: Angus and Robertson, 1973), 23.

popularizing narratives, has done much to discredit climate history for professional historians.²⁸ Lamb's meticulous amalgamation of scientific and documentary evidence and his subsequent climatic reconstructions were pivotal to the emergence of climate as a category of serious historical analysis. Still, it was not until the 1980s that historical climatologist Christian Pfister and others developed a rigorous methodology for quantifying observations of temperature and precipitation in historical documents.

Subsequently, most European climatic reconstructions employing documentary proxies have employed a variant of Pfister's seven-step ordinal scale, in which seasonal temperatures, for example, fell somewhere between 3 (extremely hot) and -3 (extremely cold). The unusual density of historical source material compiled in the Low Countries has enabled researchers reconstructing regional temperatures to employ Pfister's methodology on a more precise nine-grade scale measuring seasonal intensity. Numerical values in that system have, in turn, been correlated to temperature through a synthesis of documentary and scientific evidence from historical and natural archives.²⁹ In recent decades, the precision provided by the Pfister methodology, coupled with the continued refinement and increasing scope of analysed material proxy data, have allowed historians to reliably link particular historical events to meteorological conditions and, in turn, climatic trends. Subsequent studies are particularly persuasive for regions in which cultural frameworks stimulated the production of a sufficient density of relevant

²⁸ In *The Little Ice Age* (2001) Brian Fagan, for example, assumed that "like the Norse conquests, [gothic] cathedrals too are a consequence of a global climatic phenomenon, an enduring legacy of the Medieval Warm Period." In 2007, John James, while relying largely on 50-year-old climatic reconstructions, nevertheless nuanced these conclusions. James still found a correlation between climatic fluctuations and French cathedral building, which was largely financed by wine production. However, James outlined exceptions to this trend, and concluded that climate was one factor among the many that encouraged the construction of cathedrals in the French High Gothic. Fagan, *The Little Ice Age*, 59. John James, *In Search of the Unknown in Medieval Architecture*. (London: The Pindar Press, 2007), 55. Mark Carey and Philip Garone, "Forum Introduction." *Environmental History* 19 (2014): 286.

²⁹ Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 44. A.F.V. van Engelen, J. Buisman and F. IJnsen, "A Millennium of Weather, Winds and Water in the Low Countries," in *History and Climate: Memories of the Future?*, ed. P.D. Jones et al. (New York: Kluwer Academic/Plenum Publishers, 2001), 112. M.V. Shabalova and A.F.V. van Engelen, "Evaluation of a reconstruction of temperature in the Low Countries AD 764-1998." *Climatic Change* (March 2000), 225.

documentary evidence for the development of new quantitative evidence, and the qualitative application of existing quantitative data. That condition existed in many parts of Europe from the high medieval centuries.³⁰

Reconstruction of the European Climate, 1200-1850

The existence of a “Medieval Warm Period” across much of Europe was dramatically supported by Hubert Lamb’s exhaustive climate reconstructions, and it was later popularized in works like Brian Fagan’s *The Little Ice Age* (2000) and *The Great Warming* (2008). According to Lamb and other historical climatologists, the warmth and dryness of medieval Europe reached its height in the late thirteenth century, with temperatures exceeding those experienced in the late twentieth century.³¹ Newly considered scientific proxy data clearly demonstrate significant warming for much of the Northern Hemisphere during the eleventh century. However, they also reveal that the early twelfth and late thirteenth centuries were, on average, actually quite cool, particularly in Europe (Figure I.1).³² Moreover, recent analysis of Lamb’s documentary sources using the precise methodology for climatic reconstruction pioneered by Pfister has similarly cast doubt on the scope, if not the existence, of medieval warming.³³ A critical analysis of surviving documentary evidence suggests that while much of Europe experienced a warming, drying trend

³⁰ Brazdil et al. “Historical Climatology in Europe - the State of the Art,” 377.

³¹ By as much as one degree Celsius in England, and perhaps 1.4 degrees Celsius in central Europe. Lamb, *Climate, History and the Modern World*, 260. Fagan, *The Little Ice Age*, 17. Brian Fagan, *The Great Warming: Climate Change and the Rise and Fall of Civilizations*. (New York: Bloomsbury Press, 2009), xi.

³² M. E. Mann et al., “Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly.” *Science* 326 (2009): 1257. Jan Esper et al., “Orbital Forcing of tree-ring data.” *Nature Climate Change* (2012): 2. William J. D’Andrea et al., “Mild Little Ice Age and unprecedented recent warmth in an 1800 year lake sediment record from Svalbard.” *Geology* 10.1130 (2012): 1010.

³³ Lamb’s documentary evidence included secondary sources that recorded primary sources written well after the meteorological events they described, and primary documents written outside Lamb’s geographic focus. Astrid Ogilvie and Graham Farmer, “Documenting the Medieval Climate,” in *Climates of the British Isles*, ed. Mike Hulme and Elaine Barrow. (London: Routledge, 1997), 113.

around 1200 CE, English temperatures began a lengthy decline only 40 years later. In the Low Countries and their surroundings the most significant trend from the end of the thirteenth century through the beginning of the sixteenth century was likely an increase in precipitation.³⁴

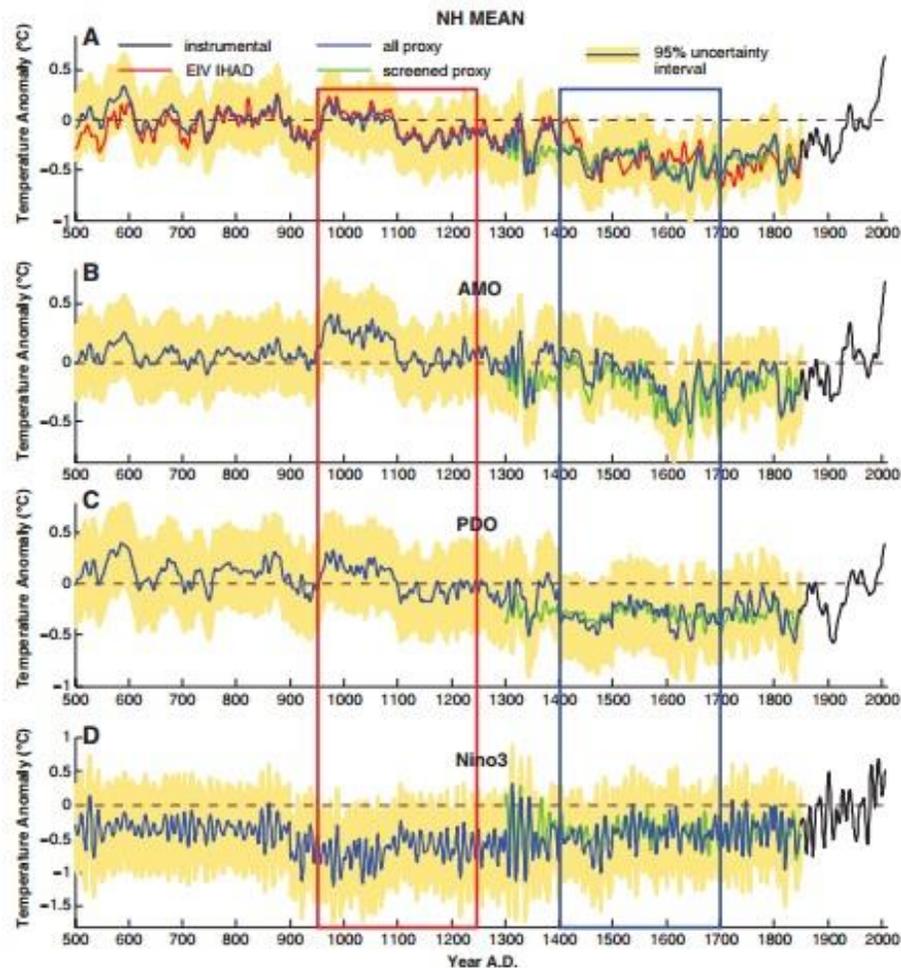


Fig. I.1. Multi-proxy reconstruction of fluctuations in mean temperatures for the entire Northern Hemisphere (top), the northern Atlantic, the northern Pacific, and the Niño3 region (2.5°S - 2.5°N; 92.5°W - 147.5°W). Both medieval warming and early modern cooling are particularly visible in the Northern Hemisphere and Northern Atlantic reconstructions. Mann et al., “Global Signatures and Dynamical Origins,” 1257.

³⁴ Astrid Ogilvie and Graham Farmer write that if a Medieval Warm Period did exist it was “less well-defined and climatologically more complex than has popularly been believed.” Ogilvie and Farmer, “Documenting the Medieval Climate,” 130.

At the periphery of the medieval European world, sustained cooling was already evident before 1200 CE. Inuit populations belonging to the Dorset culture, once present throughout high latitudes in Canada and Greenland, began migrating south as early as the twelfth century. The severe winter of 1197/98 in Iceland abruptly ushered in a period of far colder temperatures and increased sea ice, contributing to a period of crisis for the island's population. Meanwhile, conditions for Norse settlers in Greenland also deteriorated, and in 1250 the *Konungs Skuggsjá* or "King's Mirror," a Norwegian work, described the "great superfluity of ice on the sea" near Greenland that had no known parallel "anywhere else in the whole world."³⁵ As yearly temperatures fell and sea ice expanded, Norse settlers in Iceland gradually abandoned farming, yet their relatives in Greenland generally failed to dispense with sedentary agriculture in favour of hunting, trapping, or southerly migration. By 1350 the Vesterbygd, or "West Settlement," was destroyed, while the larger and more southerly Østerbygd, or "East Settlement," endured with great difficulty until 1500.³⁶

In the late thirteenth century, four major volcanic eruptions released aerosol particles into the atmosphere that reflected sunlight and temporarily cooled the Earth. These events likely coincided with a change in Earth's orbit that reduced solar radiation across the Northern Hemisphere. Sea ice expanded in the Arctic, and the bright ice in turn reflected more sunlight into space than the darker water it replaced. Combined, these changes weakened the Atlantic Gulf Stream, allowing colder temperatures to endure long after the volcanic eruptions ended. Thereafter, temperatures gradually – if erratically – cooled across Europe, while the continent's

³⁵ Lamb, *Climate, History and the Modern World*, 176.

³⁶ Behringer, *A Cultural History of Climate*, 86. Pearce, *Climate and Man*, 29. Lamb, *Climate, History and the Modern World*, 187. William J. D'Andrea et al., "Abrupt Holocene climate change as an important factor for human migration in West Greenland." *Proceedings of the National Academy of Sciences* 108:24 (2011): 9766.

western periphery was repeatedly afflicted with catastrophic storms and associated flooding.³⁷ The Thames froze over for the first time in a century during the winter of 1269/70, but it was the torrentially wet spring, summer, and autumn of 1314 that, for many historical climatologists, heralded the beginning of the Little Ice Age in Europe. In much of Europe, exceptional wetness lingered with little relief until as late as 1321, ruining crops, stimulating disease among cattle, and contributing to widespread famine.³⁸ Chillier temperatures in a new climatic regime encouraged the widespread desertion of villages located across the agricultural periphery of Europe, and perhaps 4,000 were abandoned in England alone in the centuries after 1300. Masked by the general cooling trend, wild fluctuations in decadal, yearly, and seasonal weather endured for over two centuries, culminating in a short-lived reprieve of relative warmth and tranquillity in the early sixteenth century.³⁹

In 1565 a severe winter and chilly summer marked what many historical climatologists have identified as the beginning of the first great cold period – or minimum – of the Little Ice Age. The expansion of the glacier bordering Grindelwald, a Swiss town, was among the most obvious and traumatic manifestations of the cooler climate, prompting historical climatologist Christian Pfister to coin the term “Grindelwald Fluctuation” to describe the period. Influenced by the lingering effect of volcanism, in vast swaths of the northern hemisphere temperatures across all seasons fell at least one degree Celsius below twentieth-century averages until the aftermath

³⁷ Gifford Miller et al., “Abrupt onset of the Little Ice Age triggered by volcanism and sustained by sea-ice/ocean feedbacks.” *Geophysical Research Letters*, 39:2 (2012), 4. Y. Zhong et al. “Centennial-scale climate change from decadal-paced explosive volcanism: a coupled sea ice-ocean mechanism.” *Climate Dynamics* 37 (2011): 2373. Petra van Dam, “De amfibische cultuur: een visie op watersnoodrampen.” Vrije Universiteit inaugural lecture. Accessed 23 February 2014, <http://dare.ubvu.vu.nl/handle/1871/18457>. A.M.J. de Kraker, “A method to assess the impact of high tides, storms and storm surges as vital elements in climatic history. The case of stormy weather and dikes in the Northern part of Flanders, 1488-1609”, *Climatic Change* 43 (1999): 288.

³⁸ Behringer, *A Cultural History of Climate*, 106.

³⁹ Pearce, *Climate and Man*, 29. Behringer, *A Cultural History of Climate*, 101.

of the “year without summer” in 1628.⁴⁰ Although colder weather typically reduces the rate of water evaporation, precipitation and average surface moisture declined in many European regions during the coldest phases of the Little Ice Age, particularly along the shores of the Mediterranean. On the other hand, precipitation and surface wetness rose across much of Northwestern Europe, particularly during spring and autumn.⁴¹ Meanwhile, the southward movement of the Arctic circumpolar vortex, a persistent cyclonic band of high winds surrounding the Arctic, also stimulated increased storminess in many European regions. In particular, the frequency of gales rose sharply in the continental Northwest.⁴²

During the coldest years of the Grindelwald Fluctuation the growing season in many parts of Europe was reduced by as much as six weeks, encouraging farmers to abandon wheat, which thrives in warm, dry conditions, for cold weather crops like barley, oats, or rye. In the sixteenth century, expanding agricultural commercialization in slivers of Northwestern Europe, and the simultaneous development of increasingly sophisticated networks of transportation, ensured that the kind of food shortages that had contributed to famine in the fourteenth century often encouraged regional price increases or political change two hundred years later.⁴³ Nevertheless, regional famines could still afflict the populations of typically less

⁴⁰ K. R. Briffa et al., “European Tree Rings and Climate in the 16th Century,” *Climatic Change* 43:1 (1999): 166.

⁴¹ Christoph C. Raible, “Climate variability - observations, reconstructions, and model simulations for the Atlantic-European and Alpine region from 1500–2100 AD.” *Climatic Change* 79 (2006): 19. Brazdil et al., “Historical Climatology in Europe - the State of the Art,” 404. Dennis Wheeler, “British Naval Logbooks from the Late Seventeenth Century: New climatic information from old sources.” *History of Meteorology* 2 (2005), 142. Lamb, *Climate, History, and the Modern World 2nd ed.*, 231. Rüdiger Glaser, *Klimageschichte Mitteleuropas. 1000 Jahre Wetter, Klima, Katastrophen*. (Darmstadt: Buchgesellschaft, 2001), 58.

⁴² These conclusions are generalizations of complex climatic and meteorological conditions, masking local contradictions and exceptions. For example, analysis of the accounts of Flemish dikes by Adriaan de Kraker and others has revealed that during the second half of the 16th Century severe storms in the North Sea increased by 400%, yet the number of mild storms actually declined slightly. Still, overall the accounts record an 85% increase in the number of storms during these decades. Christian Pfister and Rudolf Brázdil, “Climatic Variability in Sixteenth-Century Europe and its Social Dimension: A Synthesis,” *Climatic Change* 43:1 (1999): 32. See also: Shabalova and Van Engelen, “Evaluation of a reconstruction of temperature in the Low Countries.” Raible, “Climate variability - observations, reconstructions, and model simulations.”

⁴³ Bauernfeind and Woitek, “The Influence of Climatic Change on Price Fluctuations in Germany,” 307.

economically developed areas when devastating events in the incessant religious warfare set off by the Reformation intersected with years marked by particularly extreme weather during the Grindelwald Fluctuation. Malnutrition, coupled with frigid conditions and unusually high or low precipitation, frequently rendered vulnerable populations of both humans and dependent animals more susceptible to disease. The perception of meteorological change and, in particular, decline was nearly as important as the reality, stimulating a wave of suicides during the coldest years of the Grindelwald Fluctuation while encouraging a surge in the prosecution of witches blamed for destructive weather, famine, and “unnatural” diseases (Figure I.2).⁴⁴

⁴⁴ While likely influenced in part by unusually prolonged bouts of Seasonal Affective Disorder, more frequent suicides, generally considered a crime against God, were widely believed to help cause destructive weather. Behringer, *A Cultural History of Climate*, 117. Wolfgang Behringer, "Climatic Change and Witch-Hunting: The Impact of the Little Ice Age on Mentalities," *Climatic Change* 43:1 (1999), 345. Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 37.



Fig. I.2. Ulrich Molitor, “Witches sacrificing cock and snake to raise hailstorm,” in *De Ianjjs et phitonicis mulieribus*. 1489.

By the fourth decade of the seventeenth century, temperatures, precipitation patterns, and storm frequency in Europe rebounded to something approximating twentieth-century averages. The relatively benign climate of the following thirty years, while rarely considered by historical climatologists, reflects the variable nature of a period that is, in some respects, misrepresented by the term “Little Ice Age.” If an ice age constitutes a global phenomenon defined by profound cooling, it would be better applied to three great minima – “Very Little Ice Ages” – that each endured for significantly less than a century. Indeed, even these frigid decades were

distinguished less by a suite of meteorological characteristics that returned year after year than by weather extremes, expressed most clearly in calamitous storms.⁴⁵

The European climate had cooled again by 1662. Continental temperatures dropped between 1 and 2° C below their twentieth-century averages as precipitation patterns changed and storminess increased in many regions. This “Maunder Minimum,” the second great cold phase of the Little Ice Age, was named after the sharp reduction in sunspots discovered by astronomer Edward Maunder in the late seventeenth century. A combination of volcanism, orbital variation, ongoing reforestation, and the slight reduction in solar radiation that accompanied the decline in sunspots likely contributed to the global onset of a cooler climate. European crops had diversified considerably since the conclusion of the Grindelwald Fluctuation, yet cultivation limits for agricultural staples shifted in conjunction with broader changes in the ranges of continental flora and fauna. Owing in part to cooler temperatures, increased rainfall, and perhaps greater storm frequency, English and Baltic vineyards had already been abandoned centuries earlier. By contrast, during each Little Ice Age minimum the cultivation limit for crops like olives shifted to the south, before rebounding in warmer decades.

⁴⁵ Jean M. Grove, *Little Ice Ages: Ancient and Modern*. (London: Routledge, 2004), 2.

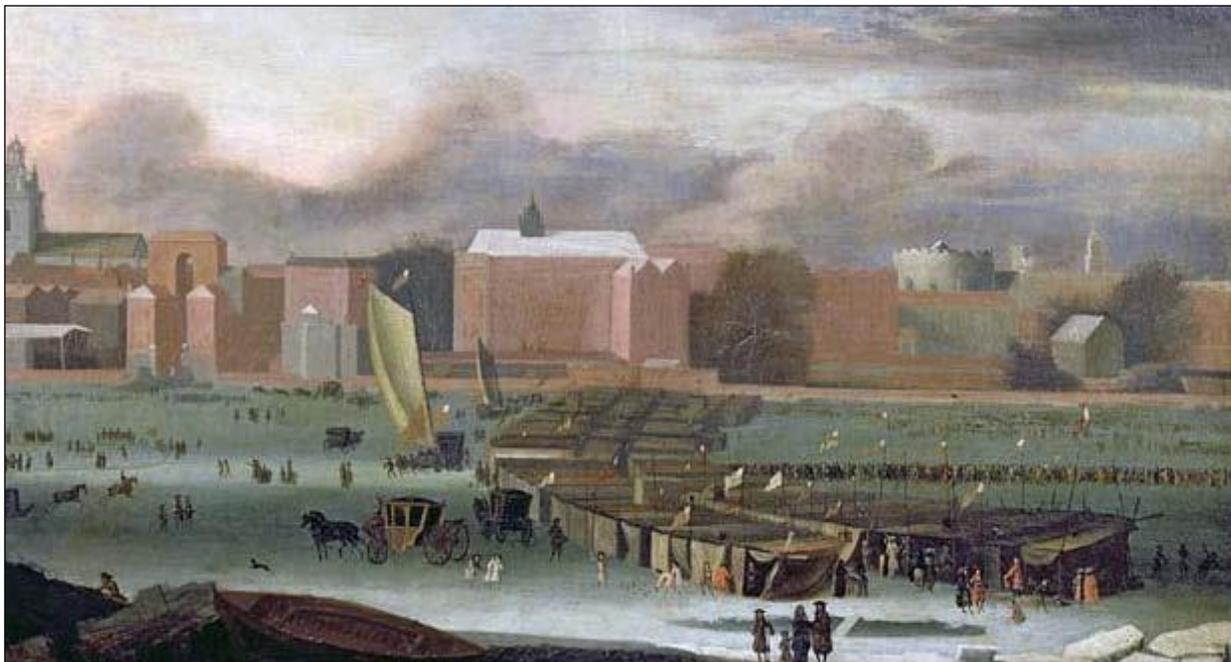


Fig. I.3. An ice fair on the frozen Thames in 1684, during the Maunder Minimum. Abraham Hondius, “A Frost Fair on the Thames at Temple Stairs,” painting, 1684, Museum of London, <http://www.museumoflondon.org.uk/london-wall/whats-on/exhibitions-displays/frost-fairs>.

In the northern periphery of Europe, cooler temperatures and shifting vegetation ranges complicated pastoralism, and more farmers reared sheep instead of cows. Moreover, wild plant diversity probably decreased at high altitudes and latitudes. Scavenging wolves increasingly entered population centres during cold winters, and vultures departed the frigid Alps. The Thames and other European rivers froze over completely during the coldest winters of the period, halting seaborne traffic while encouraging frost fairs (Figure I.3). During its nadir in the last decade of the seventeenth century, the Maunder Minimum coincided with a rise in witchcraft prosecution in regions where cooling was especially pronounced.⁴⁶

⁴⁶ Behringer, *A Cultural History of Climate*, 96. As with other periods in the chronology of climate the dates framing the Maunder Minimum are subject to controversy, often caused by both the various patterns of climate over different geographical regions and the different ways of measuring climatic changes. Behringer, for example, advocated the taking into account the “subjective factor” to measure human reactions to climatic fluctuations in order to determine when these began. Examining oceanic temperatures in unprecedented detail, Dennis Wheeler concluded that the twenty years from 1670 to 1690 were the coolest of the Little Ice Age. Meanwhile, Jürg Luterbacher expanded this

European temperatures recovered around 1720, although the warmer, drier climatic regime that followed was interrupted by frigid winters during the 1740s. By 1760 global temperatures had again declined, with conditions echoing those of the Grindelwald Fluctuation and the Maunder Minimum gradually returning across much of Europe. Named for another paucity of sunspots, this time detected by astronomer Richard Dalton, the Dalton Minimum with its accompanying cold temperatures, unusual patterns of precipitation, and increased storminess lingered in Europe until approximately 1850. In 1814 the Thames froze entirely for the last time, and by the end of the century precipitation and storminess had moderated while global temperatures fitfully recovered, culminating in the current climatic regime of accelerating anthropogenic warming.⁴⁷

A Brief History of the Dutch Republic

In the Low Countries, medieval and early modern climatic fluctuations coincided with even more dramatic environmental changes. Once dominated by coastal dunes, salt marshes, and spongy, dome-like peat bogs, large tracts of the lowland Netherlands bordering the North Sea were reclaimed and settled in the medieval period. However, the ditch-digging, surface oxidation, and animal trampling that accompanied this transformation steadily lowered the land

period, suggesting that the decades from 1645 to 1715 were the coldest of the Little Ice Age. In this dissertation the Maunder Minimum is understood to begin late in 1662. Thereafter, winter temperatures declined, storms were more frequent, and precipitation increased until the conclusion of the Maunder Minimum. Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*. (Cambridge: Cambridge University Press, 1991), 22. Jürg Luterbacher, "The Late Maunder Minimum (1675-1715) – Climax of the 'Little Ice Age' in Europe." In *History and Climate: Memories of the Future?*, ed. P.D. Jones et al. (New York: Kluwer Academic/Plenum Publishers, 2001), 30. Behringer, "Climatic Change and Witch-Hunting," 345. Dennis Wheeler, "Understanding Seventeenth-Century Ships' Logbooks: An Exercise in Historical Climatology." *Journal for Maritime Research* (2004), 30.

⁴⁷ Sebastian Wagner and Eduardo Zorita, "The influence of volcanic, solar and CO₂ forcing on the temperatures in the Dalton Minimum (1790-1830): a model study," *Climate Dynamics* 25 (2005): 210. Robert M. Wilson, "Volcanism, Cold Temperature and Paucity of Sunspot Observing Days (1818-1858): A Connection?" The Smithsonian/NASA Astrophysics Data System, 1998. Accessed July 7, 2012, <http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19980233233.pdf>.

and necessitated ever more sophisticated defences against the sea. In the fourteenth century, the construction of a vast network of dikes, dams, sluices, and eventually windmills, initially pursued by individual communities, mirrored social developments that gathered these capital-intensive technological achievements under collective institutions of increasing scale. By the sixteenth century, the economy of the coastal Low Countries was highly developed and remarkably “modern,” with far more workers employed in industry than in agriculture. Moreover, the rising pace of peat harvesting, the continued construction of wind and watermills, and the importance of shipping by sail ensured that the energy foundation of the Low Countries was uniquely effective in a continent dominated by agricultural economies. Easy access to plentiful energy supplies encouraged industrial development in coastal regions, which, in turn, necessitated urbanization while stimulating – and being stimulated by – trade in Baltic cereals already passing through the burgeoning town of Amsterdam. Located at the maritime crossroads between the Mediterranean and the rising economies of northern Europe, the coastal provinces of the Low Countries were connected by a network of natural and artificial waterways that allowed imports as well as exports to move relatively efficiently between centres of production and consumption.⁴⁸

In 1549, the historically decentralized seventeen provinces that together constituted the Low Countries were united as a single entity within the Holy Roman Empire. After Emperor Charles V abdicated in 1555, his son Philip II incorporated the provinces within the Spanish Hapsburg Empire. Motivated by the creeping expansion of Protestantism through the provinces

⁴⁸ Audrey M. Lambert, *The Making of the Dutch Landscape: An Historical Geography of the Netherlands*. (London: Academic Press, 1985), 203. William TeBrake, “Hydraulic Engineering in the Netherlands during the Middle Ages.” In Squatriti, Paolo, ed. *Working with Water in Medieval Europe: Technology and Resource Use*. (Leiden: Brill, 2000), 121. De Vries and Van der Woude, *The First Modern Economy*, 14. Jan van Zanden, “The ‘revolt of the early modernists’ and the ‘first modern economy’: an assessment.” *Economic History Review* 4 (2002): 634. For more on the transformation of the Dutch landscape see: M. van Tielhof and P.J.E.M. van Dam, *Waterstaat in Stedenland: het Hoogheemraadschap van Rijnland voor 1857*. Utrecht: Matrijs, 2006.

of the Low Countries, the imposition and brutality of the Spanish Inquisition coincided with a worsening trade war with England, the disruption of the Baltic grain trade, and crop failures influenced by the onset of the Grindelwald Fluctuation. The Inquisition was symptomatic of a broader attempt by Philip II to centralize the Low Countries under Spanish dominion by imposing new taxes, curbing the relative legal independence of towns and nobles, and suppressing unsanctioned religious movements.



Map I.1. Provinces and territories of the Dutch Republic in its seventeenth-century Golden Age. Holland, the focus of this study, is in the centre, on the coast, and filled in with orange. Other important locations in this dissertation: the Zuider Zee (the inland sea at centre), Zeeland (the green islands at bottom left), Texel (the southernmost perimeter island in the Zuider Zee, orange), and Friesland (purple, the north-eastern coast of the Zuider Zee). Johannes Janssonius, *Novus Atlas Sive Theatrum Orbis Terrarum*. Amsterdam, 1658.

Between 1565 and 1568, legal opposition to Hapsburg rule, launched by a cabal of powerful nobles, was joined by popular iconoclastic fury and eventually military revolt that culminated in the lasting division of the Low Countries between the Protestant North and the Catholic South.⁴⁹ In 1579, representatives from the provinces of Holland, Zeeland, Utrecht, Friesland, Gelderland, and Ommelanden (the area surrounding but not including Groningen) gathered to sign the Union of Utrecht (Map I.1). An Act of Abjuration that formally renounced the King of Spain was passed by the States General in 1581, signifying the emergence of an independent Dutch Republic. Thereafter, the Union effectively functioned as a constitution for the northern Netherlands. Envisioned as a defensive alliance for the prosecution of the war against Spain, the Union entrenched the radically decentralized political structure of the new United Provinces of the Dutch Republic. Decisions were reached only through laborious consultation between largely bourgeois elites within towns, provincial legislatures (or States), and the representatives of the States-General in The Hague. This unwieldy political system existed in uneasy parallel with the House of Orange, the Republic's preeminent noble dynasty. The princes of Orange continued to exercise great political influence, and most held the hereditary position of *stadthouder* of the provincial States. In this faculty they served as heads of state and consuls in time of war, although their authority was technically bestowed by the States-General.⁵⁰

During their long war with contemporary Europe's greatest empire, the disjointed collection of towns and provinces that constituted the Republic, and together housed no more than two million people, emerged as the leading economy of the early modern world. The

⁴⁹ Parker, *The Dutch Revolt*, 57. Parker, *The Army of Flanders and the Spanish Road*, 195. Maarten Prak, *The Dutch Republic in the Seventeenth Century*. (Cambridge: Cambridge University Press, 2005), 8.

⁵⁰ Jonathan Israel, *The Dutch Republic: Its Rise, Greatness, and Fall, 1477-1806*. (Oxford: Clarendon Press, 1998), 209. K.H.D. Haley, *The Dutch in the Seventeenth Century*. (London: Thames and Hudson Ltd., 1972), 74. Jan de Vries and Ad van der Woude, *The First Modern Economy*, 96.

coevolving influences behind this apparent economic miracle were central to the Republic's distinct experience with the climatic fluctuations of the Little Ice Age. Many involved the intensification of earlier foundations for prosperity in the maritime provinces. Essential to that effort was the deepening of existing canals, and the construction of new canals, which further connected the major coastal towns of the Republic. Even more important was the introduction of regulated sailing routes, called *beurtvaarten*, which provided dependable times of arrival and departure for travellers.⁵¹ The rising value of land, and the growing cost of agricultural commodities across Europe, also encouraged increasingly wealthy urbanites to invest in massive reclamation projects, while the expansion of grain production east of the Elbe prompted many Dutch farmers to experiment with new crops. Small-scale improvements completed by individual farmers predated the Dutch revolt, yet in the late sixteenth-century market changes intersected with the growth of urban commercial networks to accelerate and expand agricultural commercialization in the northern Netherlands.⁵² Technical innovations that improved the efficiency of windmills were central to increasing the quantity and value of cultivated land, and the development of new technologies was encouraged by the Republic's mercantile elite. In 1595, the technical adaptation of the full-rigged ship to intra-European trade culminated in the creation of the *fluyt*, or flute, a merchant vessel that required minimal crews and therefore generated maximum profit. Flutes helped the Dutch dominate the profitable single-season triangle trade in which Baltic bulk goods like timber or grain were exchanged for French and, in years free from Spanish embargos, Iberian wine, salt, and other merchandise through the ports of

⁵¹ Lambert, *The Making of the Dutch Landscape*, 203. Erik van der Vleuten and Cornelis Disco, "Water Wizards: Reshaping Wet Nature and Society." *History and Technology* 20:3 (2004): 292.

⁵² Beyond the province of Holland, this urban takeover of agricultural land was concentrated around the fertile, clay soils of major rivers. Bas van Bavel, "Manors and markets. Economy and society in the Low Countries (500-1600): a synopsis." *Tijdschrift voor Sociale en Economische Geschiedenis* 8:2 (2011): 63. Petra J.E.M. van Dam, "Fuzzy boundaries and three-legged tables. A comment on ecological and spatial dynamics in Bas van Bavel's Manors and markets." *Tijdschrift voor Sociale en Economische Geschiedenis* 8:2 (2011): 108.

the Republic's coastal provinces. The herring *buss*, a floating factory that enabled herring to be salted at sea, was an earlier technological innovation that allowed Dutch fishermen to exploit herring populations beyond the coast and helped fuel the profitable expansion of the fishery.⁵³

Industrial activity in the northern Low Countries received great stimulus from refugees escaping war and religious persecution in the south. After the first years of the Revolt, the heavily fortified towns of the coastal provinces were relatively safe from capture. The atrocities that accompanied the sack of Antwerp by mutinous Spanish troops in 1576, followed by its recapture in 1585, encouraged many refugees to seek the security of the northern Netherlands. Once the industrial and commercial centre of Europe, Antwerp had been home to prominent mercantile families who brought their wealth and expertise to the major towns of Holland. Many settled in Leiden, cultivating a woollen cloth industry that helped the city emerge as one of the most important industrial centres in Europe. Ironically, Spanish measures intended to suppress the Revolt also indirectly stimulated Dutch commercial expansion, encouraging Dutch merchants to finance exploratory voyages that culminated in the development of the East and West India Companies (VOC and WIC) in 1602 and 1621, respectively. The VOC, the more successful of these companies, transported precious metals to Asia in exchange for spices, textiles, and other high-value, low-volume commodities. It dominated trade between Europe and Asia, and within

⁵³ Maarten Prak, *Gouden Eeuw: Het raadsel van de Republiek*. (Nijmegen: Uitgeverij SUN, 2002), 105. J. L. Price, *Dutch society, 1588-1713*. (New York: Longman, 2000), 70. De Vries and Van der Woude, *The First Modern Economy*, 357. Bo Poulsen, *Dutch Herring: An Environmental History, C. 1600-1860*. (Amsterdam: Amsterdam University Press, 2009), 73. Milja van Tielhof, *The 'Mother of All Trades: The Baltic Grain Trade in Amsterdam from the Late 16th to the Early 19th Century*. (Leiden: Brill, 2002), 3. Richard W. Unger, "Grain, beer and shipping in the North and Baltic Seas." In *Medieval Ships and the Birth of Technological Societies: Volume 1: Northern Europe*, ed. Villain-Gandossi, Christiane; Salvino Busuttill and Paul Adam. (Malta: European Coordination Centre for Research and Documentation in Social Sciences, 1989), 121. On fisheries, see also: J. R. Bruijn, "Dutch Fisheries: An Historiographical and Thematic Overview." In *The North Atlantic Fisheries, 1100-1976: National Perspectives on a Common Resource*, ed. Poul Holm, David J. Starkey and Jón Th. Thór, 105-20. (Esbjerg Fiskerimuseet, 1996). Karel Davids, *The Rise and Decline of Dutch Technological Leadership (2 Vols): Technology, Economy and Culture in the Netherlands, 1350-1800, Vol. I*. (Leiden: Brill, 2008), 138.

Asia, for most of the seventeenth century, while assuming an increasingly central position in the Republic's economy.⁵⁴

Following the creation of the Exchange Bank of Amsterdam in 1609, the province of Holland, and in particular the burgeoning city of Amsterdam, emerged as the financial, commercial, and industrial capital of Europe. Unlike Antwerp, Amsterdam became a global *entrepôt*, and was host to continuous trade that contrasted with Antwerp's regular fairs. Moreover, Amsterdam's merchants combined shipping, trade, and distribution, while their counterparts in sixteenth-century Antwerp had primarily handled goods brought to the city by foreign merchants. The Republic's ascendancy within Europe was stimulated by the refinement and, in turn, simultaneous application of existing financial, commercial, and industrial technologies within a unique cultural and environmental setting. This process encouraged the growth of an economy with sophisticated capitalist structures that displayed unprecedented characteristics of modernity, despite the persistence of local privileges, guilds, cash trading, and other lingering medieval anachronisms. In its urbanization, monetization, patterns of energy use, education levels, social and physical mobility, financial institutions, and interventionist governments, the Republic during its Golden Age more closely resembled a stereotypically "modern" economy than it did its contemporary European neighbours.⁵⁵ Frequently stimulated

⁵⁴ Oscar Gelderblom, *Zuid-Nederlandse kooplieden en de opkomst van de Amsterdamse stapelmarkt (1578-1630)*. (Hilversum: Uitgeverij Verloren, 2000), 114. Victor Enthoven, "Early Dutch Expansion in the Atlantic Region, 1585-1621," in *Riches from Atlantic commerce: Dutch transatlantic trade and shipping, 1585-1817*, ed. Johannes Postma and Victor Enthoven. (Leiden: Brill, 2003), 23. Price, *Dutch society*, 76. De Vries and Van der Woude, *The First Modern Economy*, 180. P. W. Klein and Jan Willem Veluwenkamp, "The Role of the Entrepreneur in the Economic Expansion of the Dutch Republic." *Economic and Social History in the Netherlands* 4 (1992): 28. Gerrit Knaap and Ger Teitle, ed. *De Verenigde Oost-Indische Compagnie: Tussen Oorlog en Diplomatie*. (Leiden: KITLV Uitgeverij, 2002), 4. Jonathan Irvine Israel, *Dutch primacy in world trade, 1585-1740*. (New York: Oxford University Press, 198), 213. Anne Goldgar, *Tulipmania: Money, Honor, and Knowledge in the Dutch Golden Age*. (Chicago: University of Chicago Press, 2008), 9.

⁵⁵ Jan de Vries and Ad van der Woude define a modern economy as: "one with features that assist in the process of institutional, organizational and technological change that improve the efficiency of production and distribution." Their view is optimistic and tends to ignore the capitalist inequalities that accompany "modernity." The Dutch Republic was also the first European economy in which an urban proletariat, many of them immigrants from less

by unsupportable speculation and exacerbated by environmental degradation, its economic booms and busts resembled those that accompany capitalism today. Owing to its relative modernity, the Dutch Republic's financial and economic influence was disproportionate to its small population and meagre natural resources. By 1636, as many as 1,750 Dutch merchant vessels were active in European waters, not including 600 herring busses and more than 200 cavernous ships belonging to the VOC and WIC.⁵⁶

The economic dynamism of the Republic's Golden Age encouraged, and was stimulated by, a remarkable flowering of intellectual life in the northern Netherlands. Among many other luminaries, Justus Lipsius, Joseph Justus Scaliger, Hugo de Groot, Rembrandt van Rijn, Joost van den Vondel, René Descartes, Christiaan Huygens, Johannes Vermeer, Baruch Spinoza, and

developed peripheral regions, formed a large proportion of the total workforce. The conclusions of De Vries and Van der Woude were described by Jan van Zanden as the most extreme expression of the recent "revolt of the early modernists" against the claims of British historians who discern the dawn of the modern economic in the industrialization of the late eighteenth and early nineteenth centuries. However, Van Zanden has tempered some of their conclusions by examining newly identified Dutch wage data. He identifies the origin of Dutch economy "modernity" in the fifteenth century, and argues that Dutch growth rates were comparable to those of England in the seventeenth century (even if per capita GDP was substantially higher). Ultimately, to Van Zanden the Dutch economy was precociously modern, but that modernity was a medieval development. Jan van Zanden, "The 'revolt of the early modernists,' 632. Many other historians have joined this debate. For a good summary see: Davids, *The Rise and Decline of Dutch Technological Leadership Vol. I*, 16-22. See also: Catharina Lis and Hugo Soly, "Different Paths of Development: Capitalism in the Northern and Southern Netherlands during the Late Middle Ages and the Early Modern Period." *Review (Fernand Braudel Center)* 20:2 (1997): 211. De Vries and Van der Woude, *The First Modern Economy*, 713. Israel, *Dutch primacy in world trade*, 355. Violet Barbour, *Capitalism in Amsterdam in the 17th Century*. (Ann Arbor: University of Michigan Press, 1963), 12. Erika Kuijpers, "Poor, Illiterate and Superstitious? Social and Cultural Characteristics of the 'Noordse Natie' in the Amsterdam Lutheran Church in the Seventeenth Century." In *Dutch Light in the Norwegian Night: Maritime Relations and Migration across the North Sea in Early Modern Times*, ed. Louis Sicking, Harry de Bles and Erlend des Bouvrie. (Hilversum: Uitgeverij Verloren, 2004), 67.

⁵⁶ Barbour, *Capitalism in Amsterdam in the 17th Century*, 44. P.C. Emmer, *The Dutch in the Atlantic economy, 1580-1880*. (Aldershot: Ashgate, 1998), 14. Clé Lesger, *Handel in Amsterdam ten tijde van de Opstand: kooplieden, commerciële expansie en verandering in de ruimtelijke economie van de Nederlanden ca. 1550 - ca. 1630*. (Hilversum: Uitgeverij Verloren, 2001), 88. See also: Lodewijk Petram, "The world's first stock exchange: How the Amsterdam market for Dutch East India Company shares became a modern securities market, 1602-1700." (PhD diss., University of Amsterdam, 2014). Oscar Gelderblom and Joost Jonker, "Completing a Financial Revolution: The Finance of the Dutch East India Trade and the Rise of the Amsterdam Capital Market, 1595-1612." *The Journal of Economic History* 64:3 (2004): 644. J. Thomas Landblad, "Foreign trade of the Dutch Republic in the Seventeenth Century." *Economic and Social History in the Netherlands* 4 (1992): 1. R. Liesker and W. Fritschy, *Gewestelijke financiën ten tijde van de Republiek der Verenigde Nederlanden, Deel IV: Holland (1572-1795)*. Den Haag: Instituut voor Nederlandse Geschiedenis, 2004), 33. Jan Luiten van Zanden, "Economische Groei in Holland tussen 1500 en 1800." *NEHA-Bulletin* 16:2 (2001): 65.

Pierre Bayle lived in the cities of the Republic. Amsterdam in particular emerged as an international centre for publishing, mapmaking, and the other commercial expressions of a vigorous intellectual life. Moreover, the vitality of Dutch scholarship was not divorced from broader Dutch society. In the context of seventeenth-century Europe, the Republic, and particularly Holland, was exceptionally urbanized, highly literate, and possessed of a striking variety of technological innovations that improved the lives of ordinary citizens.⁵⁷

The conclusion of the Eighty Years' War with Spain in 1648 briefly left the Republic in a position of unchallenged economic primacy within Europe. However, within the strengthening states of England and France the Republic's commercial success encouraged protectionism, outright hostility, and ultimately emulation as the seventeenth century drew to a close. The coastal provinces of the Republic usually remained secure from invasion, yet incessant warfare from 1652 until the conclusion of the War of the Quadruple Alliance in 1720 dangerously strained the state's financial resources. By 1730, the introduction of the *paal worm* or "pile worm" (*Teredo limmoria*), a wood-boring mollusc, undermined the Republic's wooden defences against the sea and mandated their enormously expensive replacement with stone structures.⁵⁸

Despite repeated political, financial, and environmental setbacks, for decades the Republic's economy was distinguished more by transformation and relative decline than outright collapse.⁵⁹ Falling commodity prices, rising taxes, the increasing cost of labour, and a series of

⁵⁷ Lesger, *Handel in Amsterdam ten tijde van de Opstand*, 210. Israel, *The Dutch Republic*, 6. Price, *Dutch society, 1588-1713*, 55. Haley, *The Dutch in the Seventeenth Century*, 49. De Vries and Van der Woude, *The First Modern Economy*, 15, 60. Prak, *The Dutch Republic in the Seventeenth Century*, 5. Israel, *Dutch primacy in world trade*, 70. Davids, *The Rise and Decline of Dutch Technological Leadership*, 11.

⁵⁸ De Vries and Van der Woude, *The First Modern Economy*, 22. Lisa Jardine, *Going Dutch: How England Plundered Holland's Glory*. (New York: Harper Collins Publishers, 2008), 357. J. de Jong van Persyn et al., *Beschryvinge, van de schade en rasinge aan de zee-dyken van Noort-Hollanden West-Vriesland, door de worm in de palen, en de daar op gevolgde storm*. (Hoorn: Jacob Duyn, 1732), 5.

⁵⁹ Jan Luiten van Zanden, "The Emergence of Modern Economic Growth in the North Sea Region." In *The Long Road to the Industrial Revolution: The European Economy in a Global Perspective, 1000-1800*, ed. J.L. van Zanden. (Leiden: Brill, 2009), 248.

natural disasters undermined the Republic's agricultural productivity, while the destruction of much of the herring fleet during the War of the Spanish Succession was exacerbated when demand for fish faltered as the price for other forms of meat declined. Nevertheless, farmers in the coastal provinces responded by implementing labour-saving devices and planting new crops like tobacco, while in the early eighteenth century the whaling industry rebounded from a series of disastrous years. Shipbuilding, textiles, brickmaking, pottery, brewing, and the other traditional industries of the Golden Age all declined after 1670, yet the growth of paper-making, sugar-refining, distillery, tobacco-processing, and other new industries in the eighteenth century reflected the continued economic flexibility of the Republic. Trade experienced a similar transformation, as the importance of intra-European commerce declined within the Republic's economy after the middle of the seventeenth century while the VOC continued to increase the volume of its trade, even if its profits stagnated. However, transformation ultimately yielded to absolute decline after the first decades of the eighteenth century, and the government of the heavily indebted Republic settled into a policy of official neutrality. Nevertheless, Amsterdam, still one of Europe's largest cities, remained the continent's principal financial, commercial, and printing centre for most of the eighteenth century.⁶⁰

The Frigid Golden Age: an Overview of Climate Change in the Dutch Republic

The tumultuous history of the northern Netherlands in the late medieval and early modern periods overlapped with five centuries of relentless climatic variability. Climate reconstructions

⁶⁰ Israel, *Dutch primacy in world trade*, 376. De Vries and Van der Woude, *The First Modern Economy*, 336. W. Fritschy, "Schulden als leerschool? De Unie der Zeven Verenigde Provinciën en de Europese Unie." *Tijdschrift voor Sociale en Economische Geschiedenis*, 9:2 (2012), 9. Wantje Fritschy, Marjolein 't Hart and Edwin Horlings, "Long term trends in the fiscal history of the Netherlands, 1515-1914." In *The Rise of Fiscal States: A Global History, 1500-1914*, ed. B. Yun-Casalilla & P.K. O'Brien. (Cambridge: Cambridge UP, 2012), 47.

compiled from a variety of scientific and documentary proxy data reveal that variations in average temperature in the Low Countries roughly mirrored what was experienced elsewhere in northern Europe. As the Medieval Climatic Anomaly drew to a close, the region joined the rest of Europe in experiencing the relatively cool, wet, and stormy weather of the late thirteenth and early fourteenth centuries. Moderate summer temperatures were juxtaposed with decadal fluctuations in average temperatures in winter, spring, and autumn, but in the early sixteenth century these fluctuations yielded to general warmth across all seasons. However, the frigid winter of 1561 was the first of a series of cold winters that culminated in the remarkably severe winter of 1565 and heralded the onset of the Grindelwald Fluctuation (Figure I.4). The summer of 1628 was among the coldest of the Little Ice Age, yet relatively mild winters and warm summers between 1629 and 1631 demonstrated the influence of a new climatic regime. Two decades later, winters in the early 1650s were cooler than average, but summers were correspondingly warm until 1658. Despite the hot summer of 1666, 1662 can be considered the first year of the Maunder Minimum in the Low Countries given the increasingly cold temperatures that subsequently affected most seasons, coupled with the amplified yearly variability in temperature, precipitation, and storminess. The Maunder Minimum in the Republic concluded in 1718, when a decade of cool summers abruptly yielded to two summers that were among the hottest in the history of the Low Countries. Thereafter, seasonal temperatures rebounded, with winters in general growing milder and summers usually remaining warm until 1740, although 1725 was among the coldest years of the century, and a very chilly exception to the climatic trend. Following the very warm year of 1759, temperatures again declined in the Dalton Minimum, which despite substantial variations in annual temperatures endured in the Republic until approximately 1850.⁶¹

⁶¹ “Winter” here refers to December, January, and February, while “summer” is defined as June, July, and August.



Fig. I.4. One of many winter scenes created by Pieter Bruegel the Elder. This one, perhaps the most famous, was painted from Brussels during the frigid winter of 1565. Pieter Bruegel, the Elder, “Hunters in the Snow,” painting, 1565, Kunsthistorisches Museum Vienna, <http://www.google.com/culturalinstitute/asset-viewer/hunters-in-the-snow-winter/WgFmzFNNN74nUg?hl=en>.

Climate reconstructions reveal the extraordinary variability of seasonal temperatures during the height of the Dutch Republic, particularly in the minima that frame the origins and climax of its Golden Age. Nevertheless, they also reflect a persistent and severe reduction in average temperatures during the coldest phases of the Little Ice Age. During the Maunder and

In the Low Countries, temperature anomalies associated with the Maunder Minimum most closely reflected those experienced in the rest of Europe. The Grindelwald Fluctuation was generally milder in the Low Countries than elsewhere in Europe, while the Dalton minimum at the turn of the century was significantly more severe. Shabalova and Van Engelen, “Evaluation of a reconstruction of temperature in the Low Countries,” 236. H. M. van den Dool, H. J. Krijnen and C. J. E. Schuurmans, “Average winter temperatures at De Bilt (the Netherlands) 1634-1977,” *Climatic Change* 1 (1978): 327.

Dalton minima, winter temperatures declined by approximately one degree Celsius below twentieth-century averages. Spring temperatures fell by nearly as much, plunging during the early Maunder Minimum to a low exceeded only in the middle of the Grindelwald Fluctuation. Fall temperatures clearly demonstrated the influence of the Grindelwald Fluctuation, yet dipped relatively slightly during the Maunder Minimum, and actually rebounded strongly during the otherwise frigid 1690s. Summer temperatures reflect the least variation, yet reveal the influence of the Grindelwald Fluctuation more clearly than the Maunder Minimum. Indeed, average summer temperature during the late seventeenth century and early eighteenth century was likely slightly warmer than twentieth-century averages, although summer temperatures were subject to unusually pronounced changes from year to year. Overall, the cool summers of the late 1580s appear to have been matched in chilliness only by the summers of the early 1690s, while many of the winters during the 1590s, 1680s, and 1690s were among the coldest of the Little Ice Age (Figure I.5).⁶²

⁶² Van Engelen, Buisman and IJnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112. J. Buisman and A.F.V. van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575-1675*. (Franeker: Uitgeverij Van Wijnen, 2000), 707.

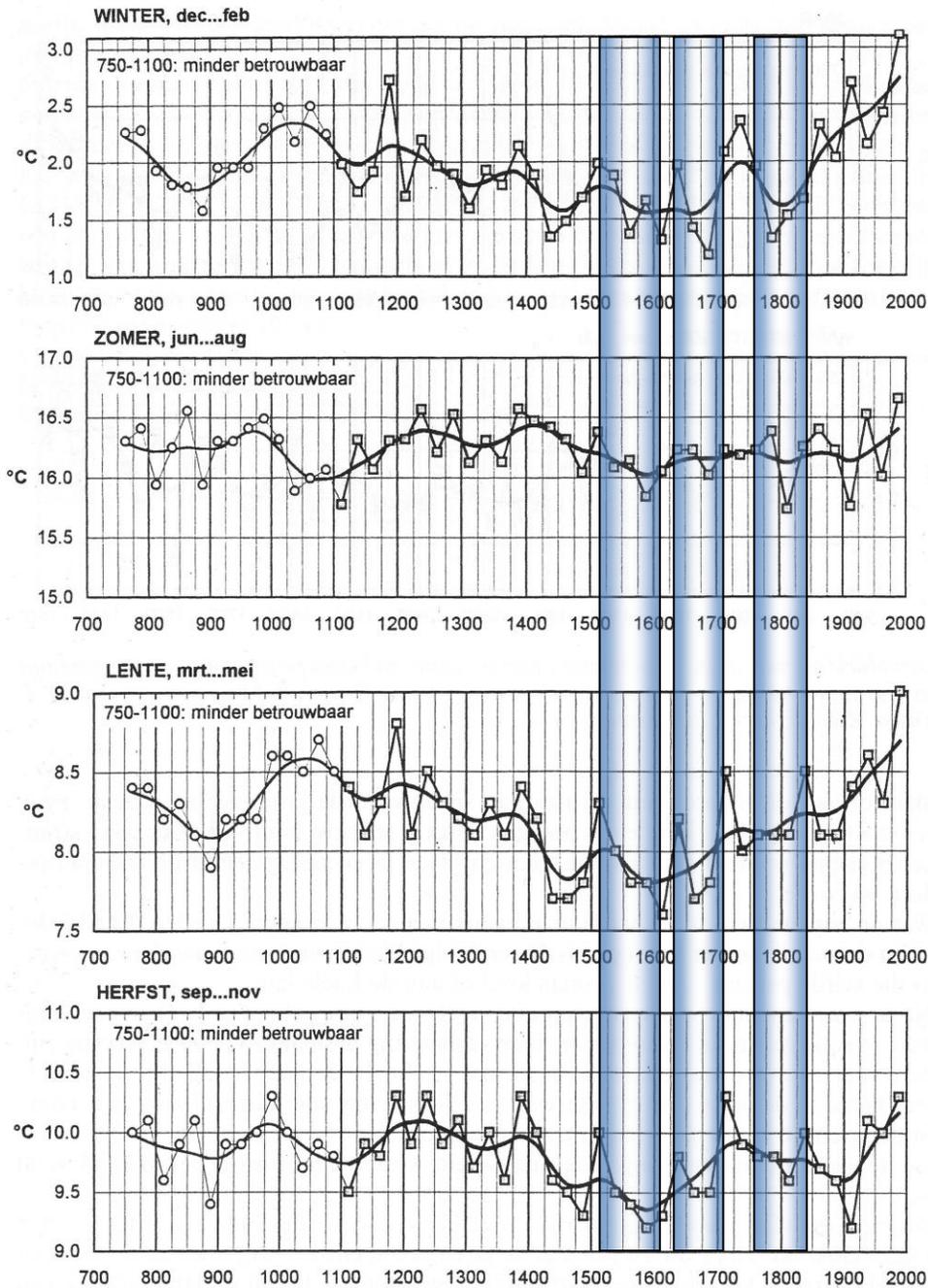


Fig. I.5. Multi-proxy reconstructions of fluctuations in average temperature in winter, summer, spring and fall for the Low Countries, compiled by F. IJnsen. Blue bars represent years during the Grindelwald Fluctuation (left), the Maunder Minimum (centre) and the Dalton Minimum (right). Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV, 707.*

Reconstructions of seasonal temperature in the early modern Low Countries clearly reflect the meteorological variability and, ultimately, chilliness of the three major minima of the

Little Ice Age. On the other hand, attempts to reconstruct seasonal or even annual fluctuations in regional precipitation are fraught with difficulty, and have consequently proven less definitive. Reliable seventeenth-century reconstructions for North Sea regions do not encompass precipitation in all seasons, and reconstructions crafted from proxy data for winter and summer do not appear to agree with those developed by the most current models.⁶³ Moreover, fluctuations in precipitation did not directly correspond to the amount of moisture on land, which was also subject to rates of evaporation that were influenced by fluctuations in temperature. Overall, it remains uncertain whether all Little Ice Age minima in Europe were similarly accompanied by generally wet or dry weather from region to region, in part because fluctuations in precipitation did not precisely accompany changes in seasonal temperature.

Still, trends in precipitation and temperature intersected in a manner that has led scholars like Jürg Luterbacher to conclude that European winters during the Maunder Minimum were, on average, colder and drier than they were during the twentieth century, while summers were cooler and wetter. Moreover, Pfister's study of Alpine Europe inspired him to propose the concept of "Little Ice Age Type-Impacts" to model how cold, rainy mid-summers with cold springs and rainy autumns influenced agricultural yields. Nevertheless, ship logbooks compiled in the North Sea between 1685 and 1700 examined by Dennis Wheeler recorded significant annual variability in the scale of recorded precipitation that does not easily fit with the concept of "Little Ice Age Type-Impacts." While ship logbooks likely underreported precipitation and are consequently better suited for the reconstruction of relative rather than absolute frequencies of precipitation, their measurements reflect a shift from drier to wetter conditions over the course of Wheeler's study period. Ultimately, low-resolution Dutch reconstructions suggest that

⁶³ Raible, "Climate variability - observations, reconstructions, and model simulations for the Atlantic-European and Alpine region," 19.

precipitation was very abundant during the height of the Grindelwald Fluctuation, while dry conditions prevailed in the warmer climatic “intervals” of the seventeenth and eighteenth centuries. In Northwestern Europe, the coldest phases of the Little Ice Age were likely among the wettest, but conclusions regarding changes in the abundance of precipitation during the Maunder Minimum, let alone the extent of surface moisture, are less robust than they are for other meteorological phenomena.⁶⁴

In the North Sea region, fluctuations in storminess have also been associated with the minima of the Little Ice Age. Reconstructions of shifts in European temperature and precipitation rely largely on scientific proxy data, especially at temporal or geographic resolutions of lower precision than the seasonal or the local. Expanding the analysis of regional climatic variability to include changes in storm frequency and intensity in the Low Countries, however, is more dependent on the interdisciplinary consideration of records compiled by contemporary observers. While many of these documentary sources are quantitative in nature, their interpretation remains a subjective exercise, and that has stimulated historiographic controversy. In her landmark 1977 survey of primary sources related to storm surges and river flooding in the Low Countries, Elisabeth Gottschalk charted a surge in storminess during the Grindelwald Fluctuation and a subsequent return to relative tranquillity after 1630. To Gottschalk, catastrophic storms accompanied the onset of the Maunder Minimum, with a series of particularly devastating storm surges afflicting the Dutch coast between 1664 and 1686. Gottschalk’s reconstructions revealed that the number of severe storm surges doubled after 1650 relative to the first half of the century, although overall there were fewer storm surges in the

⁶⁴ Brazdil et al., “Historical Climatology in Europe - the State of the Art,” 404. Dennis Wheeler, “British Naval Logbooks from the Late Seventeenth Century,” 142. Rüdiger Glaser, *Klimageschichte Mitteleuropas*, 58. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V*, 927.

seventeenth century than there had been in the previous century.⁶⁵ Similarly, in 1984 Hubert Lamb argued that the frequency of severe gales in the North Sea region rose during Little Ice Age minima. According to Lamb, seven severe storms ravaged the shores of the North Sea in 1660s alone, after just six in the first half of the seventeenth century.⁶⁶

Fifteen years later, Adriaan de Kraker examined the maintenance accounts of Flemish dikes and dunes, concluding that severe storminess increased by 400% during the Grindelwald Fluctuation, even as moderate storminess declined slightly after 1550. According to De Kraker, storm activity diminished during warm or average winters but intensified in relation to winter cooling. However, in 2005 De Kraker tempered some of these conclusions. De Kraker again employed accounts of coastal towns and records of dike and dune maintenance in a methodology that interpreted only continuous, uniform data gathered over many decades, while ignoring more fragmentary sources. Although revealing significant variability in storminess, and confirming that the Grindelwald Fluctuation was particularly tempestuous, De Kraker uncovered no clear link between cold winters and enhanced storminess.⁶⁷

De Kraker's methodology, while meticulous, nevertheless fails to consider that quantitative maintenance accounts, which recorded the cost of infrastructural repairs, did not document storms but rather storm damage. The impact of storms was mediated by geographical conditions, environmental structures, economic transformations, and the subsequent arrangement of human infrastructure. If maintenance accounts recorded any meteorological shifts at all, they

⁶⁵ According to Gottschalk, the three decades between 1660 and 1690 were each marked by at least one catastrophic storm surge, with further, less severe storm surges occurring in 1651, 1662, 1671 and 1683. Elisabeth M.K. Gottschalk, *Stormvloeden en rivieroverstromingen in Nederland, Vol. II: de periode 1400-1600*. (Assen: Van Gorcum, 1975), 817. Elisabeth M.K. Gottschalk, *Stormvloeden en rivieroverstromingen in Nederland, Vol. III: de periode 1600-1700*. (Assen: Van Gorcum, 1977), 414.

⁶⁶ Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 22.

⁶⁷ Adriaan M.J. de Kraker, "Reconstruction of Storm Frequency in the North Sea Area of the Preindustrial Period, 1400-1625 and the Connection with Reconstructed Time Series of Temperatures," *History of Meteorology* 2 (2005), 66. Pfister and Brázdil, "Climatic Variability in Sixteenth-Century Europe and its Social Dimension," 32.

over-represented gales that blew from the sea and consequently inflicted greater damage to dikes, dunes, and coastal towns in Flanders, while under-representing storms that blew from less destructive directions. Similarly, Lamb's striking conclusions reflecting an extreme rise in severe storminess along the English coast of the North Sea were likely influenced by the greater damage inflicted by winds that blew from the east. Both Lamb and De Kraker therefore measured not fluctuations in storm frequency per se, but rather changes in the impact of storms that blew from the east or west, respectively, in socioeconomically diverse regions.⁶⁸

Records that relate to early modern ship journeys can be a much more effective proxy than maintenance accounts for measuring changes in storm frequency and severity. However, storm reconstruction using such sources can also be complicated by methodological problems. For example, seventeenth-century shifts in shipwreck distribution and frequency might, at first, suggest changes in contemporary storm behaviour. In fact, the likelihood that a gale would sink a ship was also a product of the competence of its crew, the size and seaworthiness of the vessel, and the location of landscape features that could threaten the hull. In a storm, the coast and underwater sandbanks, known as shoals, threatened a ship only when they were in a lee position from that vessel (Figure I.6). In other words, if storm winds did not blow a ship towards a shoal or shore, they were far less likely to influence a shipwreck. Similarly, storms were more threatening when they struck fleets, as ships could run afoul of one another and so be sunk.

⁶⁸ Tim Soens, "Floods and money: funding drainage and flood control in coastal Flanders from the thirteenth to the sixteenth centuries." *Continuity and Change* 26:3 (2011): 334. Tim Soens, "Explaining deficiencies of water management in the late medieval Flemish coastal plain, 13th-16th centuries," in *Water Management, Communities, and Environment: The Low Countries in Comparative Perspective, C. 1000 - C. 1800*, ed. Hilde Greefs. (Hilversum: Academia Press, 2006), 36.

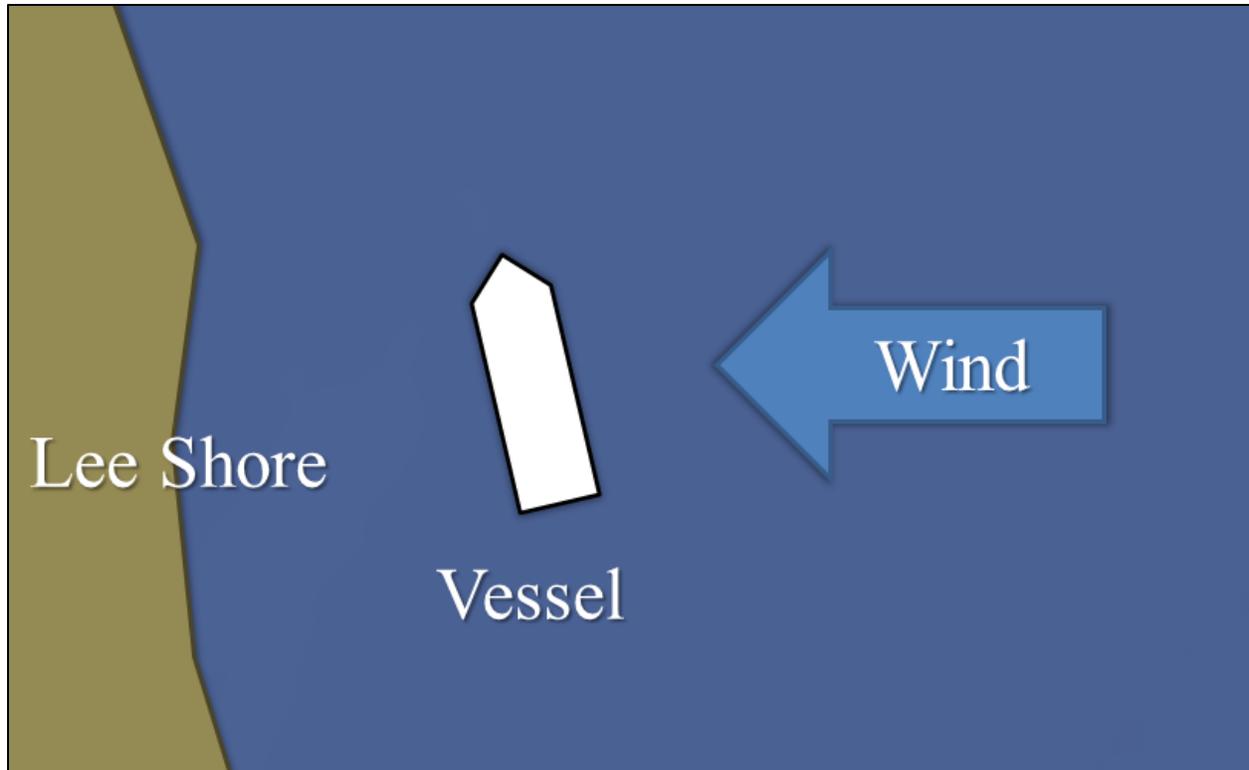


Fig. I.6. Location of a lee shore or coast. In sufficiently high winds, the vessel depicted would be in peril. The “lee side” of this ship is to the left, while the “weather side” is on the right. The Dictionary of English Nautical Language, accessed 28 February, 2014, http://www.seatalk.info/cgi-bin/nautical-marine-sailing-dictionary/db.cgi?db=db&uid=default&FirstLetter=l&sb=Term&view_records=View+Records&nh=3

On the other hand, ship logbooks naturally recorded not just wrecks but daily or even hourly weather conditions. Moreover, ships at sea were generally – if not invariably – removed from landscape features and patterns of settlement that affected the manner in which storms were recorded. On the Beaufort Scale of nautical wind velocity, wind speeds during a gale blow at or above Beaufort (BF) 8 (at least 34 knots), which creates waves more than 5.5 metres high.⁶⁹ In 2009, Wheeler analysed weather data in 300 English ship logbooks, and confirmed earlier studies that demonstrated a remarkable increase in the frequency of weather measurements

⁶⁹ Ricardo García-Herrera et al., *CLIWOC Multilingual Meteorological Dictionary: An English-Spanish-Dutch-French dictionary of wind force terms used by mariners from 1750 to 1850*. (Den Haag: Koninklijke Nederlands Meteorologisch Instituut), 44.

describing winds at or above BF 8 during the late Maunder Minimum.⁷⁰ These findings are echoed in the writings of early modern Dutch weather observers, who did record a surge in severe storminess during the minima of the Little Ice Age. Whether storminess in the Low Countries rose during all seasons remains uncertain, as does the precise relationship between increases in storm frequency and storm intensity, yet the majority of evidence reflects an increase in violent weather along the shores of the North Sea during the minima of the Little Ice Age that was more severe than what was experienced in most of Europe.⁷¹

Hubert Lamb was among the first historical climatologists to chart shifts in wind direction, not just velocity, across early modern Europe. By using seventeenth- and eighteenth-century measurements of wind direction kept in contemporary England, Lamb concluded that the frequency of westerly winds rose in the warmer decades of the Little Ice Age, while declining during its minima.⁷² Lamb's conclusions found little echo within historical climatology until the very recent rise of interest in the meteorological data contained within ship logbooks. In 2005, Wheeler used 52 logbooks compiled by English officers in the English Channel to reconstruct shifts in prevailing wind during the heart of the Maunder Minimum between 1685 and 1700. The resulting statistics demonstrate a high yearly variability of westerly winds, with a deep nadir in 1688 and further minima in 1692, 1695, and 1697.⁷³ In 2009, Wheeler's study of additional ship logbooks recorded up to 1750 reveals that westerlies during the Maunder Minimum were especially rare from January to May, and again in September, while easterlies were more

⁷⁰ This finding did not necessarily reveal a rise in *average* wind intensity; an increase in the number of days with severe winds may have been balanced by an increase in the number of days with light winds.

⁷¹ Dennis Wheeler et al., "Atmospheric circulation and storminess derived from Royal Navy logbooks: 1685 to 1750." *Climatic Change* 18 (2009): 257. Adriaen Van der Goes, "Hage, den 8 December 1665," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I*, ed. C.J. Gonnet. (Amsterdam: Johannes Müller, 1899), 221.

⁷² Lamb, *Climate, History and the Modern World*, 198.

⁷³ Wheeler, "British Naval Logbooks from the Late Seventeenth Century," 140.

common during colder winters.⁷⁴ The change in the frequency of easterlies during the period was therefore most felt during the months in which easterlies were more common even in warmer climates, and overall winter easterlies were 10% more frequent than they are today. These changes to the patterns of prevailing wind were probably caused by increased meridional airflow. In the middle latitudes air usually flows from west to east, but this system can break down, enabling so-called “meridional” winds to persistently blow from otherwise unusual directions. During the Maunder Minimum such a breakdown probably occurred over the north-eastern Atlantic as a result of the changes in the position of the North Atlantic Oscillation (NAO), a pattern of atmospheric pressure at sea level between the Icelandic low and the Azores high. These changes subsequently permitted the persistent intrusion of frigid Arctic air into the North Sea region.⁷⁵

To Wheeler, the weather data given within the logbooks appear to rule out any direct link between persistent winter easterlies and the overall cooling of the North Sea region in the late seventeenth century. Still, Wheeler’s summary of cold spells noted in the same logbooks between 1685 and 1700 suggests a strong correlation between northeasterlies and periods of particularly cold weather.⁷⁶ This is not surprising, because westerly winds funnel heat from the Atlantic, sustaining Europe’s mild climate relative to North America at similar latitudes.⁷⁷ Indeed, the detailed reconstruction of average temperatures in the Netherlands compiled by A.F.V. van Engelen, J. Buisman, and F. IJnsen seems to demonstrate that years distinguished by reduced westerly winds – such as 1688, 1692, 1695, and 1697 – were also marked by frigid

⁷⁴ Wheeler et al., “Atmospheric circulation and storminess derived from Royal Navy logbooks, 13.

⁷⁵ Wheeler, “Understanding Seventeenth-Century Ships’ Logbooks,” 16. See also: Rüdiger Glaser and Gerhard Koslowski, “Variations in reconstructed ice winter severity in the western Baltic from 1501 to 1995, and their implications for the North Atlantic Oscillation.” *Climatic Change* 41 (1999): 188.

⁷⁶ Wheeler, “British Naval Logbooks from the Late Seventeenth Century,” 144.

⁷⁷ S.D. Outten and I. Esau, “A link between Arctic sea ice and recent cooling trends over Eurasia.” *Climatic Change* 110:3-4 (2011): 1069.

winters and cool summers.⁷⁸ Furthermore, Rüdiger Glaser and Gerhard Koslowski have revealed that frequent westerlies accompanied Little Ice Age maxima and, in turn, periods of diminished winter ice in the Baltic region, while Little Ice Age minima brought abundant easterlies and severe winter ice. According to Glaser and Koslowski, a prolonged warmer period dominated by westerly winds faltered in 1654, after which a cooler period marked by frequent meridional blocking and expansive ice coverage endured until 1710. Since these changes corresponded to shifts in the position of the NAO, similar fluctuations in average temperatures and prevailing winds were likely also felt further south, on the shores of the English Channel.⁷⁹

Because changes in wind patterns were as important as decade-scale shifts in temperature or precipitation for the mariners and millers of the Dutch Republic, this dissertation will quantify Anglo-Dutch ship logbooks previously unexamined by historical climatologists to contribute to ground-breaking reconstructions of prevailing wind across early modern Europe. Logs kept aboard East Indiamen plying the oceanic rich trades, and warships sailing in the fleets that fought the Anglo-Dutch Wars, reflect an increase in storms and easterlies during the Maunder Minimum. Moreover, weather diaries and personal correspondence, kept in areas that provided little shelter from coastal winds, support these accounts. Ultimately, in this dissertation a rise in easterly winds is included among the weather patterns rendered more frequent by the Maunder Minimum in the North Sea region.

Methodology and Conceptualization

⁷⁸ Van Engelen, Buisman and IJnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112.

⁷⁹ Glaser and Koslowski, "Variations in reconstructed ice winter severity in the western Baltic," 184.

Climate history can be methodologically problematic. Decadal climate change, which gradually affects large geographic expanses, influences human history through weather events that are immediate and local. Some weather patterns are rendered more or less likely under different climatic regimes, but most expressions of weather can occur under any climate. Weather that is atypical under a particular climatic regime can influence human history as much as weather that conforms to the climatic norm. Environmental historians of past climates should consequently establish three broad relationships. The first must plausibly link immediate and local environmental changes, usually but not exclusively expressed in weather, to long-term climate change. The second must connect a substantial quantity of local or regional environmental phenomena – again, including weather events – to activities conducted by human beings. Only then can historians of climate consider the third and final relationship, that between climate change and human history.⁸⁰

This dissertation will consider weather to be symptomatic of a given climatic regime if it is repeatedly present – if not necessarily continuous – in months where it was atypical during a preceding or subsequent climatic regime. For example, in the warmer climate of the mid-seventeenth century, and again in the twentieth century, westerly winds were typical in June. In the late seventeenth century, repeated easterlies in that month can therefore be plausibly, if not certainly, associated with a colder climatic regime. On the other hand, during the minima of the Little Ice Age, continuous westerlies in February were likely anomalous, worthy of mention but probably not associated with the prevailing climate. Furthermore, this study will link weather events with a given climatic regime if they were particularly consistent over the course of a

⁸⁰ Bernstein et al., *Climate Change 2007: Synthesis Report*, 30. Charles Tilly, *Big Structures, Large Processes, Huge Comparisons*. (New York: Russell Sage Foundation, 1984), 12. Fernand Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II, Vol. I*. (California: University of California Press, 1995), 102. *The Global Climate 2001-2010, A Decade of Climate Extremes – Summary Report*. (Geneva: World Meteorological Organization, 2013), 2.

month, even where such weather had been common – if not relentless – in the preceding or succeeding climatic regime. For instance, during the coldest phases of the Little Ice Age, constant, largely uninterrupted easterly winds in February were probably a consequence of a new climatic regime, even if easterlies were more common in February than in other months during the twentieth century.⁸¹

Supercomputer reconstructions of connections between modern climate change and short-term environmental fluctuations are only now becoming possible. Lacking the vast, real-time data networks that measure the global climate today, historians of past climates must incorporate probability into their methodology. Some discussion of probability invariably accompanies historical analysis, particularly in narratives that identify connections between structures and events. Still, few historical narratives hinge on probability the way climate histories do. Relationships between weather and human affairs reconstructed in this dissertation rest on firmer ground than links between weather and climate change, or climate change and human history. Moreover, the environmental consequences of climate change were hardly the only influences that shaped the political, economic, social, and cultural histories of the Dutch Republic. Weather typical of different climatic regimes during the Little Ice Age limited or expanded the choices open to historical actors without determining the course of human action. Nevertheless, this dissertation reveals that climatic fluctuations ultimately contributed to the character of the Dutch Golden Age.⁸²

⁸¹ C.G. Korevaar, *North Sea Climate, based on observations from ships and lightvessels*. (Dordrecht: Kluwer Academic Publishers, 1990), 65.

⁸² John McNeill has eloquently described the issues that emerge from the somewhat speculative nature of environmental history: “at root, the issue is a question of what is the proper ambition for historians. Is it to offer the most plausible vision of the past, or to offer a reliably documented vision of the past? The former necessarily requires speculation, and could therefore easily be misleading. The latter avoids speculation, but must leave large blanks.” It is my belief – and, probably, that of most historians working in the field’s newer sub-disciplines – that some informed speculation or subjectivity in the quest for a more accurate and holistic understanding of the past is not necessarily a bad thing. J.R. McNeill, “Author’s Response by J. R. McNeill, Georgetown University,”

Examining relationships between weather, human activity, and climatic trends requires constant movement from the particular to the general, from the very short to the very *longue durée*. Because climate change is a gradual process, quantitative comparisons between human and climate histories over long timeframes can seem to yield more convincing climate histories than those that identify links between particular human or meteorological events and broader climatic shifts. However, if discrete human activities cannot be tied to the manifestations of a climatic regime through a chain of probable causality, it is difficult to understand how that climatic regime can be reliably linked to broader trends in human history. Moreover, quantitative records are subjectively compiled, and linking quantitative datasets based solely on the presence of similar statistical trends is fraught with peril.⁸³ Hence, firm conclusions are only provided in this dissertation when convincing qualitative sources are available to link different quantitative trends by providing first-hand accounts of how weather influenced human affairs. To further unravel these interactions, most chapters in this dissertation will also compare trends or events in colder, wetter, stormier decades of the Little Ice Age with those occurring in the warmer, drier, and more tranquil periods. These comparisons will verify that Dutch military, economic, and cultural developments were indeed influenced by early modern changes in prevailing weather.⁸⁴

Reconstructing general trends in the development of a particular form of weather – such as a storm – requires the unravelling of complex connections between its different expressions over time. Overlapping trends for different meteorological expressions can then be gathered into

H-Environment Roundtable Reviews, Vol. 1, 1 (2011): 25. Edwards, *A Vast Machine*, 289. Helge Salvesen, “The Climate as a factor of historical causation,” in *European climate reconstructed from documentary data: methods and results*, ed. Buckhard Frenzel. Stuttgart: Gustav Fischer Verlag, 1992), 219. Tilly, *Big Structures, Large Processes, Huge Comparisons*, 12.

⁸³ It is as methodologically problematic to associate climate and human history by using simplistic quantitative data as it is to link, for example, urbanization and economic performance by comparing demographic data to annual gross domestic product. Tilly, *Big Structures, Large Processes, Huge Comparisons*, 12.

⁸⁴ The *Annales* school was particularly interested in these relationships. Fernand Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II*, 355. Edwards, *A Vast Machine*, 4. Jan de Vries, “The Economic Crisis of the Seventeenth Century after Fifty Years.” *Journal of Interdisciplinary History* 40:2 (2009): 164.

a chronology of climatic fluctuation. However, under the broad scholarly umbrella of historical climatology different methodologies and, in turn, different forms of conceptualizing a climatic shift can spring from different disciplines. Reconstructions of the climatic oscillations of the Little Ice Age provide some of the clearest examples of this potential problem. From the perspective of climatologists attempting to unravel natural relationships, the Little Ice Age is viewed as a period marked by general if uneven global cooling that, in Northern Europe, stimulated a unique pattern of meteorological effects. For historians searching through documentary evidence for connections between environment and society, however, the Little Ice Age can as easily be conceived as a subjectively defined series of decades marked by a shifting catalogue of often-related weather phenomena that usually included cooler yearly temperatures.

From this perspective, why and how a given weather event endured are less important than its human influence and, in turn, the manner of its categorization by historians. Why should several years of regional storminess directly preceding the commonly accepted beginning of the Little Ice Age, whatever its atmospheric origin, not be included under the umbrella of Little Ice Age tempestuousness when examining human affairs? There is no easy answer to this question for the historian, since it made little difference for contemporaries whether storminess was stimulated by anomalous circumstances, or by what is now termed the “Little Ice Age.” Still, for the interdisciplinary study of historical climatology the climatic causes underlying weather events and their expression through local environments are as important as the influence of weather on human populations. The assumption underlying this dissertation is that there is inherent value in uncovering the network of environmental and human influences cascading only from weather typical of (that is, more frequent during) a specific, narrowly-defined climatic shift. For environmental historians, engaging in such research can not only isolate a previously ignored

historical influence, but also provide critical context for the study of anthropogenic global warming.

An analysis of the Little Ice Age in the Dutch Republic can not only shed light on the ways in which climate change can be conceptualized, but also on the history of energy in early modern Europe. The “organic economy,” as defined by energy historian E. A. Wrigley, was the pre-modern condition in which energy was harnessed largely by sail, mill, and especially human or animal muscles. Without the extensive exploitation of the much higher energy potential of fossil fuels, trade was limited, populations were diffused, and economies were dependent on the produce of the land. Historians have debated whether the economy and society of the Dutch Republic tested, or exceeded, the limitations of this organic economy. In this argument, the Republic’s high urbanization, extensive networks of trade, thriving industrial centres, and commercialized agriculture are often perceived as symptoms of an unusually efficient energy supply. Wrigley, for example, has maintained that the Dutch economy achieved its dynamism through the exploitation of peat, an ostensibly potent but finite source of energy that ultimately limited the maximum duration of the Republic’s Golden Age. On the other hand, burning peat provided scarcely more energy than burning wood, while the exploitation of wind, water, and coal also accounted for a sizeable portion of the Republic’s energy use.⁸⁵ Wrigley’s argument, therefore, seems incomplete.⁸⁶

⁸⁵ Moreover, Dutch supplies of peat were not exhausted by the nineteenth century. Instead, peat was increasingly supplanted by inexpensive coal from England and coal mines in Limburg. Ben Gales et al. “North versus South: Energy transition and energy intensity in Europe over 200 years.” *European Review of Economic History* 11 (2007): 224.

⁸⁶ Indeed Wrigley’s conclusions were based on J. W. de Zeeuw’s trailblazing but now-discredited statistics on the importance of peat for Dutch energy consumption. E.A. Wrigley, *Continuity, Chance and Change: The character of the industrial revolution in England*. (Cambridge: Cambridge University Press, 1988), 57. R.W. Unger, “Energy sources for the Dutch Golden Age; Peat, wind and coal.” *Research in Economic History* 9 (1984): 228. Davids, *The Rise and Decline of Dutch Technological Leadership, Vol. I.*, 17. Karel Davids, “Technological Change and the Economic Expansion of the Dutch Republic, 1580-1680,” in *The Dutch Economy in the Golden Age: Nine Studies*, ed. K. Davids and L. Noordegraaf. (Amsterdam: Nederlandsch Economisch-Historisch Archief, 1993): 83. Vaclav

More important was the way in which energy was exploited in the Republic. In that context, an examination of climatic fluctuations in the Republic reveals that total energy consumption actually mattered less than the flexibility and adaptability with which even modest sources of energy could be applied to work. Dutch citizens developed financial institutions, transportation networks, and technologies that allowed them to exploit, or at least substantially mediate, changing patterns of prevailing weather. In this they were often synthesizers rather than innovators: the institutions and infrastructure developed in the Republic were usually not unprecedented in European history, nor were they confined to the northern Low Countries. Nevertheless, waterborne trade, for example, or commercial capitalism were more important in the seventeenth-century Republic than they were anywhere else in Europe. This had consequences for the Dutch manipulation of energy during the climatic shifts of the Little Ice Age.

Energy from the sun, expressed in light and warmth, is absorbed by plants through photosynthesis. This process provides the nutrients that, in turn, yield useable energy for animals and human beings. In agricultural economies, cold annual temperatures typically lead to shorter growing seasons, reducing the dominant source of useable energy and, in turn, worsening or even threatening human life. Farmers in the agricultural societies of early modern Europe were capable of adapting to gradual climatic cooling.⁸⁷ Still, interactions between agricultural yields and climatic cooling were essentially declensionist in many parts of Europe, which accounts for the overwhelmingly negative tone of most climate histories of the Little Ice Age. Of course,

Smil, *Energy in World History*. (Boulder: Westview, 1994), 248. John Landers, *The Field and the Forge: Population, Production and Power in the Pre-Industrial West*. (New York: Oxford University Press, 2003), 7. Brazdil et al., "Historical Climatology in Europe - the State of the Art," 403.

⁸⁷ Overall, from the mid-sixteenth to the mid-seventeenth centuries, English agriculture diversified considerably, perhaps stimulated in part by cooling climatic conditions. De Vries, "Measuring the Impact of Climate on History," 626.

Dutch citizens also depended on nutrients created through photosynthesis. However, in the Republic many of these nutrients were imported from the Baltic, through trade that was part of a commercial network that, in turn, was largely driven by relationships between wind and water. It was generally easier for Dutch merchants, mariners, and soldiers to benefit from, or at least adapt to, changed wind dynamics or greater ice cover during the minima of the Little Ice Age, than it was for farmers elsewhere in Europe to adjust to cooler, wetter conditions. Cold temperatures did not necessarily reduce the amount of useable energy for the Dutch economy. Whether or not it possessed an organic economy, the Dutch Republic was certainly not an agricultural economy, which allowed it to exceed the limitations of such economies in the face of a climate, and an environment, in flux.⁸⁸

Energy is a conceptual tool in this analysis of the Little Ice Age in the Dutch Republic, but it is not an explanatory device. The limitations of surviving sources complicate any attempt to quantify precisely how the energy employed by the ships, boats, mills, animals, and people of the Republic was tied to weather events at a particular point in time. It is therefore impractical to link the climatic fluctuations of the Little Ice Age to changes in the efficiency of Dutch energy exploitation between the sixteenth and eighteenth centuries. However, it is possible to suggest likely relationships on the grounds of existing evidence. Ultimately, introducing the Republic's adaptable energy exploitation can provide a new method of perceiving, but not explaining, the distinct way that the Dutch experienced the Little Ice Age.

This dissertation is informed by a diverse selection of documentary evidence compiled by Dutch and English citizens in the sixteenth, seventeenth, and eighteenth centuries. The most revealing of these written sources, usually ship logbooks, letters, intelligence reports, or diary

⁸⁸ Rolf P. Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution*. (Cambridge: White Horse Press, 2001), ix. E.A. Wrigley, *Poverty, Progress and Population*. (Cambridge: Cambridge University Press, 2004), 33.

entries, explicitly described the ways in which contemporary weather events affected human affairs. Such documents were often penned by those whose livelihoods were tied to weather. For example, Claas Ariszoon Caeskoper, who lived on the western coast of the Zaan near Amsterdam, worked a windmill that pressed oil. Wind and temperature influenced the efficiency of the mill, the transport of its commodities, and even the success of Caeskoper's investments in whaling. The activity of sailors was even more closely shaped by weather. Ship logbooks of the kind meticulously compiled by Dutch and English officers entered the historical record as European mariners sailed more regularly into deep ocean, and were primarily compiled to facilitate navigation. Hence, ship logs abound with reliable meteorological information taken several times on virtually every day of journeys. With thousands of surviving records from across the globe, ship logbooks are among the few premodern sources with continuous, standardized, and easily quantifiable weather data. However, they have only recently attracted the concerted attention of historical climatologists.⁸⁹

Other documents that referred to weather were written by those who had the means, and consequently the literary training, to meticulously describe environmental conditions even when these did not directly affect their lives. For instance, Adriaen van der Goes, a lawyer for the Court of Holland in The Hague, was scarcely impacted by meteorological conditions in other towns, yet he nevertheless reported them to his brother. Finally, many of these sources were written by those whose responsibilities were tied to affairs of state that, in a maritime country, were frequently shaped by weather. Grand pensionary Anthonie Heinsius, for instance, routinely sent and received correspondence that outlined precisely how weather events had affected the

⁸⁹ Wheeler, "British Naval Logbooks from the Late Seventeenth Century," 136. H.E. Lansberg, "Past Climates from Unexploited Written Sources," *Journal of Interdisciplinary History*, No. 10 (1980), 631. Lamb, Hubert. *Climate, History, and the Modern World*. 2nd ed., 85. R. García-Herrera et al. "CLIWOC: A climatological database for the world's oceans 1750-1854," *Climatic Change* 73 (2005): 1-12.

movement of a fleet, the conduct of diplomacy, or the arrival of Baltic commodities. Ultimately, most of the documents that explicitly detail the influence of weather were written by men of at least middling means. When reconstructing the influence of past weather and, in turn, past climate, the unfiltered voices of women and the poor are far harder to discern. This dissertation can serve as a necessary stepping stone towards a more inclusive climate history of the Dutch Republic and, indeed, early modern Europe.⁹⁰

In the seventeenth century, the coastal province of Holland was home to nearly half of the Republic's population and supplied most of its annual budget. Consequently, it is the focus of the following chapters. While no single province was representative of a country where not even the date was standardized, Holland was as central to economic, cultural, and political life within the Republic in the seventeenth century as England was within the United Kingdom two centuries later.⁹¹ Urbanization in Holland reached 61% by 1675, and its crowded centres of population formed the core of the Republic's unique experience with the climatic fluctuations of the Little Ice Age. Holland's demographic, financial, and cultural hegemony among the United Provinces ensured that its times of crisis and prosperity shaped the history of the Republic as a whole. Moreover, the wealth of surviving documentation in the archives of Holland enables the kind of quantitative source analysis that is central to historical climatology.⁹²

Outline: Acquiring and Defending Wealth in a Changing Climate

⁹⁰ Bert Koene, *De Caeskopers: Een Zaanse koopmansfamilie in de Gouden Eeuw*. Hilversum: Uitgeverij Verloren, 2011), 11. C. J. Gonnet, "Inleiding," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, ed. C.J. Gonnet. (Amsterdam: Johannes Müller, 1899), XXIV.

⁹¹ And Amsterdam was arguably as central to Holland as London would later be to England, or as Venice had been to its *Terraferma*. David Ormrod, *The Rise of Commercial Empires: England and the Netherlands in the Age of Mercantilism, 1650-1770*. (Cambridge: Cambridge University Press, 2003), 11.

⁹² De Vries and Van der Woude, *The First Modern Economy*, 100. Haley, *The Dutch in the Seventeenth Century*, 65. Price, *Dutch society*, 70.

The first part of this dissertation employs a series of case studies to explore how climatic fluctuations during the Little Ice Age influenced mobility through the Dutch trading empire. Changing patterns of prevailing weather during the Little Ice Age affected Dutch commerce, and in turn the acquisition of wealth in the Republic, by altering the ability of mariners and merchants to move through their world. The first chapter employs new reconstructions of the early modern Arctic environment to investigate the Dutch quest for a Northeast Passage between 1594 and 1597. For Dutch merchants, cartographers, and politicians, the passage promised a quicker sea route to Asia that was safe from Spanish harassment. Dutch voyages in search of the passage were conducted during the nadir of the Grindelwald Fluctuation, and all failed in the Arctic ice near Novaya Zemlya. However, the journeys were shaped not by unrelenting cold, but rather by a complex suite of occasionally counterbalancing, sometimes mutually reinforcing interactions between the regional atmosphere, hydrosphere, cryosphere,⁹³ and biosphere that usually, but not invariably, reflected the influence of the Grindelwald Fluctuation. These environmental relationships may have contributed to the failure of the Dutch expeditions to chart a passage, but they also encouraged discoveries that would later contribute to the Dutch Golden Age.

The second chapter remains at the periphery of the Dutch world, yet its focus is much further south. Journey data and meteorological information in day registers, ship logbooks, and correspondence is standardized and quantified to explore the Republic's oceanic "rich trades" from the height of the Grindelwald Fluctuation through the conclusion of the Maunder Minimum. Extensive statistical analysis is synthesized with qualitative reflections to reveal that an increase in easterly winds in the Northeastern Atlantic during the minima of the Little Ice Age

⁹³ The cryosphere refers to all portions of the Earth where water and soil are frozen. Jonathan L. Bamber and Antony J. Payne (eds). *Mass Balance of the Cryosphere: Observations and Modelling of Contemporary and Future Changes*. (Cambridge: Cambridge University Press, 2004), 1.

significantly quickened outbound VOC ship journeys to Asia. Because returning VOC voyages usually followed a different course than outbound journeys, the influence of shifting wind patterns usually did not correspondingly slow inbound ships. More frequent gales in the North Sea region during the coldest phases of the Little Ice Age did not often sink the sturdy VOC ships, which often sailed far from the threatening coasts. In fact, storms could accelerate the progress of VOC vessels if they blew in a favourable direction. Ultimately, the weather that grew more common during the minima of the Little Ice Age generally facilitated the transmission of goods, people, and information between the opposite poles of the Republic's commercial empire.

The third chapter that unravels entanglements between climate, weather, and mobility through the Dutch trading empire turns from the periphery to the metropole and its immediate vicinity. The chapter begins by examining how climatic fluctuations influenced what the Dutch called the "mother of all trades:" the acquisition of Baltic commodities for low-volume, high-value goods from the south. The influence of weather that grew more frequent during the coldest phases of the Little Ice Age was less ambiguous for those who serviced this critical commerce than it was for northern explorers or the VOC. Lengthier winter freezing prohibited travel through the Baltic and could imperil ships in icy harbours. More common storms could be deadly, because ships travelling to and from the Baltic often lingered near the coast. Not only trade but also the supply of armies, the flow of information, and the progress of diplomacy was routinely hampered during the minima of the Little Ice Age. Still, the Republic's merchants responded creatively to the risks imposed by storms, and rising grain prices in cold years could benefit the Dutch economy.

The third chapter continues by investigating mobility within the Republic's borders. During the Dutch Golden Age, boats were the most efficient conduits of people, goods, and

information through the watery landscape of the Low Countries. During the nadir of the Little Ice Age, sailboats that relied on favourable wind direction and velocity were gradually supplemented by horse-drawn barges that were far less susceptible to the whims of weather. On the other hand, boats of all kinds remained vulnerable to storms, and none could be operated when water turned to ice. Ice could also impede travel along the Republic's meandering network of unhardened roads, and in cold winters many Dutch citizens therefore employed skates and sleds to travel in ice-covered waterways. Roads were also rendered unnavigable by heavy rainfall or snowfall, and most destinations were accordingly serviced by more than one road. Overall, the Republic's diverse networks of transportation allowed Dutch citizens to maintain their mobility during the minima of the Little Ice Age, although some weather events could jeopardize all forms of regional travel.

The second part of the dissertation uncovers how climatic shifts strengthened or weakened attempts to defend the Republic's economic hegemony. Consequently, the fourth chapter contributes to the recent historiographical synthesis of military and environmental histories by introducing the Anglo-Dutch Wars as a case study into the relationship between a shifting climate, weather events, and early modern military operations. The chapter considers how differences between Dutch and English military systems yielded distinct patterns of vulnerability and resilience in the face of the warmer weather and more common westerlies that prevailed during the First Anglo-Dutch War. The war was contested in the narrow waters of the North Sea, where the calm, westerly winds typical of the seventeenth-century interval between Little Ice Age minima allowed crews aboard larger English warships to field all their guns and granted them the initiative in most engagements.

The following two chapters analyse the Second and Third Anglo-Dutch Wars, which were fought on land and at sea in the colder, wetter, stormier climate of the Maunder Minimum. Evolving Anglo-Dutch military systems produced new weaknesses and strengths in the face of a new climatic regime, with more frequent easterlies now granting critical advantages to Dutch fleets that had adopted elements of English tactics and technology. High winds typical of the Maunder Minimum undermined English attempts to open their more numerous gun tiers and, when sufficiently severe, thwarted attempts to blockade the Dutch coast. During the French and German invasion that commenced the third war, the Republic's desperate defences were undercut and, later, supported by a complex constellation of meteorological phenomena that partially reflected the influence of the Maunder Minimum. Indeed, the weather experienced during military engagements on land during the third war reveals both the possibilities and the limitations of examining climatic fluctuation as a historical influence. Ultimately, the fourth, fifth, and sixth chapters argue that the changing climate of the mid-seventeenth century must be considered alongside human agency and the political, economic, or cultural influences typically considered by military historians to explain the course of the Anglo-Dutch Wars.

The third and final part of this dissertation explores how the Little Ice Age was understood in the Dutch Republic, and how it can be conceptualized by historical climatologists today. The seventh chapter reaches beyond the material ramifications of climate change in the Dutch Republic to investigate the mentalities that shaped, and were shaped by, the influence of the Little Ice Age. Between the sixteenth and eighteenth centuries, understandings of weather evolved in different ways among different social groups. While Dutch scholars developed a more secular natural philosophy, supernatural explanations for weather persisted among other literate observers, and particularly practical attitudes dominated among the less educated. As Dutch

observers sought to identify the spiritual significance, natural origin, and practical consequences of weather, they compared meteorological conditions in their present with events in the past. These remarkably accurate comparisons may have reflected an emerging awareness of long-term shifts in prevailing weather that plausibly contributed to the development of new military and economic strategies in the Dutch Republic. Moreover, both artistic responses to weather and the development of new technologies and practices during the nadir of the Little Ice Age reflect the belief that the consequences of adverse weather could be endured and overcome.

The conclusion summarizes the ways in which the influence of the Little Ice Age in the Dutch Republic was ambiguous. It conceptualizes the distinct influence of early modern climatic fluctuations in the Republic by exploring how the Dutch economy was sustained by different sources of energy than those that were harnessed in Europe's more agricultural societies. The conclusion then employs the case studies pursued in previous chapters to unravel how the climatic fluctuations of the Little Ice Age helped shape the broader history of the Dutch Republic from revolt to decline. It continues by evaluating the value of different interdisciplinary models in conceptualizing the influence of the Little Ice Age in the Republic. Finally, the dissertation concludes with a reflection on the ways in which an understanding of climate change in the Dutch Republic can improve projections of life in a warmer future.

PART I: COMMERCE AND CLIMATE CHANGE

**Acquiring Wealth in the Little Ice Age: Case Studies on Exploration, Trade,
and Travel in the Dutch Trading Empire, 1565-1750**

While conceptualizing the Mediterranean world, Fernand Braudel concluded that, in the sixteenth century, distance was “the first enemy.”¹ Braudel’s much-quoted phrase was not concerned with space so much as its cousin, time; the “tyranny of distance” lay less in, for example, the many miles between Spain and the Philippines than in the years required by a ship to traverse those miles. After spending so long in transit, it was rare that goods, messages, and people arrived at their destinations precisely when needed. Often information was received when obsolete, goods when demand had ebbed, people when their presence was no longer required. Both time and space were, to an extent, social constructs, increasingly relevant for European societies sustained and enriched by commerce or plunder.² Nevertheless, time spent in transit was time exposed to the very real hazards of travel, which could manifest on land as at sea in heightened exposure to disease, crime, deprivation, and environmental catastrophe. In early modern Europe, travel was therefore dangerous, expensive, irregularly planned, and, above all, time-consuming.³

Speed of travel across much of the early modern world was primarily – if not exclusively – hampered by two variables: the weakness of government authority, and the limitations of contemporary technology. Most local, regional or, in particular, national governments could not collect the resources necessary to build and maintain major improvements to the dirt paths and winding rivers used for transportation in much of early modern Europe. The limitations of early modern infrastructure generally exacerbated the constraints of contemporary technology, which,

¹ Braudel explained that “today we have too little space, the world is shrinking around us. In the sixteenth century there was too much and it could be both an advantage and an obstacle.” Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II*, Vol. I., 355.

² Henri Lefebvre, *Rhythmanalysis: Space, Time and Everyday Life*. (London: Continuum, 2004), 89. Geoffrey Parker, “Braudel’s Mediterranean: The Making and Marketing of a Masterpiece.” *The Journal of the Historical Association* 59: 195 (1974): 239. Geoffrey Parker, *The Army of Flanders and the Spanish Road*, 18. See also: Bethany Aram, “Chapter 12: Distance and Misinformation in the Conquest of America” in *The Limits of Empire: European Imperial Formations in Early Modern World History: Essays in Honor of Geoffrey Parker*, ed. William Reger. Farnham: Ashgate Publishing, 2013.

³ Landers, *The Field and the Forge*, 4.

on roads and modest waterways, primarily harnessed only the minimal energy derived from human or animal muscles. Ultimately, travel was accelerated or delayed by the efficiency with which energy was siphoned from, and then applied to, environments that co-evolved with decidedly limited human activity.⁴

From bureaucrats and wealthy merchants to millers and farmers, Dutch citizens fuelled the Republic's rise to global commercial primacy by engaging in and improving forms of early modern travel that either required less energy, or accessed greater sources of energy, than modes of transportation predominant elsewhere in Europe. Many of the vessels that plied Dutch trades by the thousands through inland waterways and across distant oceans harnessed the power of wind, not muscle, and together constituted a greater share of total energy use in the Republic than elsewhere in early modern Europe. Although horses pulled wagons over dirt roads in the Republic as in the rest of Europe, during the Golden Age the transportation of people, goods, and information across significant distances within the coastal provinces was overwhelmingly accomplished by boat, barge, or ship. Vessels that did not use sails employed the limited energy provided by human or animal muscles to drag heavy cargo across the relatively frictionless surface of water.⁵

By the Republic's seventeenth-century Golden Age, complex natural, human, and hybrid structures had yielded a unique transportation network that was vast in scope and central to the

⁴ Still, methods for movement across early modern Europe were extraordinary diverse. Pockets of particularly efficient travel existed across Europe, and even Braudel acknowledged that travel through sixteenth-century Europe could be "positively pleasant where towns and villages were close together." Of course, in few regions were they more congregated than in the Golden-Age Dutch Republic. Catherine Delano-Smith, "Milieus of Mobility: Itineraries, Route Maps and Road Maps." In *Cartographies of Travel and Navigation*, ed. James R. Akerman. Chicago: University of Chicago Press (2006), 29. Smil, *Energy in World History*, 229.

⁵ Richard Unger, "Energy Sources for the Dutch Golden Age: Peat, Wind and Coal," 228. Frits H. Horsten, *Doorgaande wegen in Nederland, 16e tot 19e eeuw: Een historische wegenatlas*. (Amsterdam: Uitgeverij Aksant, 2005), 47.

relatively modern economy of the coastal provinces.⁶ In the 1630s more than 100 vessels, some exceeding 1,000 tons, carried high-value goods from Africa and the Americas in the service of the West East India Company (WIC). By 1657 the Dutch East India Company (or VOC), the WIC's much larger and more successful counterpart, maintained over 160 ships for service between Asian ports alone. In 1636 perhaps 1,750 merchant vessels, on average far smaller than the typical East Indiaman, supported Dutch trade in European waters. While the most important routes serviced Iberia, France, and especially the Baltic, Dutch merchants dominated seaborne trade in ports from Archangel in the far north to Constantinople in the south.⁷ An additional 450 ships of no more than 80 tons plied the sea trades near the Republic's home waters, carrying goods between ports like Hamburg and London.⁸

Altogether, by the middle of the seventeenth century Dutch ocean-going vessels likely possessed a total carrying capacity of over 400,000 tons. The raw materials and resources carried by this immense merchant fleet were consumed, refined, and worked into finished goods across the Republic. Consequently, the quantity of light vessels that ferried goods, people and information through the lakes, rivers, channels and creeks of the Republic itself was correspondingly vast. Comprehensive figures dating from the Golden Age are not available, yet statistics compiled in 1808 reveal that 18,421 inland commercial vessels, from small boats to 60-ton barges, possessed a carrying capacity of more than 250,000 tons. Given the lengthy

⁶ It should be stressed that the use of the terms "transportation network" or "transportation system" in this chapter does not suggest that the Dutch possessed a necessarily coherent, centralized system for moving goods, people and information. Any reference to the Republic's transportation network is an abstraction of what was, in practice, an organically developed product of private investment and municipal or provincial competition that was rife with redundancies below the level of the major international monopolies.

⁷ While most of the Republic's commerce in European waters concerned low-value, high-volume cargo, the Levantine trade servicing the Ottoman Empire carried high-value, low-volume goods. Because the Republic's access to this market was heavily influenced by Spanish tolerance, it declined sharply during Spanish embargoes in the Eighty Years' War, to the benefit of English merchants. Jonathan Israel, *The Dutch Republic*, 314.

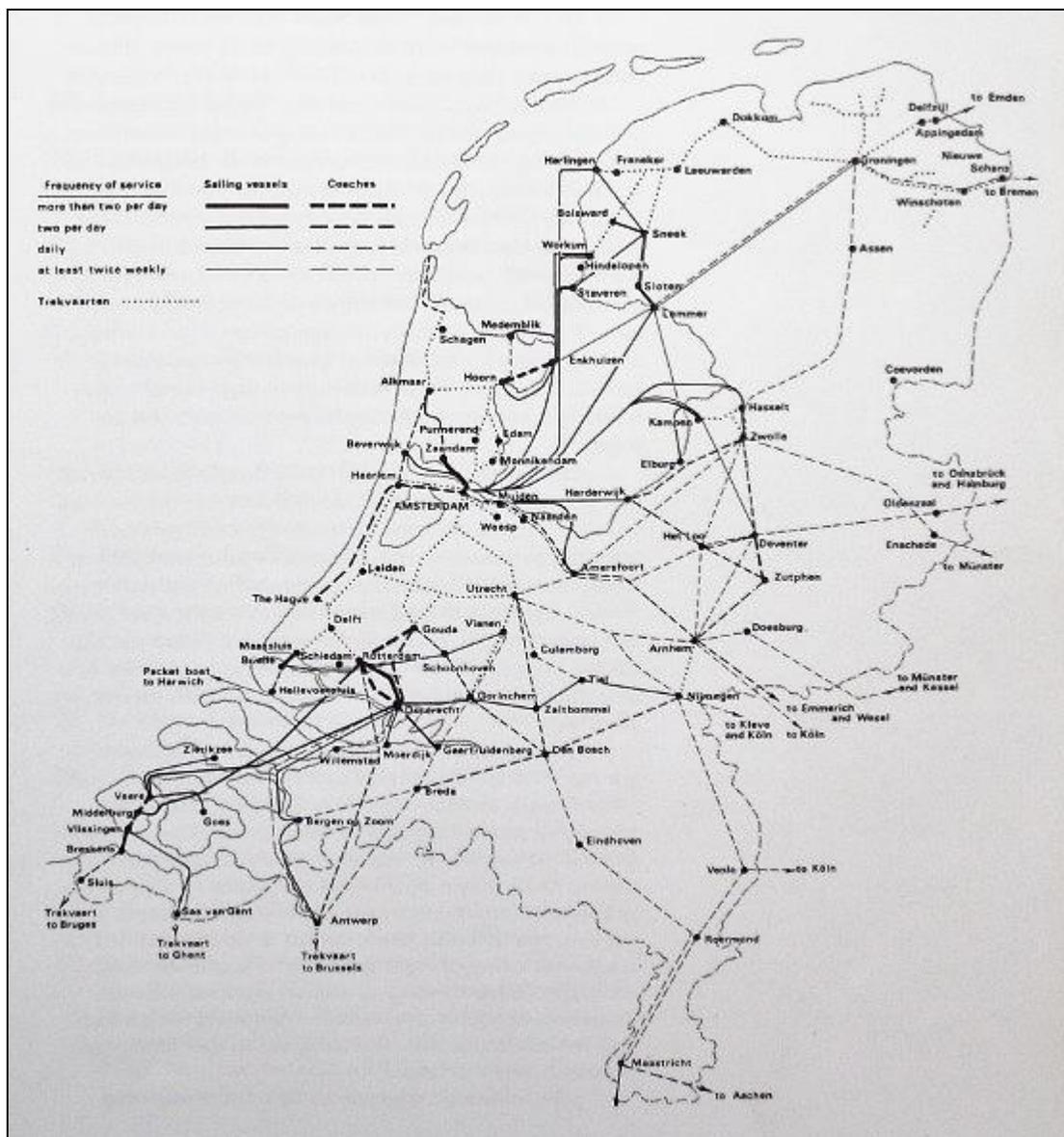
⁸ De Vries and Van der Woude, *The First Modern Economy*, 404. Israel, *The Dutch Republic*, 940.

economic stagnation of the Low Countries in the eighteenth century, it is likely that comparable numbers represented inland commerce in the century before.⁹

Travel over the Republic's dirt roads was relatively insignificant in the coastal provinces. However, it assumed greater importance in the poorer and topographically higher provinces and territories that surrounded the watery, low-lying Netherlands. Even in the seventeenth and eighteenth centuries, the intricate system of roads and waterways (Map 1.1) that supported movement within the Republic hardly facilitated more rapid travel than what was experienced in the rest of Europe. Moreover, the Republic's uniquely federated government helped generate relentless municipal competition, with a subsequently bewildering variety of tolls, myriad redundancies and chronic underinvestment in the infrastructure of the inland provinces and territories.¹⁰ Despite these very real problems, the economic significance of the Dutch transportation network lay in its relative regularity, its low cost, its substantial carrying capacity, and its flexibility. That combination of advantages, distinct within contemporary Europe, in turn flowed from its comparatively efficient use of energy.

⁹ De Vries and Van der Woude, *The First Modern Economy*, 191. Price, *Dutch Society*, 45.

¹⁰ These problems should, however, be seen in the context of an early modern Europe where, in many regions, redundancy and petty legal strife between local or regional authorities regarding networks of transportation would have been an improvement over the status quo. De Vries and Van der Woude, *The First Modern Economy*, 192. Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II*, 357.



Map 1.1. Transportation networks by land and water in the late (mid-eighteenth century) Republic, originally drawn by Jan de Vries. De Vries, *Barges and Capitalism*, 58.

Technological, cultural, economic, and political developments co-evolved with environmental structures in the Republic's relatively successful struggle against distance and time. For trade at sea the Low Countries were ideally situated between the wealthy Mediterranean and the burgeoning early modern economies of northern Europe.¹¹ Commerce

¹¹ Klompmaker, *Handel in de Gouden Eeuw*, 64.

across land and water from England to the European interior and back again also flowed naturally through the region. While geographical advantages encouraged industry, trade, and urbanization within the provinces that would become the Republic, they were of limited use without infrastructure designed to accommodate the large-scale movement of goods, people, and information. The landscape of the medieval coastal Netherlands hardly yielded a readymade network of communications, yet the presence of so much water provided the means for far-ranging travel by boat if improvements could be constructed and maintained. Medieval Netherlanders consequently built the region's first channels and sluices, creating inland water routes and beginning a process that would yield the Republic's extensive system of waterborne transport.¹² The Republic's economic growth encouraged, and was encouraged by, the transformation of its uniquely unstable environmental structures, yet reclamation, like infrastructural development, stimulated silting in the harbours of port cities that were increasingly central to the dawning Golden Age.¹³ Ultimately, the natural frameworks of land and water initially motivated but increasingly hampered Dutch attempts to exploit the most efficient forms of energy useful for transportation through the most advanced – or pertinent – technology, in the most effective manner possible.

Grafted upon, and working through, these relationships was the influence of prevailing weather affected by a fluctuating climate. The following chapters explore the most important expressions of Dutch mobility for the Republic's economic, demographic, and cultural heartland in Holland. In doing so, they develop a representative, if not entirely comprehensive, analysis of interactions between climatic variability, prevailing weather, and movement through the Republic's expanding commercial world. The chapters initially examine renowned and usually

¹² De Vries and Van der Woude, *The First Modern Economy*, 13.

¹³ *Ibid*, 44. Lambert, *The Making of the Dutch Landscape*, 202.

lucrative voyages at the periphery of the Dutch trading empire, but ultimately turn to consider far humbler trips across muddy paths, over frozen lakes, or through winding creeks in the Republic's coastal provinces.

In warmer and cooler decades, distinct manifestations of Little Ice Age climatic shifts offered different advantages and disadvantages for the various expressions of the Dutch transportation system. Explorers seeking passage to Asia through the frigid waters of the Arctic braved unusually frequent storms, and sea ice that had expanded in the colder temperatures of the Grindelwald Fluctuation. While extensive sea ice and storminess helped thwart efforts to uncover a Northeast Passage, they also encouraged changes in journeys of exploration that transformed European perceptions of the Arctic. It was not ice but rather shifts in prevailing wind across the Northeastern Atlantic, associated with Little Ice Age minima, that most influenced Dutch East India Company ship journeys. During the Maunder Minimum, outbound VOC vessels travelled more quickly as regional winds blew more frequently from the East, shortening total time spent in transit. More ambiguous was the influence of altered wind patterns on inbound East Indiamen, and unusually abundant storms likely quickened some journeys even as other voyages were hampered or prevented.

Closer to home, the passage of Dutch vessels to and from the Baltic was likely shaped, in part, by shifts in prevailing wind direction. More important, however, were changes in the frequency of storms and, in particular, the extent of sea ice, which more directly influenced when and how bulk goods could be transported. Also affected were the transfer of information, regional Dutch diplomacy, relevant legal disputes, and, possibly, the price of key commodities. Within the borders of the Republic, many kinds of movement pursued through different forms of infrastructure by ship, boat, barge, horse, and foot all responded differently to different weather

conditions. That, in turn, bestowed great flexibility and resilience to the Republic's inland transportation network in the face of climatic oscillation. Nevertheless, particularly cold and stormy weather did hamper most forms of travel, especially those associated with the large-scale movement of goods, people, and information. Indeed, some meteorological conditions linked to Little Ice Age minima could interact with local environments to impede all forms of mobility.

Chapter 1

Exploring the Periphery in a Colder Climate: The Quest for a Northeast Passage

In August 2009, two German freighters embarked from South Korea for a long voyage to the Netherlands. Rather than bearing south as their route normally demanded, the two vessels steamed north, stopping briefly in the port of Vladivostok before departing for Arctic waters on the 21st. From Vladivostok they were escorted by Russian icebreakers, quickly rendered redundant in open seas that continued far beyond the Bering Strait. On 12 September the ships arrived in the Siberian port of Yamburg, just east of the Kara Sea, having encountered little more than a spell of harmless drift ice. After stopping briefly in the more westerly harbour of Archangel, the vessels rounded the northern coast of Norway before arriving at the sprawling havens of Rotterdam. The freighters had crossed nearly 15,000 kilometres, but their northern course had cut the duration of the journey to Europe by nearly 25%, and it was void of pirates.¹⁴ The German vessels were the first non-Russian ships to complete the “Northeast Passage,” the seaborne route north of Eurasia opened by rapid Arctic melting in the summer of 2008.¹⁵ Although anthropogenic global warming is a recent phenomenon, the relationship between climatic shifts, polar ice, and the quest to link East and West through Arctic waters has a long history. As the climate cooled across sixteenth-century Europe, improvements in ship design

¹⁴ Artyom Liss, “Arctic trail blazers make history.” BBC News, 19 September 2009, <http://news.bbc.co.uk/2/hi/8264345.stm>. Andrew E. Kreamer, “Warming Revives Dream of Sea Route in Russian Arctic.” New York Times, 17 October 2011, <http://www.nytimes.com/2011/10/18/business/global/warming-revives-old-dream-of-sea-route-in-russian-arctic.html>.

¹⁵ More and more ships have followed their lead. Just two years later, the passage was completed by some 33 vessels. Liat Clark, “Arctic Northeast Passage will melt even earlier this summer.” Wired UK, 14 June 2012. <http://www.wired.co.uk/news/archive/2012-06/14/northeast-passage-melts>.

coevolved with reformation, revolt, and the expansion of seaborne trade to encourage the first serious attempts at charting a northeast passage to Asia.

The most significant early modern expeditions in pursuit of a passage to Asia through the waters north of Europe were launched in 1594, 1595, and 1596 under the aegis of merchants from major ports in the emerging Dutch Republic. The Dutch expeditions set sail during the Grindelwald Fluctuation, which lasted in Europe from approximately 1565 until 1629. Cooling in Europe was mirrored in the Arctic, where temperatures were more than 0.5 ° C lower than the twentieth-century average. Consequently the environmental circumstances for Arctic exploration during the Grindelwald Fluctuation were hardly auspicious, and the Dutch expeditions each succumbed either to sea ice or the threat of sea ice before they had pressed far beyond the Barents Sea.¹⁶

Nevertheless, detailed climatic reconstructions can now refresh traditional narratives of the voyages, which abound with descriptions of heroic failure in the Arctic cold. In fact, the journeys were shaped by a complex suite of occasionally counterbalancing, sometimes mutually reinforcing interactions between the regional atmosphere, hydrosphere, cryosphere, and biosphere. The influence of these environmental relationships was mediated by cultural and economic structures that were, in turn, complicated by the personal agency of the explorers and their financiers. The first expedition, in 1594, penetrated deeply into the Arctic owing in part to unusual summer warmth, and this success was particularly encouraging for Dutch merchants who were just beginning to compete with their Iberian counterparts for access to Asian markets. In 1595 and 1596 the Dutch financed two more expeditions, which were hampered by sea ice and frigid temperatures more typical of the coldest decades of the Little Ice Age. These

¹⁶ M. E. Mann et al., "Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly." *Science* 326 (2009): 1257.

conditions blocked access to a Northeast Passage but encouraged the exploration of new islands, which revolutionized European conceptions of the Arctic and stimulated the development of important, if ecologically destructive, new industries.

For centuries, most histories of the Dutch expeditions to the Arctic between 1594 and 1597 have included a description of the region's frigid weather.¹⁷ Many recent narratives mention both the polar cold and its accompanying ice, without which the outcome of the Dutch voyages is difficult to comprehend.¹⁸ On the other hand, the Arctic environment is hardly a central concern for many modern historians of the expeditions, who instead investigate the explorers as particularly bold representatives of a distinct society. Recent histories have examined the artifacts left behind by the explorers in the Russian arctic, the culture that informed their journeys, and their contribution to the Republic as a nexus of cartographical knowledge.¹⁹ Overall, very few historians have connected the characteristics of Arctic weather in the years of the voyages to the influence of the Little Ice Age. An exception is Jaap Jan Zeeberg, who in 2007 briefly summarized some scientific reconstructions of the polar environment in the late sixteenth century. Still, Zeeberg's cursory analysis did not itself contribute to the analysis of specific

¹⁷ Captain Jansen, "Notes on the Ice between Greenland and Nova Zembla; Being the Results of Investigations into the Records of Early Dutch Voyages in the Spitzbergen Seas." *Proceedings of the Royal Geographical Society of London* 9:4 (1864 - 1865): 165. Clements R. Markham, "On Discoveries east of Spitzbergen, and Attempts to reach the Pole on the Spitzbergen Meridians." *Proceedings of the Royal Geographical Society of London* 17:2 (1872-73): 97.

¹⁸ Rayner Unwin, *A Winter Away from Home: Willem Barents and the North-east Passage*. (Seafarer Books: London, 1995), 111. Gerben Graddesz. Hellinga, *Pioniers van de Gouden Eeuw*. (Zutphen: Walburg Pers, 2007), 34. J. Braat, "Dutch activities in the North and the Arctic during the sixteenth and seventeenth centuries." *Arctic* 37:4 (1984): 473.

¹⁹ Louwrens Hacqueborn, "In Search of *Het Behouden Huys*: A Survey of the Remains of the House of Willem Barentsz on Novaya Zemlya." *Arctic* 48:3 (1995): 248. W.A. Ligtdag, "Willem Barentsz en de kartografie van het hoge noorden." *Kartografisch tijdschrift* 23:1 (1997): 5. J. Braat, *Behouden uit het Behouden Huys. Catalogus van voorwerpen van de Barentsexpeditie (1596), gevonden op Nova Zembla. De Rijksmuseumcollectie, aangevuld met Russische en Noorse vondsten*. (Amsterdam: De Bataaf sehe leeuw, 1998), 12. The ships used by the explorers have also attracted recent attention. A. J. Hoving and Cor Emke, *Het schip van Willem Barents: een hypothetische reconstructie van een laat-zestiende-eeuws jacht*. (Hilversum: Uitgeverij Verloren, 2004), 61.

connections between the expeditions, daily weather conditions, and the complex regional manifestations of the Grindelwald Fluctuation.²⁰

This chapter opens by examining the cultural and economic contexts within the Republic, and the changing environmental structures in the Arctic, that would shape the Dutch quest for a Northeast Passage during the last decade of the sixteenth century. It introduces the cartographers, merchants, and mariners whose beliefs influenced the successes and failures of the polar expeditions. Using journals later published by the Arctic explorers, it then provides a detailed narrative that reconstructs each of the three voyages undertaken between 1594 and 1597. In every narrative, the precise characteristics of local environmental conditions, reconstructed using interdisciplinary sources, are linked both to the course of an expedition, and the broader climatic trends of the Grindelwald Fluctuation. Finally, the chapter concludes with an analysis of the ways in which the voyages, which pushed back the borders of the world known to the Dutch, ultimately contributed to the Republic's Golden Age. The quest for the Northeast Passage, shaped by the complex manifestations of the Little Ice Age in the Arctic, was more than an interesting footnote in the history of the Dutch Republic.

Planning the Expeditions during the Grindelwald Fluctuation

The Dutch search for a Northeast Passage was initially motivated by developments in Iberia. Since the fifteenth century, the Portuguese *Estado* had dominated the commerce in low volume, high value commodities from Asia, and in 1580 its crown had been united with that of Spain. In the last decade of the sixteenth century, many Dutch merchants, their access to the

²⁰ Jaap Jan Zeeberg, *Terugkeer naar Nova Zembla: de laatste en tragische reis van Willem Barents*. (Zutphen: Walburg Pers, 2007), 75.

Iberian market increasingly uncertain, wished to control the lucrative commerce in spices, textiles, and other Asian goods directly from its source. It was a testament to the intellectual vigour of Dutch culture in the emerging Golden Age that Dutch merchants, explorers, and cartographers sought not only to retrace but also to dramatically improve Iberian sea routes to Asia. In the early 1590s a group devoted to the exploration and exploitation of a Northeast Passage to Asia formed in Enkhuizen, a town on the Zuider Zee (Introduction, Map I.1), around the merchant Jan Huyghen van Linschoten and the publisher-cartographer Lucas Waghenaer. Another circle committed to the passage emerged in Amsterdam through the ideas and ambitions of publisher Cornelis Claeszoon, cartographer-clergyman Petrus Plancius, and cartographer-navigator Willem Barentszoon.²¹

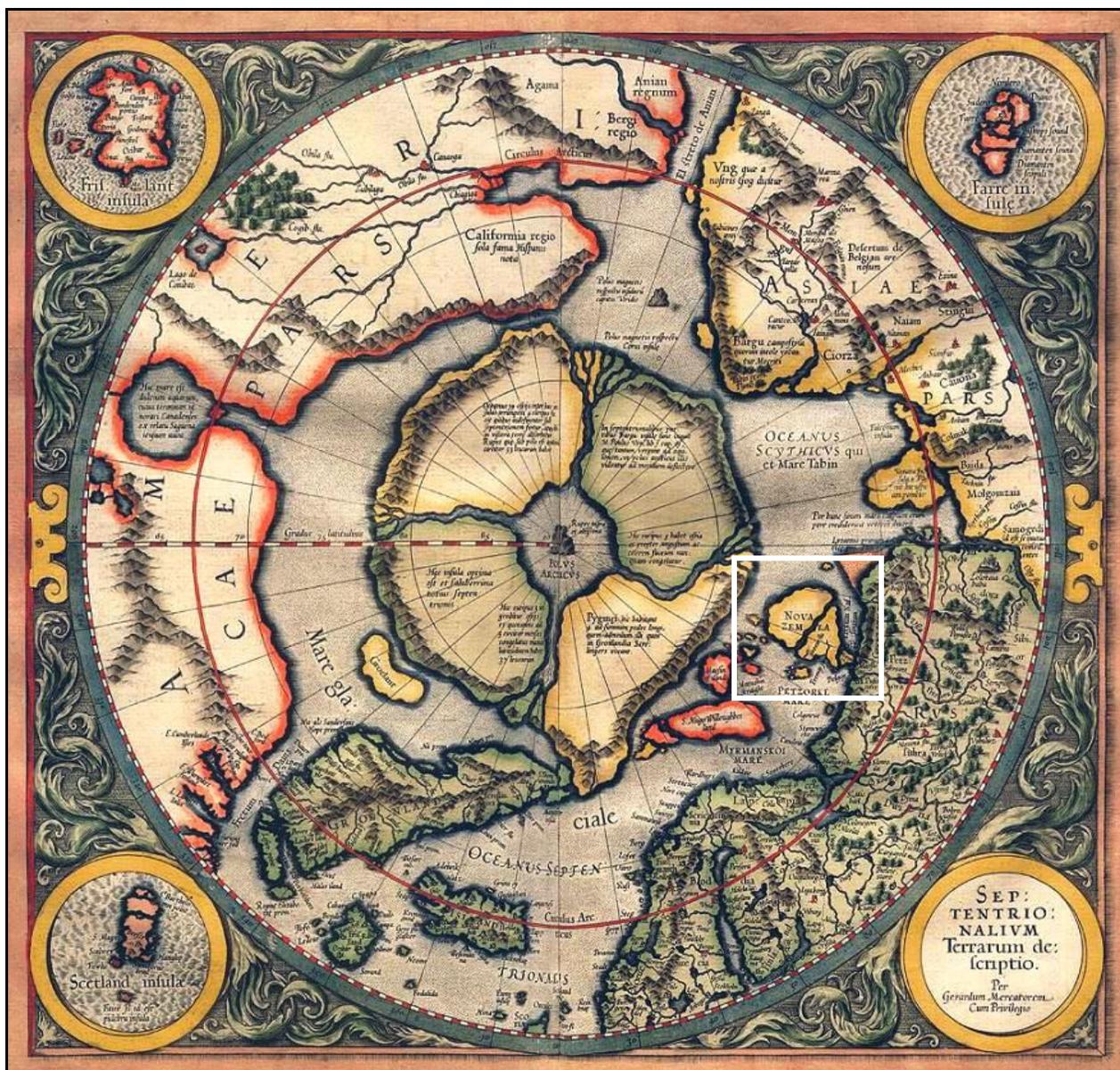
The occupations of these men were hardly coincidental. Accurate maps, financed by merchants, drawn by exploring cartographers, and disseminated by publishers, were invaluable for early modern trade. Any attempt to reveal a Northeast Passage would necessarily be informed by the most reliable maps available, and would, in turn, produce a map – in effect, a key – for Dutch trade through the far north. Thereafter, the entrepreneurs hoped to secure exclusive rights to northern trade routes that they estimated would shorten the distance of a voyage to Asia by two-thirds.²² Balthasar de Moucheron, a wealthy merchant from the city of Middelburg in Zeeland, helped finance the first polar expeditions of the 1590s and provided the latest cartographical information. A close friend of celebrated cartographer Gerard Mercator, De Moucheron likely supplied the entrepreneurs with a map similar to what was published by

²¹ G. V. Scammell, *The First Imperial Age: European Overseas Expansion c. 1400~1715*. Abingdon: Routledge, 1989), 97. Because “Barentszoon,” for example, means son or *zoon* of Barents, such last names can be shortened simply to, for instance, “Barents.”

²² Once a Northeast Passage was found, the entrepreneurs planned to petition the Republic’s governing bodies for massive Arctic fortifications for defense against Iberian encroachments. Peter van der Krogt, “Introduction,” in John Blaeu, *Atlas Major of 1665*. (Cologne: Taschen, 2010), 35. Zeeberg, *Terugkeer naar Nova Zembla*, 26. Hellinga, *Pioniers van de Gouden Eeuw*, 31.

Mercator in 1595, a year after the first expedition (Map 1.2). Although his earlier maps depicted a polar continent joined to the European mainland, by the late sixteenth century Mercator had himself become a proponent of a Northeast Passage, writing in 1580 that “the voyage to Cathaio by the East is doutlesse verie easie and short.”²³

²³ Marijke Spies, *Arctic Routes to Fabled Lands: Olivier Brunel and the Passage to China and Cathay in the Sixteenth Century*. (Amsterdam: Amsterdam University Press, 1997), 41. Braat, “Dutch activities in the North and the Arctic,” 473.

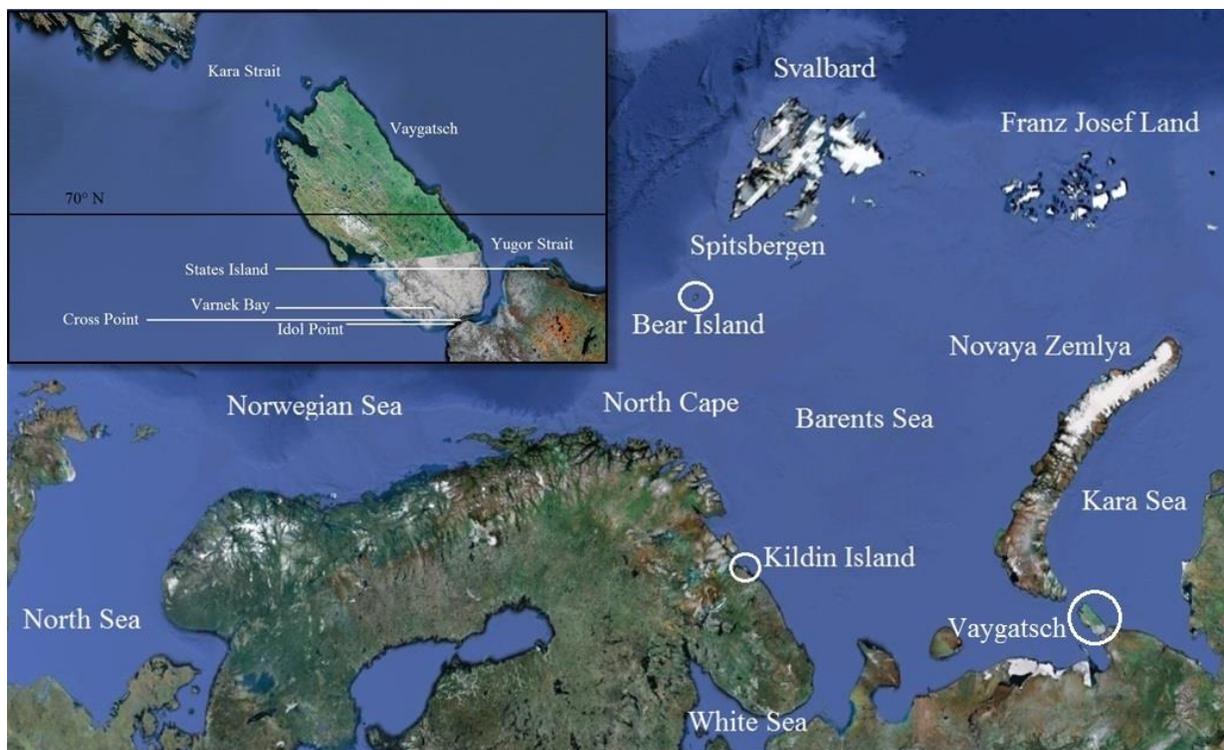


Map 1.2. The most current European perception of the Arctic on the eve of the Barents voyages. The North Pole lay at the centre of many world maps created by Mercator. Gerard Mercator, *Septentrionalium Terrarum descriptio* 1595. Amsterdam, 1595.

Despite Mercator's confidence, the level of detail on his map, as on its early modern counterparts, varied according to the depth of cartographical knowledge that informed its depiction of different regions. Journeys of exploration would necessarily sail towards relatively unknown and, in turn, poorly detailed areas portrayed on existing maps, yet some real or

apparent geographical precision was necessary to analyze the initial feasibility of a voyage. Unfortunately for the collaborators in Amsterdam and Enkhuizen, the Arctic was poorly understood. The ancient notion of an Arctic continent was amended by some cartographers in the middle of the sixteenth century in favour of four continents surrounding a towering magnetic rock. That concept was, in turn, grounded on recently popularized observations made by Nicholas of Lynn in 1360, which had outlived the more reliable records of the earlier Viking explorers. Meanwhile, fanciful descriptions of bizarre Arctic civilizations, monsters, and treasures endured long into the sixteenth century. On the other hand, from the middle of the sixteenth century forays into the waters north of Europe had charted parts of the Scandinavian and Russian coast with increasing accuracy. That allowed the entrepreneurs to focus on the newly discovered land of Novaya Zemlya or, in Dutch, *Nova Zembla*, which seemed to lie in the path of a possible Northeast Passage.²⁴

²⁴ Novaya Zemlya was discovered for sixteenth-century Europeans by the explorers of the English Muscovy Company in 1553. Zeeberg, *Terugkeer naar Nova Zembla*, 36. Unwin, *A Winter Away from Home*, 4. Samuel Bawlf, *The Secret Voyage of Sir Francis Drake, 1577-1580*. (Vancouver: Douglas & McIntyre, 2003), 48.



Map 1.3. Satellite view of the northern environment in which the Republic's quest for a Northeast Passage took place. Inset: detail of the island Vaygatsch and surrounding straits, with locations relevant to the Barents Voyages as they were named by the explorers (translated into English). These maps do not depict sea ice. The subarctic and arctic north of Europe. (20 December 2012). Google Earth 6. Google. Zeeberg, *Terugkeer naar Nova Zembla*, 35.

Long known to Russian hunters, Novaya Zemlya was discovered for the Dutch by the merchant Olivier Brunel in the cold 1570s. The fragmentary records that survive to document his voyages reveal that further progress east had been blocked by extensive sea ice.²⁵ In 1580/81 a subsequent attempt by Arthur Pet and Charles Jackman, funded by the English Muscovy Company, was the first Western European expedition to enter the Kara Sea. Pet entered the sea through the Yugor Strait, a narrow passage between the island of Vaygatsch south of Novaya

²⁵ Braat, "Dutch activities in the North and the Arctic," 473. V. Ye. Borodachev, V. Yu. Alexandrov, "History of the Northern Sea Route." In *Remote Sensing of Sea Ice in the Northern Sea Route: Studies and Applications*, ed. Ola M. Johannessen. (New York: Springer Praxis Books, 2007), 1. Jaap Jan Zeeberg, *Into the Ice Sea: Barents' winter on Novaya Zemlya – a Renaissance voyage of discovery*. (Amsterdam: Rozenberg Publishers, 2005), 57. See also: Marijke Spies, *Bij noorden om. Olivier Brunel en de doorvaart naar China en Cathay in de zestiende eeuw*. Amsterdam, 1994). V.D. Roeper and G.J.D. Wildeman, *Ontdekkingsreizen van Nederlanders (1590-1650)*. (Utrecht: Kosmos Uitgevers, 1993). P. T. G. Horensma, "Olivier Brunel and the Dutch involvement in the discovery of the Northeast Passage." *Fram* 2:1 (1985): 121-128.

Zemlya (Map 1.3), and the Russian mainland, but stayed only briefly before being forced back by ice and fog. Years later De Moucheron strongly supported further exploration of the passage around Vaygatsch, and wrote to the States-General that the Republic was playing a “dangerous game” without a firm foothold in the Yugor Strait.²⁶

On the other hand, Plancius and his associates in Amsterdam deduced from the failure of the English expedition that the straits around Vaygatsch were too shallow to afford passage into the seas beyond.²⁷ Like many of his contemporaries, Plancius believed that deep water in rough, open seas could not freeze, and consequently thought that there would actually be less ice north of Novaya Zemlya, despite the high latitude. It was this conviction that encouraged many cartographers and mariners to infer the existence of vast islands and continents north of the European mainland. Consequently, earlier explorers may have extrapolated the existence of land from the distribution of Arctic sea ice, and indeed the polar continents recorded in maps like those published by Mercator overlapped the typical extent of Arctic sea ice during the Little Ice Age (Map 1.2).²⁸

In fact, ice cover above northern Eurasia manifested as a complex pattern of vast ice massifs, which generally do not fully melt in the summer; icebergs calved from massifs in the summer melt; “fast ice” attached to the seabed that expands for thousands of kilometres in winter but vanishes in summer; drift ice that, unlike fast ice, is a kind of sea ice that moves with the current and wind; and typically ice-free corridors called “polynyas.” The extent, movement, and consistency of the ice on a scale relevant for the Dutch Arctic expeditions was directly affected by the rotation of the earth, internal ice stress, and sea surface tilt influenced by minute

²⁶ “Heeft U [in the Yugor Strait] niet onmiddellijk vaste voet, dan speelt U gevaarlijk spel.” Zeeberg, *Terugkeer naar Nova Zembla*, 41. Hellinga, *Pioniers van de Gouden Eeuw*, 31.

²⁷ William J. Mills, *Exploring Polar Frontiers: A Historical Encyclopedia, Vol. II*. (Santa Barbara: ABC CLIO, 2003), 521.

²⁸ Jansen, “Notes on the Ice between Greenland and Nova Zembla,” 175.

gravitational variations across Earth's surface. Far more important yet far more unstable than Earth's rotation or gravitational consistency were ocean currents and, most significantly, variations in regional wind and temperature.²⁹

Ice cores and other scientifically analyzed proxy sources that respond to climatic fluctuation, taken from the natural world, have been employed alongside model simulations to yield records of average annual and seasonal temperatures across the Arctic. Admittedly, even sophisticated models are grounded on modern techniques and assumptions, yet they are also firmly rooted to past realities because their projections are impossible without both natural and documentary proxies. The best reconstructions of past climates are informed by a wide variety of sources that, like proxies, either record the past or, like models, retrace the past by computing the workings of climate as a physical system. As more sources are unearthed, models are refined and techniques are improved, inconsistencies, often but not always minor, continually emerge between different model simulations or proxy records. Accordingly, details in the overall picture of the climatic past are never entirely stable, even as many areas of consensus gradually strengthen.³⁰

Nevertheless, despite lingering incongruity between different simulations, the most current model projections and proxy records provide sufficient consensus to indicate that Arctic temperatures in the past millennium did not always fluctuate in step with European temperatures (Figure 1.1). Arctic cooling, for example, preceded European cooling before the onset of the global Little Ice Age, while the fifteenth century appears to have been comparatively warm in the

²⁹ "Dynamics." National Snow & Ice Data Center. Available at: <http://nsidc.org/cryosphere/seaice/processes/dynamics.html#wind>. (Accessed 4 Jan 2013). Nataliya Marchenko, *Russian Arctic seas: navigational conditions and accidents*. (New York: Springer, 2012), 5.

³⁰ In this sense the issues facing climatic reconstructions compiled using model projections and proxy evidence mirror those encountered by historians as they retrace familiar historical narratives. Details and interpretations remain malleable, but the grand narrative is usually far more stable. Edwards, *A Vast Machine*, xiv.

Arctic even as it was variable but generally cool across Western Europe. On the other hand, the minima of the Grindelwald Fluctuation and, to a lesser extent, the Maunder Minimum are dramatically recorded. Models and proxy data agree that average temperatures in the Arctic may have declined by 0.5 °C below the average in 1900 CE, significantly more than 1 °C below today's average temperatures. Regional sea temperatures near the surface, but below a shallow layer affected by the direct consequences of ice expansion or retreat, likely declined alongside atmospheric cooling.³¹

³¹ Extensive melting of sea ice can stimulate decreased temperatures and increased salinity in waters more shallow than 50 meters. Consequently shallower water was likely colder in the Fram Strait between Greenland and Svalbard during the Little Ice Age. E Crespin et al., "Arctic climate over the past millennium: Annual and seasonal responses to external forcings." *The Holocene* 23 (2013): 327. E. Crespin et al., "The 15th century Arctic warming in coupled model simulations with data assimilation." *Climate of the Past* (2009): 394. K.R. Briffa, T.J. Osborn and F.H. Schweingruber, "Large-scale temperature inferences from tree rings: a review." *Global and Planetary Change* 40:1-2 (2004): 18. Marie-Alexandrine Sicre et al., "Decadal variability of sea surface temperatures off North Iceland over the last 2000 years." *Earth and Planetary Science Letters* 268: 1-2 (2008): 140. Rueda et al., "Coupling of air and sea surface temperatures in the eastern Fram Strait during the last 2000 years." *The Holocene* 23:5 (2013): 695.

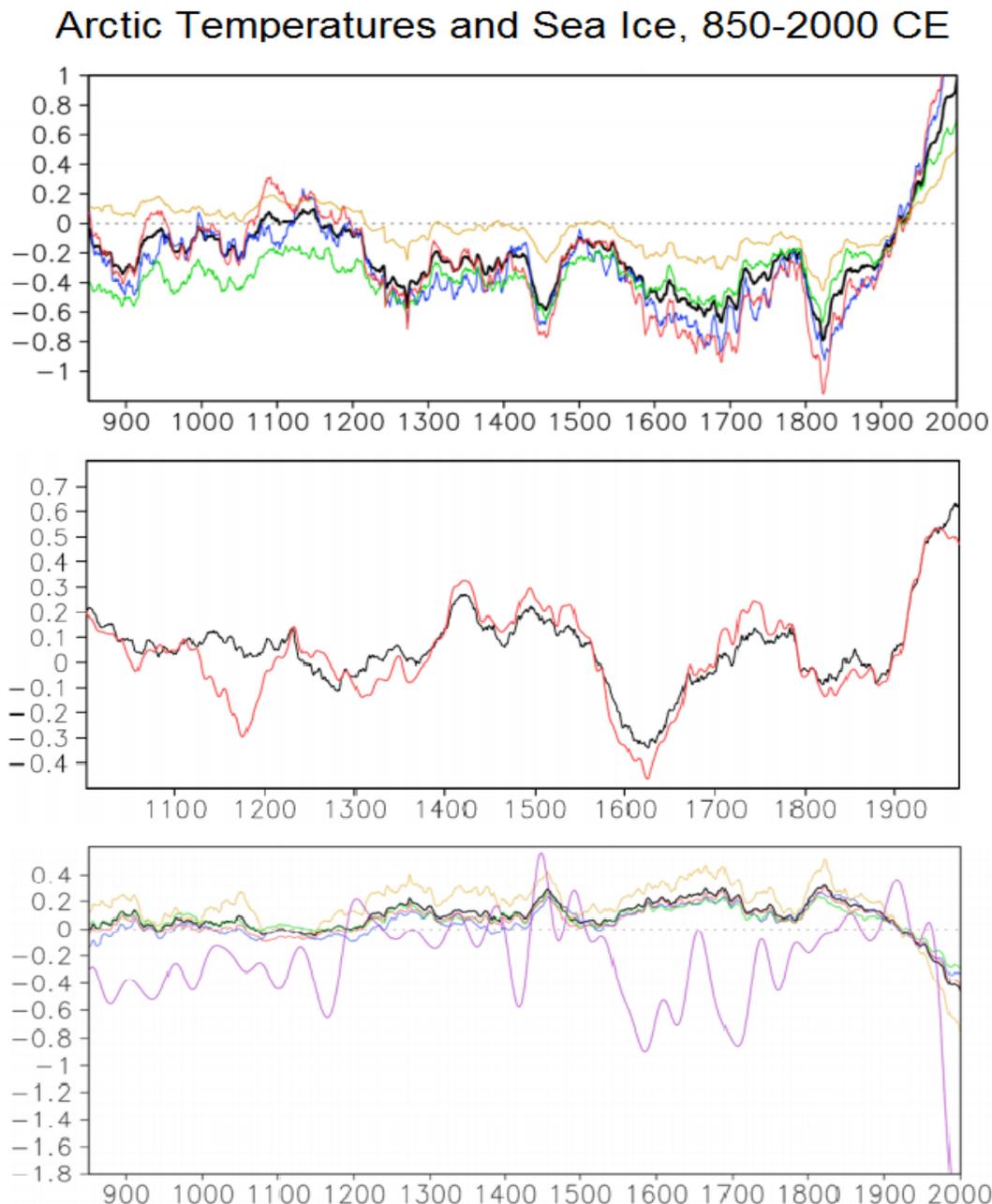


Fig. 1.1. Model simulation of changes in seasonal temperature (top, middle) and sea ice (bottom) in the Arctic. In the top and bottom graphs, the annual mean is in black, while the winter (January, February, March) is in blue. Spring (April, May, June) is in green, summer (July, August, September) in yellow, and autumn (October, November, December) in red. The reference period for both graphs is 1850-1980. The middle graph compares the proxy record (red) with the LOVECLIM1.1 model (black). There the reference period is 1600-1950. There is a strong correlation between reconstructions of annual temperature in Novaya Zemlya and the entire Arctic. E Crespin et al., “Arctic climate over the past millennium: Annual and seasonal responses to external forcings.” *The Holocene* 23 (2013): 327. E. Crespin et al., “The 15th century Arctic warming in coupled model simulations with data assimilation.” *Climate of the Past* (2009): 394. Jaap Jan Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago, Russian Arctic: With Notes on the Region’s History of Exploration*. (Amsterdam: Rozenberg Publishers, 2002), 99.

The extent of Arctic sea ice directly and consistently responded to changes in regional average temperature. Indeed, sea ice and glaciation in and around Novaya Zemlya expanded aggressively during the Grindelwald Fluctuation, although variability in sea ice extent between warm and cold years was somewhat limited by the proximity of land.³² Arctic temperatures in autumn, winter, and spring responded most dramatically to the climatic oscillations of the Little Ice Age, and these months were crucial to the expansion of local ice.³³ Logbooks kept by explorers and whalers in the far north also record a sharp increase in sea ice in more southerly latitudes across the Barents Sea during the Grindelwald Fluctuation. While such logbooks did not continuously record wind direction, they abound with reliable and highly detailed descriptions of ice cover, which powerfully influenced the success or failure of northern expeditions.³⁴

Of course, in the vicinity of Novaya Zemlya, average temperature did not shift in an environmental vacuum during the first great minimum of the Little Ice Age. In the Arctic, as in Europe, fluctuations in seasonal temperature influenced and were influenced by shifts in Arctic wind velocity and oceanic circulation. Moreover, regional atmospheric and oceanic temperatures

³² Peter Lemke, Markus Harder and Michael Hilmer. "The Response of Arctic Sea Ice to Global Change." *Climatic Change*, 46 (2000): 278. Simulations appear to reveal a pronounced decline of sea ice during the middle of the seventeenth century, even as the temperature data does not reflect a significant rebound of Arctic temperatures in those decades.

³³ It should be acknowledged that Murdmaa et al. (2004) suggest that increased regional glaciation and, in turn, enhanced sea ice during the late phase of the Little Ice Age (ca. 1600-1800 or 1900) was primarily enabled by unusually cold summers. Summer cooling appears to have been moderate in the period directly preceding 1600, however. Iver Murdmaa et al., "Paleoenvironments in Russkaya Gavan' Fjord (NW Novaya Zemlya, Barents Sea) during the last millennium." *Palaeogeography, Palaeoclimatology, Palaeoecology* 209 (2004): 153. Raymond S. Bradley and Philip D. Jones, "'Little Ice Age' summer temperature variations: their nature and relevance to recent global trends." *The Holocene* 3 (1993): 367.

³⁴ Torgny Vinje, "Barents Sea ice edge variation over the past 400 years," in *Extended abstracts, Workshop on Sea-Ice Charts of the Arctic*. WMO/TD 949 (1999): 5. Miller et al., "Abrupt onset of the Little Ice Age," 4. Flavio Lehner et al., "Amplified inception of European Little Ice Age by sea ice-ocean-atmosphere feedbacks." *Journal of Climate* 26:19 (2013): 7586. Leonid Polyak, Ivar Murdmaa and Elena Ivanova, "A high-resolution, 800-year glaciomarine record from Russkaya Gavan', a Novaya Zemlya fjord, eastern Barents Sea." *The Holocene* 14:4 (2004): 634. Spörer's map of Novaya Zemlya, published in 1867 during the final years of the Little Ice Age in the Arctic, confirms the existence of far more sea ice around the island than exists today. Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago*, 104.

were likely affected by a 10% reduction in the volume of water transported by the Gulfstream and its relatively warm North Atlantic tributary, which, in turn, also increased sea ice in the Barents Sea and along the western coast of Novaya Zemlya. Meanwhile, increased glaciation probably enhanced cyclonic activity in the Novaya Zemlya area. Ultimately, then, both increased ice cover and more common storms accompanied the reduced average temperatures and altered oceanic currents that reflected Little Ice Age minima around Novaya Zemlya.³⁵

The First Expedition: Frustration and Promise, 1594

Ignorant of contemporary shifts in the Arctic climate, the first expedition for a Northeast Passage organized by the Enkhuizen/Amsterdam groups passed the island of Texel as it departed the Zuider Zee on 5 June, 1594. While mariners had sought a Northeast Passage near Novaya Zemlya in decades past, the Dutch expedition of 1594 was uniquely prepared, plentifully provisioned, and heralded a new phase in the European exploration of the Arctic. Carrying Jan Huyghen van Linschoten, whose journal provides the most detailed account of its voyage,³⁶ the fleet sailed under the command of Admiral Cornelis Nay aboard the *Zwaan* and his subordinate, Vice-Admiral Cornelis Rijp of the *Mercurius*. Barents captained a third vessel, the smaller yacht *Het Boot* (“The Boat”), and in representing the interests of Amsterdam argued incessantly with the expedition’s other leading figures. The merchant De Moucheron financed the voyage, and

³⁵ J. Overpeck et al., “Arctic Environmental Change of the Last Four Centuries.” *Science* 278:1251 (1997): 1253. Hilary Birks, “Holocene vegetational history and climatic change in west Spitsbergen – plant macrofossils from Skardtjørna, an Arctic lake.” *The Holocene* 1:3 (1991): 216. Zeeberg, *Terugkeer naar Nova Zembla*, 75. David C. Lund, Jean Lynch-Stieglitz and William B. Curry, “Gulf Stream density structure and transport during the past millennium.” *Nature* 444 (2006): 601. Crespin et al., “Arctic climate over the past millennium,” 327. Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago*, 66 and 105.

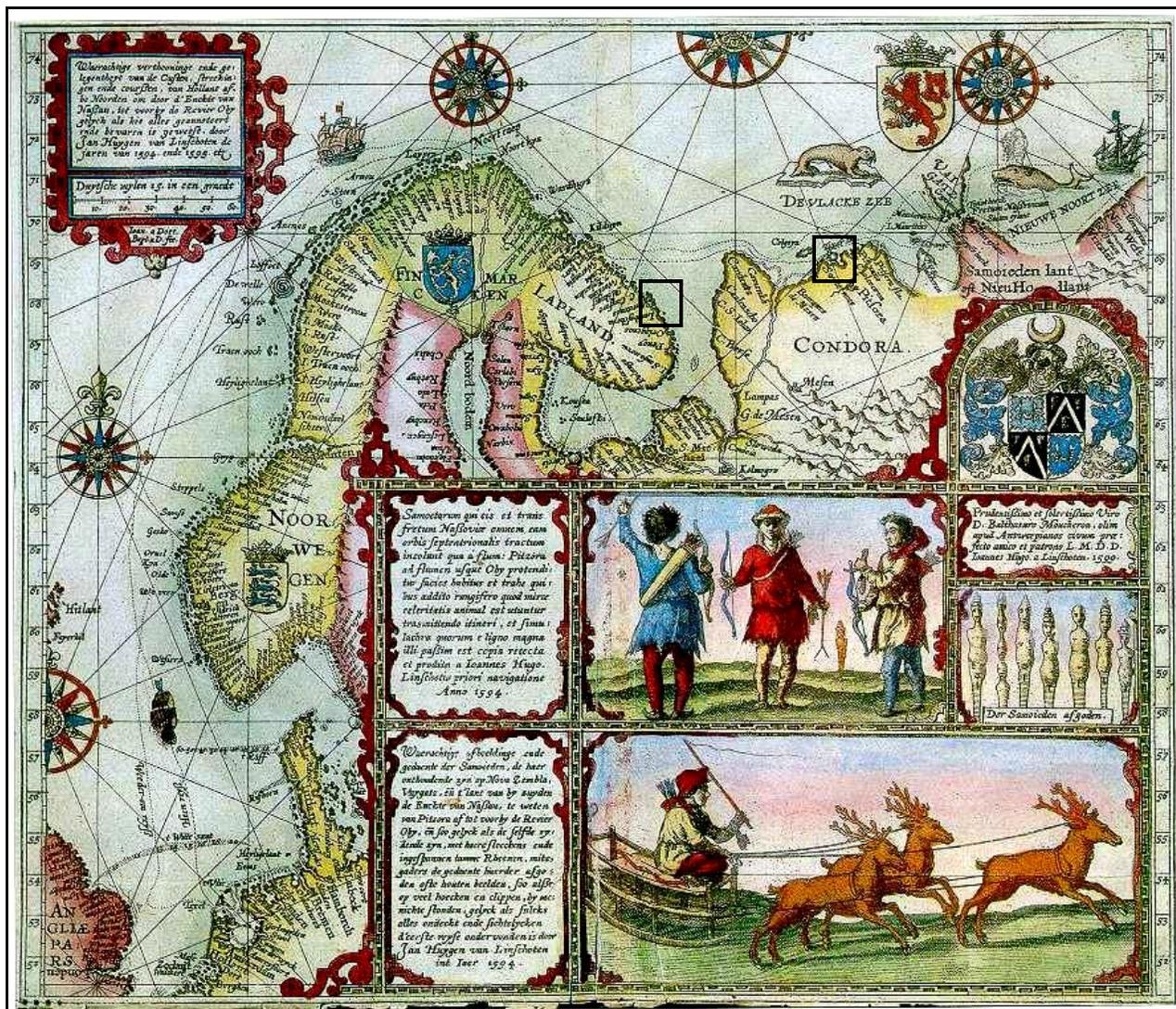
³⁶ In the sixteenth and seventeenth centuries accounts of extraordinary voyages were frequently published to fuel a rising appetite in records of adventure in exotic lands. Hence the logbooks of Van Linschoten and De Veer were published in many languages in the years directly following their voyages. Zeeberg, *Terugkeer naar Nova Zembla*, 25.

Barents' frustration consequently stemmed from orders to avoid the waters north of Novaya Zemlya. Instead, the fleet's mandate was to seek open sea and, in turn, a passage to Asia near the island Vaygatsch (Map 1.3). After braving storms on 11 and 12 June, the vessels overcame calm winds to reach Kildin Island on 21 June (Map 1.3).³⁷

After convincing Nay to divide the fleet, on 29 June Barents ordered his crew to set sail for the north coast of Novaya Zemlya. The larger vessels *Zwaan* and *Mercurius*, representing the interests of De Moucheron and the Enkhuizen circle, departed Kildin on 2 July. At 71° N three days later they were surrounded for the first time by sea ice that, according to Van Linschoten, “resembled land” as far as the eye could see. The explorers escaped the ice by evening, but on 8 July they encountered massive icebergs near the town of Svyatoi Nos on the eastern coast of Murmansk Oblast (Map 1.4), and they were again enveloped by thick sea ice later in the day. On 9 July they arrived at Svyatoi Nos, and soon anchored in a nearby harbour to await the retreat of the sea ice. Nay commanded the crews to weigh anchor on 16 July, and from Kolokolkovaya Bay the vessels, aided by high, favourable winds, made rapid progress towards Novaya Zemlya. On 21 July the explorers approached Vaygatsch, where their discovery of shipwrecks and trees far inland convinced them that severe storms must have recently raked the island.³⁸

³⁷ Jan Huyghen van Linschoten, “Voyagie, of Schipvaart, van Ian Huyghen van Linschoten, van bijnoorden om lans Noorwegen, de Noordkaap, Lapland, Finland, Rusland, &c. Anno 1594 en 1595.” Franeker: Gerard Ketel, 1601. In *Reizen van Jan Huyghen van Linschoten naar het noorden (1594-1595)*. (S-Gravenhade: Martinus Nijhoff, 1914), 38. Hellinga, *Pioniers van de Gouden Eeuw*, 32. Jan Huyghen van Linschoten, “Voyagie, of Schipvaart, van Ian Huyghen van Linschoten, van bijnoorden om lans Noorwegen, de Noordkaap, Lapland, Finland, Rusland, &c. Anno 1594 en 1595.” Franeker: Gerard Ketel, 1601.” In *Terugkeer naar Nova Zembla*. Four Days' Battle Zeeberg (ed.), 142.

³⁸ Van Linschoten, “Voyagie, of Schipvaart, van Ian Huyghen van Linschoten,” 63. Hellinga, *Pioniers van de Gouden Eeuw*, 32.



Map 1.4. A map of the course taken by the *Zwaan* and *Mercurius* in the expedition of 1594. Svyatoi Nos (left) and Kolokolkovaya Bay (right) are highlighted in black. In the top right corner of the map the Kara Sea is marked as Nieuwe Noort Zee, or “New North Sea.” Van Linschoten, “Voyagie, of Schipvaart, van Ian Huyghen van Linschoten,” 136.

Van Linschoten reported no sea ice from 19 July until 24 July, when the *Zwaan* and *Mercurius* were the first Dutch vessels to approach Yugor Strait in over two decades. As the explorers entered the strait on 25 July, however, they encountered more ice than ever drifting with the wind and current through the strait from east to west. To the leaders of the expedition, the parallel course of the current and the wind suggested a passage to the sea and, in turn, to

Asia, but that possibility was soon overshadowed by the peril of icebergs streaming through the strait. In stormy weather the Vice Admiral's smaller vessel narrowly escaped the strait with only minor damage. Icebergs continued to drift west from the Kara Sea, driven by remarkably consistent winds from the east, and on 29 July a half-mile long iceberg forced even the Admiral's ship to abandon the Yugor Strait. Many among the crew now feared that the icebergs had been dislodged by recent storms and easterly winds from a shallow or, worse, an inland sea beyond the Yugor Strait.³⁹

In fact, in the following week most of the icebergs and sea ice melted. As the explorers sailed east on 9 August the weather cleared, and while ice was again visible on all sides it was not especially solid. Before long they passed into the Kara Sea, encountering high waves and a sea so open that Van Linschoten, convinced that open water could not freeze, now believed beyond doubt that a passage to China must be ice-free and accessible.⁴⁰ On 11 August, the explorers, now approximately 300 kilometres east of Vaygatsch, encountered the rivers Morzhovka, Saltintayu, and Nyodati. From there they believed the coast curved south to allow passage to China, although before long the wind encouraged them to abandon the coast and head further to sea. There, massive icebergs, some home to aggressive walruses, combined with heavy fog to imperil the vessels and convince their crews to turn back while it was still possible.

On 15 August the vessels returned through the Yugor Strait and encountered their colleagues on *Het Boot*. Barents had sailed north of Novaya Zemlya, but his quest for a passage had been thwarted by impassable sea ice at 78 ° N, and he had been far less successful than his fellow explorers. By 10 September the fleet entered the North Sea, and six days later it returned

³⁹ Van Linschoten, "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten," 79.

⁴⁰ Van Linschoten compared the waters of the Kara Sea to those north of Norway, which, while at an even higher latitude, nevertheless did not freeze. Van Linschoten, "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten," 100.

to Texel after a journey of more than three months. The expedition of 1594 was among the most successful polar voyages undertaken in the age of sail. Still, the subsequent enthusiasm of De Moucheron and the Enkhuizen circle was hardly shared by Barents and Plancius, who still believed that a more northerly route was navigable.⁴¹

In 1594, the penetration of Dutch vessels into the seas above and beyond Novaya Zemlya was a product of co-evolution between the Republic's economic expansion, cultural values, social structures, and technological improvements, which were activated through individual agency and informed by environmental frameworks that, in polar seas, most importantly included the extent of ice at sea. These Arctic environmental structures were broadly influenced by the colder climate of the Grindelwald Fluctuation, but yearly variability in seasonal temperature and Atlantic inflow had important ramifications for regional ice cover. Years in which the Atlantic current was especially weak grew more common during the Grindelwald Fluctuation, and this shift in the average quantity of warm water flowing into the Barents Sea affected related currents around the islands of Vaygatsch and Novaya Zemlya.

In years of minimal Atlantic inflow the current through the Yugor Strait changed course to run from east to west, a phenomenon reported by the Dutch explorers in 1594 when they described how current and wind alike drove ice west into the Barents Sea. During the first expedition sea surface temperatures were likely quite low in the vicinity of Vaygatsch, and the adventurers should correspondingly have encountered unusually abundant sea ice. Instead, the mariners benefitted from relatively modest sea ice, particularly in the usually frigid Kara Sea, which is not affected by warmer currents even in years of maximum Atlantic inflow.

Accordingly, the summer of 1594 in the vicinity of the Yugor Strait was likely quite warm in the

⁴¹ Van Linschoten, "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten," 136. Hellinga, *Pioniers van de Gouden Eeuw*, 32. Van Linschoten, "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten," in *Terugkeer naar Nova Zembla*, ed. Jaap Jan Zeeberg, 155.

context of the Grindelwald Fluctuation. Summer warmth in the Arctic probably mirrored conditions in Northwestern Europe, where the summer of 1594 was only slightly cooler than the twentieth-century average.⁴²

The environment that prevailed around the Yugor Strait in 1594 represented a complex relationship between hydrological conditions rendered more frequent and atmospheric conditions rendered less common during the climate of the Grindelwald Fluctuation. Plentiful sea ice initially imperiled the *Zwaan* and *Mercurius* in the strait while impeding the progress of *Het Boot* up the coast of Novaya Zemlya. Nevertheless, in 1594 the state of the atmosphere was likely more influential to the progress of the explorers than the related but not always parallel condition of the ocean. Regional sea ice was consequently less plentiful than what was encountered in subsequent expeditions during the Grindelwald Fluctuation, and indeed Barents might have found a way forwards were he not obliged to reunite with his colleagues.⁴³ Ultimately, relatively sparse sea ice enabled the explorers to leverage the cultural, economic, and environmental structures of the Republic in an unprecedented incursion into the Kara Sea.

The Second Expedition: Failure and Discouragement, 1595

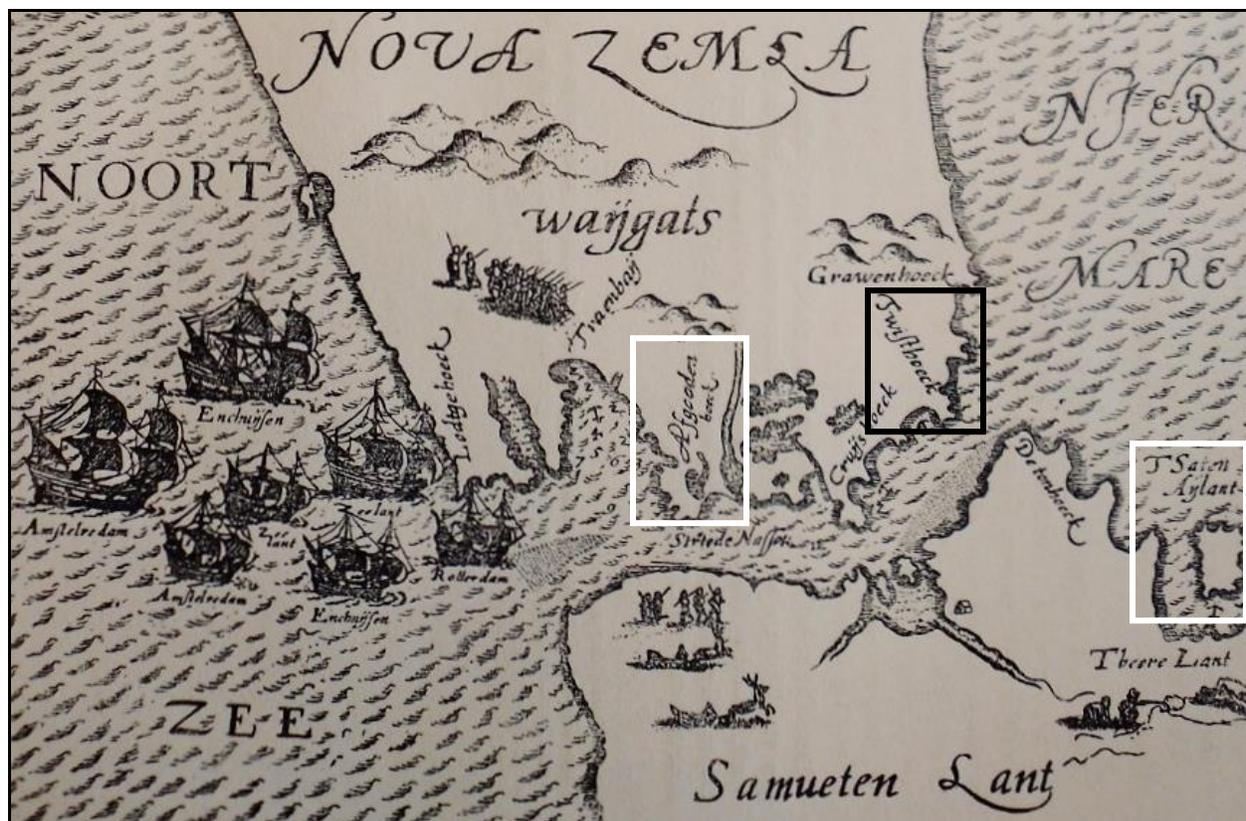
After the voyages of 1594 confirmed the promise of a passage to Asia through the Yugor Strait, De Moucheron financed a second, larger expedition in the summer of the following year. On 2 July 1595, seven vessels from Amsterdam, Enkhuizen, and Zeeland departed Texel under Nay's command. Barents served as lead pilot of the Amsterdam ships, while Van Linschoten was

⁴² Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago*, 66. Van Engelen, Buisman and Ijnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112. Shabalova and Van Engelen, "Evaluation of a reconstruction of temperature in the Low Countries," 225.

⁴³ Unfortunately, the complete logbooks kept by Barents have not survived. Only a fragment of his account of the beginning of his third journey was published in French in 1613. Zeeberg, *Terugkeer naar Nova Zembla*, 25.

head merchant on account of his travels in Asia. With Barents was the young Jacob van Heemskerck, later among the most famous explorers and admirals of the Golden Age. In the face of a Northwest wind, the fleet struggled up the North Sea and appeared off the coast of Norway on 15 July. After braving hard winds, the Dutch vessels were at 71° N on 26 July, and approached the North Cape – the northernmost tip of Norway – on 5 August (Map 1.3). Five days later the North Cape was nine miles southwest, as the explorers embarked across the Barents Sea. On 17 August, Gerrit de Veer, an explorer aboard the Dutch vessels, wrote that they were now off the coast of Novaya Zemlya, which was lined with a “great mass of ice.”⁴⁴

⁴⁴ Hellinga, *Pioniers van de Gouden Eeuw*, 32. Zeeberg, *Terugkeer naar Nova Zembla*, 46. Gerrit de Veer, *The True and Perfect Description of Three Voyages by the Ships of Holland and Zeeland*. (London, 1609), 7. Gerrit de Veer, *Reizen van Willem Barents, Jacob van Heemskerck, Jan Cornelisz. Rijp en Anderen Naar het Noorden (1594-1597), Eerste Deel*. (‘S-Gravenhade: Martinus Nijhoff, 1917), 32. Both De Veer’s original Dutch narrative and the English translation were used to compile this account. Where there was a discrepancy the Dutch journal was used.



Map 1.5. A map of the approach to Yugor Strait, published in the journal of Gerrit de Veer during the expedition of 1595. On the left, “Idol Point” is highlighted in white; “Twist Point” is highlighted in black; the States Island is highlighted in white on the right. Refer to Map 1.3 for the actual geography of the region. De Veer, *Reizen van Willem Barents*, 33.

The quantity of sea ice persuaded the mariners to reconsider their options, but after a discussion they resolved to pursue their mission by attempting to enter the Strait of Yugor. Broken sea ice forced the crews to alter course, yet the squadron arrived off the strait on 18 August. Despite abundant ice the explorers entered the strait on 19 August, but found the water near the so-called *Afgodenhoek*, or “Idol Point,” closed because of ice (Map 1.5). Varnek Bay, however, was relatively open, and provided shelter from windblown icebergs of the Strait (Map 1.3). For nearly a week the vessels anchored in Varnek Bay as groups hiked across Idol Point, seeking some prospect from which they might glimpse open water. A small boat sent to scout the Kara Sea could not get past the Strait of Yugor on account of the ice, but on 23 August the

Dutchmen encountered a party of Russians preparing to set sail for the Kara Sea. The Russians claimed that before long much of the Kara Sea would be frozen, even onto its southern coast. Perhaps prompted by the Russian warning, on 25 August the explorers made a renewed attempt to enter the sea, but were turned back at Twist Point by an overwhelming abundance of ice (Map 1.5).⁴⁵

In the next week, Barents and the other mariners spent several days among the inhabitants of the southern coast of Vaygatsch. On 2 September the vessels completed a treacherous journey through the ice to reach Cross Point, a gently protruding stretch of the coast between Idol Point and Twist Point (Maps 1.3 and 1.5). On 3 September the explorers were six kilometres north of Twist Point and entering the Kara Sea, but dense sea ice soon forced them to retreat. De Veer described “the great quantitie of Ice, and the mist that then fell, at which time the Winde blew so uncertaine, that we hold no course, but were forced continually to winde and turne about, by reason of the Ice, and the unconstantnesse of the wind.” After hours of such desperate maneuvering in variable wind the mariners correctly guessed that they had sailed back towards the southern coast of Vaygatsh in the Yugor Strait. With the season growing late, on 4 September the vessels were tied to the so-called States Island, which afforded some protection from the ice. The island was actually southeast of the Yugor Strait and in the Kara Sea, but the ice prohibited progress beyond this forward position (Maps 1.3 and 1.5).⁴⁶

With their way blocked, the explorers foraged on the island for game and crystals, hoping that the ice would soon shift to open a passage to Asia. The island was inhabited by polar bears, but the peril posed by the bears was as yet unfamiliar to the Dutch. On 6 September, two men walking far inland were ambushed by a thin and, apparently, famished bear. According to the

⁴⁵ De Veer, *The True and Perfect Description of Three Voyages*, 9. De Veer, *Reizen van Willem Barents*, 36.

⁴⁶ De Veer, *The True and Perfect Description of Three Voyages*, 13. De Veer, *Reizen van Willem Barents*, 40.

English translation of De Veer's account, the first man, pinned by the neck, cried, "who is that that pulles me so by the necke[?]" whereupon the second man responded with, "oh mate, it is a Beare." The second man hurried back to his ship, where a party of some twenty sailors was assembled and equipped with firearms that had been brought along to deal with Iberian soldiers. The men approached the bear and opened fire, yet the bear ran into the barrage, killing one mariner, and scattering the rest (Figure 1.2). The bear was eventually slain, but the bloody encounter demonstrated that the peril of the Arctic environment extended beyond windblown ice, frigid temperatures, and severe storms. Moreover, for the explorers, the threats posed by different expressions of the environment around Novaya Zemlya were entwined. Not only did ice floes directly threaten the ships, but even when the vessels themselves were secure in relatively open harbours, delays caused by ice cover exposed crews to an alien and unforgiving wilderness.⁴⁷

⁴⁷ De Veer, *The True and Perfect Description of Three Voyages*, 14. De Veer, *Reizen van Willem Barents*, 41. Hellinga, *Pioniers van de Gouden Eeuw*, 32.



Fig. 1.2. A sketch accompanying De Veer's Dutch account, depicting the tragedies of 6 September, 1595. In the foreground several men are attacked by a polar bear; in the background a party of twenty men is routed by the same bear. Ice floes are visible around the ships. De Veer, *Reizen van Willem Barents*, 36.

With the polar bear dead, some among the frightened and frustrated crews staged a short-lived mutiny, which was only quelled after five of the instigators were hanged. Between 9 and 12 September the explorers launched three desperate attempts to break through the ice drifting east of States Island. The ice was too thick, however, and afforded no passage, forcing the expedition to return to the Yugor Strait. As if to confirm that it was now too late to linger in the vicinity of Novaya Zemlya, a severe storm struck the fleet on 13 and 14 September. On the morning of the 15th, an easterly wind pushed thick sea ice into the Yugor Strait, driving the explorers west and into the Barents Sea. With any passage to Asia now clearly blocked by ice, Nay, Barents, and their subordinates agreed to return to the Republic. After weathering another gale on 17 September, the expedition crossed the Barents Sea and arrived off Kildin ten days later. On 26

October the explorers returned to Amsterdam having never left the immediate vicinity of Novaya Zemlya, with only whale bones to show for their journey.⁴⁸

Compared to the voyages of 1594, the disastrous expedition of 1595 was likely influenced by a relationship between hydrological and atmospheric conditions that was more typical of the first minimum of the Little Ice Age. In northern Europe the winter of 1595 was particularly cold, in a year when temperatures across all seasons were dropping towards their nadir during the Grindelwald Fluctuation. In the vicinity of Vaygatsch, the force of sea ice through the strait recorded by the explorers likely reflected another year of minimal inflow of relatively warm Atlantic water into the Barents Sea. Indeed both the first and second expeditions were initially hampered by sea ice pressing through the Yugor Strait from the east, but whereas the ice had melted and opened a passage to the Kara Sea in 1594, it persisted in the summer of 1595. Accordingly, average temperatures in the Russian Arctic likely mirrored the sharp decline of average European temperatures in 1595, compounding the impact of a weaker Atlantic current. These colder conditions were more common during the climatic regime of the Grindelwald Fluctuation than the relatively mild conditions of 1594, which had more than counteracted the influence of low Atlantic inflow. High winds and storms may, in turn, have funneled more sea ice into the Yugor Strait, where winds typically blew east from the frigid Kara Sea.⁴⁹

The influence of a shifting climate and, in turn, increased regional sea ice was mediated not only by cultural and economic trends that encouraged polar exploration, but also by the specific decisions made in spring of 1595. The second voyage for the Northeast Passage left later

⁴⁸ De Veer, *Reizen van Willem Barents*, 43. Hellinga, *Pioniers van de Gouden Eeuw*, 32. Spies, *Arctic Routes to Fabled Lands*, 139.

⁴⁹ Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago*, 66. Van Engelen, Buisman and Ijnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112. Shabalova and Van Engelen, "Evaluation of a reconstruction of temperature in the Low Countries," 225.

in the year than the other expeditions, arriving at the Yugor Strait halfway through August, when the first fleet had already sailed deep into the Kara Sea a year earlier. In leaving later the commanders of the second expedition failed to take advantage of a likely quirk in the seasonal fluctuation of Arctic temperature during the Grindelwald Fluctuation. Model simulations suggest that average Arctic summer temperatures declined significantly less than they did in other seasons, while average autumn temperatures likely declined more. Consequently, by exploring later in the year, the adventurers in 1595 probably subjected their efforts to a much sharper shift in temperature and, in turn, sea ice than would be experienced today between August and October (Figure 1.1).

Thick sea ice forced the explorers to wait in pockets of open water around the Yugor Strait, which, in turn, increased the likelihood of deadly encounters with local predators. The resulting mortality, coupled with the frustration caused by impenetrable sea ice, stimulated dissension and, indirectly, executions which poisoned already frayed relations between the Enkuizen and Amsterdam groups. In the final months of 1595, the passage through the Yugor Strait appeared far less promising than it had a year earlier, and it seemed as though the misgivings of the Amsterdam cabal had been realized. Now thoroughly discouraged, De Moucheron declined to finance continued Arctic exploration, while both Zeeland and Enkhuizen refused to contribute further ships.⁵⁰

The Third Expedition: Discovery, Disaster, and Survival, 1596-1597

⁵⁰ Moucheron had also secured a lucrative trade agreement with the Russians, whose tsar feared the prospect of a potential Dutch monopoly on trade through a Northeast Passage. Spies, *Arctic Routes to Fabled Lands*, 140. Zeeberg, *Terugkeer naar Nova Zembla*, 46.

In 1595, abundant sea ice rendered more common in the climate of the Grindelwald Fluctuation did not demoralize all advocates of a Northeast Passage. Van Linschoten remained convinced that “we will learn by additional investigation of the Vaygach [sic] area the right time to avoid the ice and conquer the obstacles that now, for lack of experience, appear insurmountable.” Meanwhile, Plancius and Barents, never sold on the earlier promise of the Yugor Strait, were eager to pursue the course they had long proposed. The voyages of 1594 had suggested that the Kara Sea was not merely a bay or inland sea, while the disastrous expedition of 1595 could not, of course, refute that the coast of the Kara Sea curved south towards China. In fact, Russian hunters had assured the Dutch that open seas continued well past Novaya Zemlya, possibly stretching across the entire polar region. The Amsterdammers reasoned that if ice had understandably hampered attempts to sail through the shallow Yugor Strait, the deeper waters north of Novaya Zemlya should afford a passage, just as the northerly sea off the North Cape permitted entry to the Barents Sea. On 25 March 1596, Plancius obtained a grant from townships in Holland, Zeeland, and Utrecht to launch an expedition that would, at last, lie under the unquestioned authority of the Amsterdam “merchant-adventurers.”⁵¹

On 16 May 1596, two vessels destined for the far north attempted to leave the Zuider Zee. Barents was firmly ensconced as the intellectual leader of the expedition, but the captain of his vessel was Heemskerck, and Jan Cornelisz Rijp commanded the second ship. Once again, De Veer accompanied the voyage, and his journals provide a remarkably continuous account of the ensuing months. The endeavour was quickly off to an inauspicious start, as north-easterly winds conspired with a spent tide to temporarily ground a ship and, eventually, force the fleet's return.⁵²

⁵¹ Hellinga, *Pioniers van de Gouden Eeuw*, 33. Zeeberg, *Terugkeer naar Nova Zembla*, 46. Jaap Jan Zeeberg, *Into the Ice Sea*, 60.

⁵² An easterly generally aided departure from Dutch ports, but to northerly destinations from Vlie, a north-easterly blew directly contrary.

Despite continued north-easterly winds, the expedition finally left port two days later, and struggled up the North Sea against continued north-easterlies until at least 29 May. Barents actually intended to sail far to the north before bearing east to avoid the supposed polar continent, a logical extension of the belief among the Amsterdam explorers that sufficiently deep water could not freeze. That conviction was apparently confirmed by their first days in Arctic waters; no ice was visible even after De Veer described how the vessels were so far north that “wee had no night.” On 4 June, at just under 71° N, De Veer reported “a strange sight in the Element; for on each side of the Sunne there was another Sunne, and two Raine-bowes that past cleane through the three Sunnes, and then two Raine-bowes more, the one compassing round about the Sunnes, and the other crosse through the great rundle.” De Veer was among the first in European history to give a clear description of a parhelion, an illusion either stimulated or enhanced by the low position of the sun and the iciness of the atmosphere.⁵³

At the same time, Rijp’s pilot insisted that they had sailed too far to the east, and would in fact soon encounter the Yugor Strait. As the pilot could not be convinced otherwise, Barents and Heemskerck consented to steer even further to the north. On the following day, De Veer reported a troubling sign: sea ice on the horizon, “which from afar looked like an oncoming flock of swans.” The vessels could maneuver through on 5 June, but by 4:00 PM on the sixth the ice had become so solid that passage was impossible. The explorers consequently steered south-west before resuming their north north-east course along the great mass of ice. At more than 74° N, they were now as far north as they had ever journeyed. On 7 July the ice towered around them like land, and by the eighth it was so thick that they were again forced to bear south. Before long they spotted an island, for which they sailed to avoid the ice. For four days the mariners lingered

⁵³ A parhelion is also known as a “sun dog.” De Veer, *The True and Perfect Description of Three Voyages*, 3. De Veer, *Reizen van Willem Barents*, 48. Hellinga, *Pioniers van de Gouden Eeuw*, 33. Zeeberg, *Terugkeer naar Nova Zembla*, 46. Jaap Jan Zeeberg, *Into the Ice Sea*, 61.

on the island, which they named “Bear Island” to commemorate a bear that they slew there with great difficulty (Map 1.3). After Rijp and Barents argued about their position a second time, the expedition departed the island on 13 June, and four days later the explorers again encountered thick sea ice.⁵⁴

Once more, ice forced the mariners to alter course. At just under 80° N on 19 June the explorers spotted land, although the wind, blowing from the Northeast, hindered their attempts to approach. Barents was convinced that this was the long-lost coast of Greenland, although Rijp designated it “The New Land,” while the mariners called it *Spitsbergen* or “Sharp Mountains,” because its peaks scraped the clouds. For the first time Rijp was correct in a navigational dispute with Barents: now halfway between Norway and the North Pole, the explorers had, in fact, discovered the largest island of the sprawling Svalbard archipelago. On 21 June the men reached the shore, where they discovered a remarkable abundance of virgin fauna and flora. Two days later they hoisted anchor, and for the following week they explored up and down the coast of the island, their course routinely blocked by sea ice. Ultimately, all attempts to sail around Spitsbergen’s northern coast were thwarted by the ice, but because the ships were near land the thick ice did not disprove the notion that deep water could not freeze. On 1 July the explorers returned to Bear Island, no closer to a Northeast Passage for all their discoveries.⁵⁵

Rijp now insisted on sailing north beyond 80° N to find an opening in the ice, but Barents believed that no passage was possible through the great landmass of Greenland. After a heated argument the two agreed to separate and attempt different passages: Rijp in the ice north of Spitsbergen, and Barents around the northern coast of Novaya Zemlya. In later testimony before

⁵⁴ De Veer, *The True and Perfect Description of Three Voyages*, 6. De Veer, *Reizen van Willem Barents*, 51. Jaap Jan Zeeberg, *Into the Ice Sea*, 61. Spies, *Arctic Routes to Fabled Lands*, 143.

⁵⁵ De Veer, *The True and Perfect Description of Three Voyages*, 9. De Veer, *Reizen van Willem Barents*, 55. Spies, *Arctic Routes to Fabled Lands*, 143.

the Republic's governing States-General, Rijp described how he had returned to the waters off Spitsbergen, where his ship had penetrated the ice pack to 79° N. A journal kept by crew member Thenis Claeszoon revealed that further progress was again blocked by impenetrable ice, and indeed the vessel was soon grazed by an iceberg. The ice tore a hole in the hull, but as water poured into the vessel the crew raised the leak above the sea by shifting all cargo towards the untouched side of the ship. Working from boats, the mariners repaired the hull, and after leaving messages nearby they sailed to Novaya Zemlya in pursuit of Barents.⁵⁶

The expedition of 1596 departed nearly a month earlier than even the first fleet had in 1594, and its initial discoveries were likely facilitated by average summer temperatures that, in the Arctic, cooled far less than average temperatures in other seasons during the Grindelwald Fluctuation. On the other hand, the summer was not so balmy that the mariners could avoid sea ice altogether to sail wherever they liked, and indeed model simulations suggest that, in the context of preceding centuries, water temperatures around Spitsbergen were colder than average during the 1590s.⁵⁷ Consequently, it was not a lack of sea ice but rather its particular distribution that, in the summer of 1596, encouraged the discovery of Bear Island and, more significantly, Svalbard. On 6, 8, and 17 June the expedition encountered sea ice so thick that it forced a change in course, guiding the explorers closer to discoveries that they neither intended nor desired. Encountering Spitsbergen did not lead the Dutch closer to a Northeast Passage, but it was influenced by weather symptomatic of the very moderate nature of summer cooling in the Arctic of the late sixteenth century.⁵⁸ The discovery may also have been influenced by persistent north-

⁵⁶ Jaap Jan Zeeberg, *Into the Ice Sea*, 62.

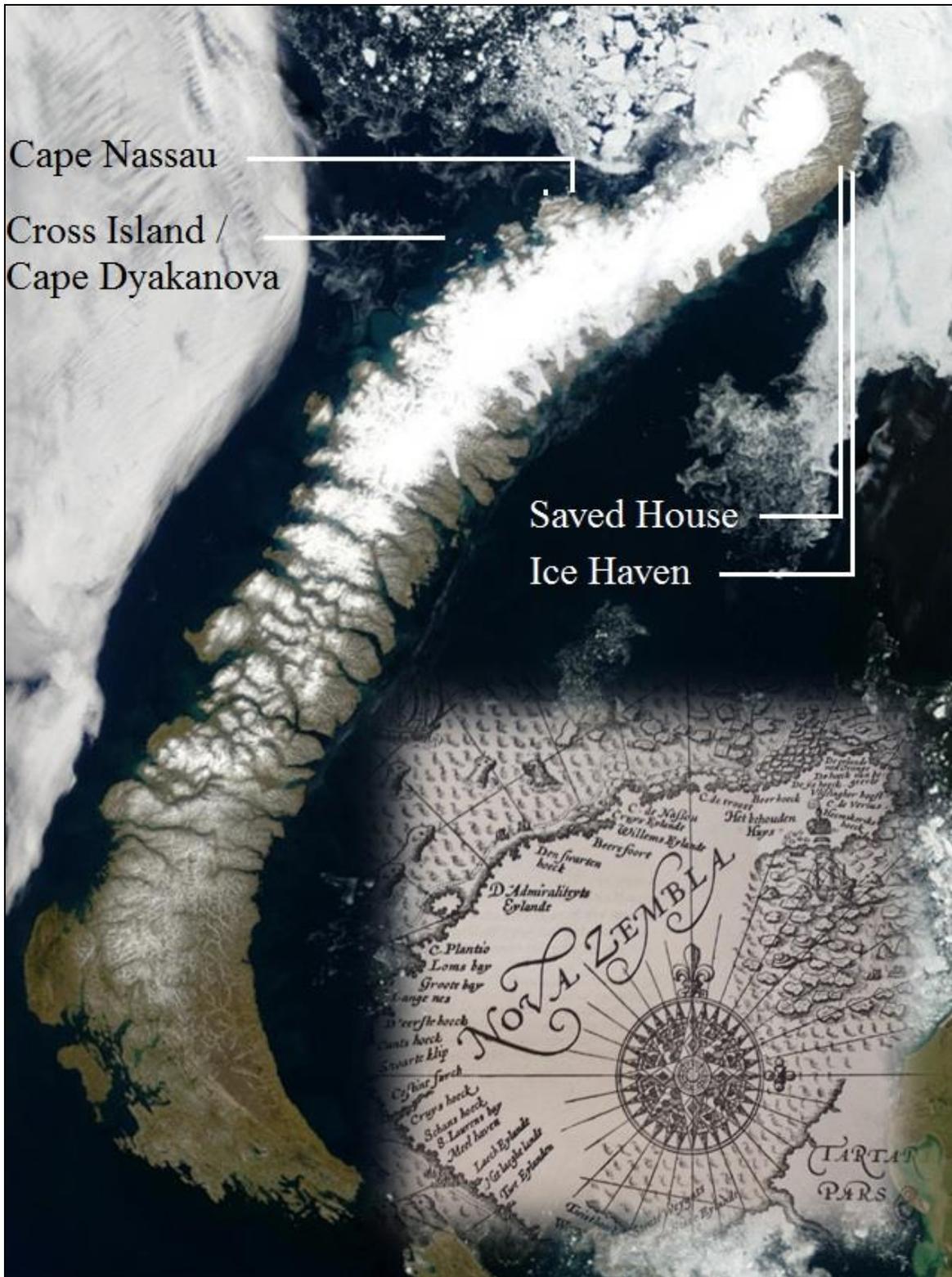
⁵⁷ Temperatures off the west coast of Spitsbergen were nearly 1°C colder in 1600 than they had been in 1350, but they may have risen slightly over the course of the sixteenth century. Lehner, "Amplified Inception of European Little Ice Age," 52.

⁵⁸ That is, it was influenced by Arctic cooling, but also the moderate nature of that cooling in the summer, which generated sufficient warmth to stimulate just enough open water.

easterly winds in the North Sea, which delayed the expedition until it could encounter the distribution of sea that, in turn, encouraged its fateful changes in course. Such easterlies probably grew more common in the cooling of the late seventeenth-century climate, but they cannot, as yet, be linked to the similarly cold climate of the Grindelwald Fluctuation.

After Rijp and his crew departed on 1 July, Heemskerck and Barents commanded their men to bear east, towards Novaya Zemlya. Evidently they were less certain now regarding the impossibility of ice in deep water; De Veer recorded that given their high latitude they “much wondered” about the short-lived lack of sea ice on 4 July. Twelve days later they arrived off Novaya Zemlya, where they began to sail up the island's western coast (Map 1.6). On 19 July the explorers reached “Cross Island” (Cape Dyakanova) at roughly 76° N, yet they found their way blocked by ice. Opting to wait for an opening in the ice, on the following day the crew foraged ashore before being chased back to the ship by two polar bears. After surviving further encounters with bears in subsequent days the mariners finally maneuvered around the ice on 4 August, and after two days they passed the *Hoek van Nassouwen* or “Point of Nassau.” Rijp reached Cape Dyakanova only days after Barents and his crew slipped through, but the way forward was now entirely sealed by ice.⁵⁹

⁵⁹ De Veer, *The True and Perfect Description of Three Voyages*, 14. De Veer, *Reizen van Willem Barents*, 60. Jaap Jan Zeeberg, *Into the Ice Sea*, 62.



Map 1.6. Significant locations for the expedition of 1596, in a Satellite image of Novaya Zemlya and, inset, as mapped in De Veer’s journal. The “Saved House” is visible on the top right of the De Veer map. Zeeberg, *Into the Ice Sea*, 17. Unwin, *A Winter Away From Home*, 68. De Veer, *Reizen van Willem Barents*, 138.

On 7 August the ice took a more sinister form, with vast icebergs constraining the ship's movement and drifting perilously close in the easterly wind. The crew attached their vessel to an iceberg to avoid colliding with other ice masses, yet on 10 August that iceberg splintered on the seabed. It was only by sailing over and through the shards of broken ice that the explorers narrowly escaped. After attempts to tie the ship to additional icebergs failed when these were also shattered, Barents and Heemskerk guided the ship nearer the shore, because the largest icebergs could not enter the shallow water.⁶⁰ Despite this tactic, the explorers were entirely surrounded by ice on 15 August, but with great difficulty eventually found a passage. Before long they reached the island of Orange, and survived a polar bear encounter of a kind that was becoming increasingly common. On the following day there was cause for relief when a scouting party climbed a hill atop Novaya Zemlya and discovered open water to the southeast and east-southeast. While Barents had worried that Novaya Zemlya was connected to a polar continent these fears now appeared groundless, and De Veer described how "we were much comforted, thinking we had won our voyage."⁶¹

Having rounded the tip of Novaya Zemlya, on 20 August the explorers braved icebergs and thick sea ice to reach "Ice Haven" on the north-western coast of the island (Map 1.6). On the following day they left the haven, but a ferocious storm forced them to attach their vessel to an

⁶⁰ The irony of this tactic given their conception of water depth and ice formation was probably lost on the explorers. In previous days De Veer in his log described how the first iceberg "began mightily to breake, and then wee first perceived that the great peece of Ice whereunto wee had made our Shippe fast, lay on the ground; for the rest of the Ice draue along [passed by] it, wherewith wee were in great feare that wee should be compassed about with the Ice." After supper, the second iceberg to which they attached their ship "began on a sodaine to burst and rende in peeeces, so fearfully that it was admirable; for with one great cracke it burst into foure hundred peeeces at the least." Escape was fortuitous. Bears attempted to enter the vessel when it was attached to one of the icebergs. De Veer, *The True and Perfect Description of Three Voyages*, 15. De Veer, *Reizen van Willem Barents*, 61.

⁶¹ Barents was still concerned about the ice, but even he was comforted. Zeeberg, *Into the Ice Sea*, 62. De Veer, *The True and Perfect Description of Three Voyages*, 17. De Veer, *Reizen van Willem Barents*, 62. Zeeberg, *Terugkeer naar Nova Zembla*, 47.

iceberg until 23 August. On 24 August, the ice began to surround their vessel, but a change in wind drew it away again, and having narrowly escaped catastrophe they resolved to sail south towards Vaygatsch. Thickening ice soon forced them to reconsider that ambition, however, and on 26 August Barents decided that the expedition should retrace its steps around the west coast of Novaya Zemlya, abandoning the quest for a passage. However, as the ship passed by Ice Haven later that day it was entirely surrounded by ice, which pressed in from the sea with a southeast wind and, on the following day, lifted the vessel four feet above the water. After the ship was briefly lowered back into the sea by retreating ice on 29 August, the ice returned with even greater force than before, so that, according to De Veer, “the whole ship was borne up and inclosed, whereby all that was about it and in it, began to crack, so that it seemed to burst in a 100 pieces, which was most fearfull both to see and heare and made all the haire of our heads to rise upright with feare.” For more than a week the ice retreated and returned, but all the while the vessel was firmly enclosed. With winter approaching and the ship again lifted high upon the ice, by 11 September it was obvious that there would be no imminent escape from the forbidding environment of Novaya Zemlya.⁶²

Faced with this grim reality, Barents, Heemskerck, and their crew decided to build a house on the shore, in which they could endure the winter without facing the possibility of being crushed by sea ice. Fortunately, on 11 September a scouting party found entire trees on the coast, likely uprooted and washed ashore in a storm. With wood laboriously harvested from these trees the men began the long and desperate struggle to erect a shelter before the onset of the polar winter, when frigid temperatures and incessant storms, worsened in the climate of the Grindelwald Fluctuation, would combine with perpetual darkness to prohibit construction altogether. On 23 September the expedition’s carpenter died, likely from overwork, but despite

⁶² De Veer, *The True and Perfect Description of Three Voyages*, 23. De Veer, *Reizen van Willem Barents*, 70.

frequent bear attacks and worsening blizzards much of the shelter, which the crew called the *Behouden Huys* or “Saved House,” was built by 12 October (Map 1.6 and Figure 1.3). By 23 October the construction of individual cabins, a chimney, and a door completed the house, which had finally been supplied with most of the ship’s victuals. The rest of the crew abandoned the vessel on 24 October, including one man who had fallen so sick that he was borne on a sled.⁶³



Fig. 1.3. An idealized depiction of the “Saved House” during the overwintering of 1596/97. With no insulation, the walls were typically coated with ice. On the left, the hourglass; on the right, the clock which soon froze. Below the clock was a wine barrel turned makeshift bath, which offered little comfort against the extraordinary cold. Destined to die, a sick man rests left of the fire. Zeeberg, *Into the Ice Sea*, 104. See also: Gerrit De Veer, *Warhafftige Relation der dreyen neuen, unerhörten seltzamen Schiffart*. Neurenberg: L. Hulsius, 1598.

⁶³ De Veer, *The True and Perfect Description of Three Voyages*, 31. De Veer, *Reizen van Willem Barents*, 79.

On 3 November the sun vanished beneath the horizon and was not seen again for months. The shimmering light of stars, moon, and aurora borealis, reflecting off the snow, allowed the explorers to forage when it was not too cold or stormy, while the sporadic thundering of the ice on the coast broke the silence. Nevertheless, when the clock froze and stood still four days later, the crew could no longer discern whether it was day or night.⁶⁴ The bears that had routinely attacked the house disappeared with the sun, but temperatures continued to decline as blizzards grew more common. The crew manufactured pelts from foxes that had emerged with the retreat of the bears, but neither fur nor boiling water could long defend against the cold. By the third day of a lengthy blizzard on 3 December the walls were coated with ice as thick as two fingers, wisps of snow had blown through the walls, and the fire could scarcely be lit because its smoke, blown by the wind, no longer funneled through the chimney.⁶⁵

In yet another blizzard three days later, De Veer wrote that the cold was “almost not to be indured, whereupon we lookt pittifully one upon the other, being in greate feare, that if the extremity of the cold grew to be more and more, we should all die there with cold.” These fears were well founded, and they deepened when shoes froze solid on 11 December, and again when the cabins were frozen in the morning of 26 December. Meanwhile, severe blizzards accompanied by unbearable cold and heavy snowfall that completely buried the Saved House had grown routine, blowing on forty-nine days from the beginning of December to the end of March.⁶⁶ On 24 January the crew’s spirits were raised when the sun appeared to rise after nearly three months of darkness. The sunrise came two weeks earlier than Barents expected, and in fact

⁶⁴ Although sand continued to pour through the hour glass, and the explorers maintained track of time. Unwin, *A Winter Away from Home*, 112.

⁶⁵ De Veer, *The True and Perfect Description of Three Voyages*, 37. De Veer, *Reizen van Willem Barents*, 87. Unwin, *A Winter Away from Home*, 111.

⁶⁶ The snow might have insulated the cabin, but there is little indication that temperatures grew more bearable for the explorers.

De Veer in his journal recorded the first observation of what was thereafter known as the “Novaya Zemlya effect,” a polar mirage stimulated by the atmospheric refraction of sunlight.⁶⁷

Despite the illusion, before long the sun returned in truth, and, although the weather remained cold and stormy for months to come, by May open water was visible from the coast. The ship, however, could not be dislodged, and open water remained fleeting, as storms or even mere shifts in the wind repeatedly drove thick sea ice back into the harbour. Consequently, on 15 May Heemskerck and Barents ordered the crew to prepare small boats, with which they would attempt a desperate journey back to the Republic.⁶⁸ Weeks of frantic construction ensued, hampered by the curiosity of bears that had long since awakened from hibernation.⁶⁹ Finally, on 14 June two boats departed Novaya Zemlya, but they had not travelled far before they were again entrapped by ice. It was a sign of things to come, as rapidly shifting ice, bears, walruses, storms, and navigational blunders all conspired to threaten the return voyage in the months to come. Shortly following their departure Barents, long sick with scurvy, died alongside Claes Adrians as they huddled on windswept ice, while Jan Franszoon perished four days after the boats capsized in frigid water on 1 July. Nevertheless, despite enduring nearly unimaginable adversity, most of the explorers arrived at Kildin on 25 August, where to their astonishment they encountered Jan Cornelisz Rijp and his crew (Map 1.3). Reunited at last, the survivors arrived in

⁶⁷ De Veer, *The True and Perfect Description of Three Voyages*, 47. De Veer, *Reizen van Willem Barents*, 99. Unwin, *A Winter Away from Home*, 125.

⁶⁸ For weeks Heemskerck, hoping that the ship could be freed, was reluctant to agree to this scheme. He realized better than most that a return in small boats would be more dangerous than the overwintering itself. De Veer, *The True and Perfect Description of Three Voyages*, 77. De Veer, *Reizen van Willem Barents*, 122.

⁶⁹ After the descent of the sun for the polar winter, the first bear was spotted on 11 February. It investigated the house, whereupon the explorers killed it with some difficulty. The bear’s grease helped fuel their lamp. Unwin, *A Winter Away from Home*, 131.

Amsterdam on 1 November, and the fur coats they had fashioned in Ice Haven created a sensation.⁷⁰

Although adventurers seeking a Northeast Passage could have been entrapped by ice even in the warmer twentieth-century climate, the pattern of moderate summer cooling and frigid temperatures in fall, winter, and spring, typical of the Grindelwald Fluctuation in the Arctic, increased the likelihood of an overwintering during the Dutch expeditions. A relative lack of ice during summer might have encouraged the Dutch explorers to penetrate deep into Arctic waters, and indeed Barents and his crew might not have slipped past Cape Dyakanova had the summer of 1596 been any colder, while Rijp might have found a way through were the summer warmer. In that case the expedition would have been reunited far sooner, and Rijp might have convinced Barents to attempt an earlier return to the Republic. On the other hand, before the expedition of 1595 ended in disappointment, Barents had unsuccessfully argued for an overwintering near the island of Vaygatsch, and indeed in 1596 the explorers were again well provisioned for that possibility.⁷¹

Surviving winter on the northern tip of Novaya Zemlya was an entirely different prospect, however, and indeed before 1597 few western Europeans had ever survived an Arctic winter. The unusually sharp shift in temperature between summer and autumn, influenced by the climate of the Grindelwald Fluctuation, likely increased the difficulty of avoiding, and decreased the possibility of escaping, a sudden thickening of sea ice off Novaya Zemlya (Figure 1.1). Thereafter, a frigid winter punctuated by relentless storms, rendered more common in the climate of the late sixteenth century, conspired with a relatively cold spring to deepen and lengthen the

⁷⁰ Remarkably, of the 17 men in Barents's vessel, perhaps 12 survived. The carpenter perished first, followed by the sick man carried into the "Saved House" (for him, ironically named). Barents died believing that a Northeast Passage could still be found. De Veer, *The True and Perfect Description of Three Voyages*, 127. De Veer, *Reizen van Willem Barents*, 178. Unwin, *A Winter Away from Home*, 229. Hellinga, *Pioniers van de Gouden Eeuw*, 37.

⁷¹ Unwin, *A Winter Away from Home*, 40.

hardships endured by the explorers of the “Saved House.” It may be that the reduced flow of the Atlantic current in the Barents Sea increased the sea ice encountered by the beleaguered mariners as they struggled to return to the Republic during the summer of 1597. Because their vessels never entered the Yugor Strait, however, there are no indications of the regional current in the logbook kept by De Veer to record the expedition.⁷²

Conclusion: the Enduring Significance of the Barents Voyages in a Colder Climate

The meteorological and hydrological conditions of the Arctic north of Europe were influenced by the climatic cooling of the Grindelwald Fluctuation in ways that shaped the quest for a Northeast Passage at the dawn of the Dutch Golden Age. Nevertheless, a climatic trend masks the annual variability of weather, and indeed it was actually seasonal warmth, rendered less common during the colder climate of the late sixteenth century, that helped enable the success of the expedition of 1594. The promise of that expedition inspired a second endeavour in 1595, but the relationship between weather and hydrology was now more typical of the Grindelwald Fluctuation. The explorers left late in the season, exposing their voyage to the sharp drop between average summer and autumn temperatures reconstructed using model simulations. Heavy sea ice subsequently thwarted all attempts to investigate the Kara Sea, but this failure only encouraged entrepreneurs in Amsterdam to attempt the more northerly passage for which they had long advocated.

Departing early in the summer of 1596, the third expedition of Willem Barents initially benefitted from weather that likely reflected how average summer temperatures in the Arctic had

⁷² Crespin et al., “Arctic climate over the past millennium,” 327. Crespin et al., “The 15th century Arctic warming in coupled model simulations with data assimilation,” 394.

not declined as much as average temperatures in other seasons. After discovering Bear Island and Spitsbergen, however, Barents and his crew were trapped off the northeastern coast of Novaya Zemlya as temperatures and, in turn, ice cover manifested the sharp transition to autumn in a cooler climate. Although the misery of their overwintering was exacerbated by weather typical of the Grindelwald Fluctuation, it was not the homogeneity but rather the heterogeneity of relationships between climate, weather, and ocean currents that influenced the history of contemporary Arctic exploration. The outcome of the quest for a Northeast Passage in the last decade of the sixteenth century can only be fully understood by matching the centuries-old logbooks with new climatic reconstructions to uncover differences in the rate of cooling between seasons and the complex, sometimes paradoxical interactions between hydrological and atmospheric manifestations of the prevailing climate.

was no indication of nearby land, the Dutch expeditions between 1594 and 1597 challenged the notion of an Arctic continent, even if they never actually approached the North Pole.

Accordingly, fictional monsters and continents vanished from maps developed using data gleaned from the expeditions (Map 1.7). New lands appeared to the European imagination as Dutch maps depicted Arctic geography and fauna with increasing accuracy.

None of the discoveries was more significant to Dutch prosperity and Arctic ecology than the Svalbard archipelago.⁷⁴ Inspired by De Veer's vivid descriptions of Spitsbergen's natural abundance, the first whaling expeditions in 1600 encountered countless bowhead whales congregated in some of the richest feeding grounds of the entire Arctic. Mirroring the process of consolidation that simultaneously strengthened Dutch imperialism in Asia and the New World, in 1614 the *Noordsche Compagnie* was granted a monopoly over the slaughter of whales and walrus from Novaya Zemlya to the Davis Strait. The Company quickly established factories at nearly every accessible site along the western coast of Spitsbergen, including the infamous slaughterhouse of Smerenburg. Increased activity in polar seas was accompanied by further attempts at a Northeast Passage, although none were as committed as the Barents expeditions, and none ended successfully.⁷⁵

Beyond encouraging the development of a large and destructive new industry, the expeditions provided important new discoveries relevant to the behaviour of sea ice, the patterns

⁷⁴ Svalbard may have been sighted earlier, perhaps even by Viking explorers, but Barents and his crew made the first indisputable discovery and subsequently mapped part of the archipelago for the first time.

⁷⁵ In particular, unsuccessful expeditions were sent out in 1603, 1609, 1611 and 1612, towards Novaya Zemlya. None found an opening through the ice. Sailing up the western coast of Spitsbergen, Torus Carolus may have reached 83°N in 1614 to discover the regional ebb tide running north. Still, deep penetration beyond Svalbard in the north and Novaya Zemlya to the northeast was impossible using contemporary technology in the nadir of the Little Ice Age. Jansen, "Notes on the Ice between Greenland and Nova Zembla," 167. De Vries and Van der Woude, *The First Modern Economy*, 257. J.M. Węśławski et al., "Greenland whales and walrus in the Svalbard food web before and after exploitation." *Oceanologia* 42:1 (2000): 37. Louwrens Hacquebord, "The hunting of the Greenland right whale in Svalbard, its interaction with climate and its impact on the marine ecosystem." *Polar Research* 18:2 (1999): 155.

of Arctic fauna or flora, and the physics of light through the polar atmosphere. Moreover, the complete journals kept by De Veer and Van Linschoten were published in many different languages, and were widely disseminated in the print culture of the Dutch coastal cities. Consequently, the voyages of the 1590s, shaped by the climate of the Grindelwald Fluctuation, emerged as enduring symbols of the ambition and resilience of the Dutch Republic in its Golden Age, influencing popular culture in the northern Low Countries while inspiring later explorers in more distant seas.⁷⁶

⁷⁶ The influence on popular culture persists. In 2011 the historical drama *Nova Zembla*, loosely based on the De Veer journals, was the first Dutch feature film shot in 3D.

Chapter 2

Exploiting the Periphery in a Fluctuating Climate: United East India Company Ship Journeys

In the 1590s, the expeditions that sought a Northeast Passage to Asia were encouraged, thwarted, and ultimately redirected by influences that included the interplay between climate, weather, and the Arctic environment during the Grindelwald Fluctuation. For Dutch merchants, the voyages strongly suggested that any attempts to exploit a Northeast Passage, even if it did exist and had somehow eluded Barents, would be prohibitively expensive. Merchants like De Moucheron therefore invested heavily in early expeditions around the Cape of Good Hope, which eventually yielded spectacular profits.¹ Such voyages were also at the periphery of the world known to the Dutch, but they occupied a periphery that was already commercialized, and would soon be normalized, for many within the Republic. Ultimately, the journeys to Asia, and the trading empire they would sustain, would be shaped by relationships between weather and climate change that were very different from those that affected exploration in the Arctic.

The first Dutch expeditions to Asia hinted not only at the potential of direct trade with the Far East, but also at the ways in which weather would affect future voyages. In August of 1597, Cornelis de Houtman salvaged the otherwise disastrous first Dutch expedition to Asia by returning to Amsterdam with word that it was possible for Dutch traders to purchase spices in the Far East.² One year later, wealthy merchants united two smaller companies to form the *Oude Oost-Indische Compagnie* ("Old East India Company"), which now possessed resources sufficient to furnish a second expedition with eight large, heavily-armed vessels. Heemskerck,

¹ In this De Moucheron was again unfortunate. After financing failed expeditions he died bankrupt. Hellinga, *Pioniers van de Gouden Eeuw*, 37.

² His expedition was supported by the *Compagnie van Verre* ("Long-Distance Company"). Israel, *The Dutch Republic*, 319.

fresh from his ordeal in Novaya Zemlya, served as chief merchant under the command of Admiral Jacob van Neck. The fleet departed on 1 May 1598, and was immediately hampered by calm winds, which impeded all forward progress in the age of sail. Thereafter still conditions alternated with storms that repeatedly scattered the ships. When Van Neck, Heemskerck, and their crew arrived at the Cape of Good Hope on the southern tip of Africa, they were left with only three ships. After much sickness and suffering, the surviving vessels reached Bantam on the island of Java, where the crew purchased spices that were loaded into their holds as their previously lost companions sailed over the horizon. The return journey of the united fleet was again hampered by tropical illness, while repeated storms finally succeeded in toppling the mast of Van Neck's flagship. At last four of the vessels arrived at Texel on 19 July 1599, and their cargo of spices was sold at great profit by the *Oude Oost-Indische Compagnie* (Figure 2.1).³

³ Hellinga, *Pioniers van de Gouden Eeuw*, 130. Israel, *The Dutch Republic*, 320.



Fig 2.1. The return of the second expedition to Asia in 1599. Two Dutch East Indiamen are visible in the centre and far left. The size and shape of the East Indiamen compared to other contemporary vessels is clearly depicted. Andries van Eeertveld, “The Return to Amsterdam of the Second Expedition to the East Indies on 19 July 1599,” painting, c. 1610-1620, National Maritime Museum, <http://collections.rmg.co.uk/collections/objects/12240.html>.

In these first Dutch voyages to Asia, delays caused by calm winds lengthened how long crews were forced to endure cramped, unsanitary conditions and meagre, often spoiled rations. Waiting for the right wind in such circumstances may have increased the threat of disease, which afflicted both journeys. Moreover, storms damaged the Dutch vessels and scattered fleets, exacerbating the risks posed by enemy action in hostile waters, while impeding navigation and, in turn, lengthening time spent in insalubrious circumstances. The eight small companies initially established to pursue Dutch commerce with Asia may have been particularly vulnerable to such environmental conditions. They lacked the means to compensate for a particularly disastrous voyage, and their competition had destabilized spice prices. The States General issued a charter on 20 March 1602 that merged these relatively small “precursor” companies into the *Vereenigde*

Oost-Indische Compagnie (“United East India Company”). The world’s first firm founded on permanent share capital, the new consortium was placed under the authority of a board known as the *Heren XVII* (“Seventeen Lords”), and granted a monopoly over Dutch trade from the Red Sea to Japan. The States-General bestowed great power upon the VOC, granting its representatives the right to conduct diplomacy, field troops, construct warships, and impose governors on indigenous populations.⁴

The merchants who founded the precursor corporations were motivated primarily by the potential profits of direct participation in the high-value, low-volume “rich trade” with Asia, but the States-General had established the VOC not only to enrich the Republic but also to undermine the Iberian economy.⁵ The expedition under Van Neck had already recorded indigenous discontent with Iberian merchants and governors, which the VOC was well positioned to exploit. Consequently the VOC’s initial successes in 1605 were both military and commercial, as its fleet seized the Indonesian islands of Amboina, Ternate, and Tidore from the Portuguese. Because these conquests had been unplanned and relatively unorganized, in 1609 the *Heren XVII* dispatched a governor general and council to Asia, to better administer and expand its new acquisitions. A decade later, the company’s fourth governor general, Jan Pieterszoon Coen, seized Batavia, at the site of modern-day Jakarta, transforming the settlement into the

⁴ To his chagrin, De Moucheron was excluded from the *Heren XVII*. De Vries and Van der Woude, *The First Modern Economy*, 384. Harm Stevens, *Dutch Enterprise and the VOC: 1602-1799*. (Zutphen: Walburg Pers, 1998), 16. Femme S. Gaastra, *The Dutch East India Company: expansion and decline*. (Zutphen: Uitgeversmaatschappij Walburg Pers, 2003), 119. Gerrit Knaap and Ger Teitler (eds.), *De Verenigde Oost-Indische Compagnie: Tussen Oorlog en Diplomatie*. (Leiden: KITLV Uitgeverij, 2002), 1. Tonio Andrade, “The Company’s Chinese Pirates: How the Dutch East India Company Tried to Lead a Coalition of Pirates to War against China, 1621-1662.” *Journal of World History* 15:4 (2004): 422.

⁵ To Grand Pensionary Johan van Oldenbarnevelt, the VOC was founded “to damage the enemy and to secure the homeland.” Stevens, *Dutch Enterprise and the VOC*, 16.

locus of European power in Asia (Map 2.1).⁶ In subsequent decades the VOC expanded rapidly across Asia, establishing factories and fortresses at the expense of the Portuguese.⁷



Map. 2.1. The “cart track,” (outbound from the Republic in green, inbound from Batavia in red) the “back way,” (yellow) and the major ports of the VOC. Routes diverged in the Indian Ocean, but for much of the Company’s history most Dutch vessels entering or leaving Asia called at Batavia.

The structure of the VOC under the authority of the Heren XVII superficially mirrored the federated organization of the Dutch state. Each equipped with its own shipyard, the Company’s six chambers reflected the geographic origins of the precursor companies. Still, Amsterdam was dominant in practice, as it was in the wider Republic. The chambers of the VOC manufactured and equipped 1,581 vessels between their establishment and their final collapse in 1803. These ranged from small boats to hulking East Indiamen capable of carrying more than

⁶ The population of Batavia grew from 8,000 in 1624 to 70,000 by 1700, which would have made it one of Europe’s largest cities. Of those 70,000, nearly 10% were Dutch. Israel, *The Dutch Republic*, 324.

⁷ Israel, *The Dutch Republic*, 324. Gaastra, *The Dutch East India Company*, 12 and 109.

1,000 tons in spices, textiles, precious metals, and other “rich” commodities.⁸ With the regular and spectacular profits gleaned from trade in such goods, the VOC, although initially a minor material contributor to Dutch prosperity, ultimately emerged as a primary engine of the Republic’s economy. Employing over 30,000 men at the height of its power, the Company dominated not only commerce between Asia and Europe, but also the equally lucrative trade between Asian ports. With silver shipped from Amsterdam, in the first decades of the seventeenth century VOC agents used the Company’s vast reach to gain a prolonged competitive advantage over local maritime powers. The Company’s control over intra-Asian trade and, in turn, its profitability peaked around 1670, although its size and gross revenues continued to expand in the following century.⁹

For the VOC to exploit price fluctuations in different ports while defending its control of Asian waters, the traffic in goods and information carried aboard the Company’s East Indiamen needed to be reliable, inexpensive, and swift. These necessities were linked: the price of commerce rose if vessels were lost, for example, while the possibilities for disaster increased the longer a ship was at sea.¹⁰ VOC correspondence, ship logbooks, and day registers reveal that the dependability, expense, and duration of voyages were connected to evolving relationships between climatic fluctuations, patterns of prevailing wind, and daily weather in the nadir of the Little Ice Age. During the Maunder Minimum, a rise in the frequency of easterly winds in the North Sea region likely increased the sailing speed of vessels departing the Republic relative to

⁸ These East Indiamen were mostly completed in the great shipyard that dominated the artificial peninsula of Oostenburg in Amsterdam. The production capacity of the complex was unsurpassed in the seventeenth-century world. Stevens, *Dutch Enterprise and the VOC*, 25.

⁹ J.R. Bruijn, F.S. Gaastra and I Schöffer, with assistance from A.C.J. Vermeulen, *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Introductory Volume*. (The Hague: Martinus Nijhoff, 1987), 19. Stevens, *Dutch Enterprise and the VOC*, 16. Jaap R. Bruijn, "The Dutch East India Company as Shipowner, 1602-1796." *American Neptune* 47:4 (September 1987): 240. Gaastra, *The Dutch East India Company*, 134. Knaap and Teitle, *De Verenigde Oost-Indische Compagnie*, 4.

¹⁰ Gaastra, *The Dutch East India Company*, 111.

the velocity of outbound ships in preceding, warmer decades. For outbound ships, more common easterlies generally blew from the point of departure, and contributed to a statistically significant shortening of their journeys to Asia. By comparison, for ships returning to the Republic from Asian ports the effect of more common easterlies was ambiguous, and the overall influence of changing in prevailing wind during the Maunder Minimum was likely to decrease the duration of VOC voyages.

Company sources also reflect a rise in the frequency of storms encountered by VOC crews during the Maunder Minimum, an increase that was likely concentrated in the North Sea region and was consequently reflected in regional documentary evidence. Most storms do not appear to have directly imperilled large, seaworthy East Indiamen, which generally sailed far from potentially threatening lee shores. Nevertheless, the influence of storms was significant, if complex. Gales routinely scattered fleets and damaged individual ships, but when high winds blew in a favourable direction, storms could propel vessels at speeds sufficient to substantially shorten their journeys.

The rise and decline of the VOC is one of the most studied aspects of the Dutch Golden Age. However, few Dutch historians, and no climate historians, have fully appreciated the importance of weather for the efficient operation of the Company. Recent scholarship on the VOC has primarily considered its networks for exchanging commodities, people, cultural attitudes, and information.¹¹ Increasingly, historians have also explored the Company's operations within Asia, including its lucrative expansion into the intra-Asian trades, which

¹¹ Kelly Ward, *Networks of Empire: Forced Migration in the Dutch East India Company*. (Cambridge: Cambridge University Press, 2009), 5. E. M. Jacobs, *In Pursuit of Pepper and Tea: The Story of the Dutch East India Company*. (Walburg: Walburg Pers, 2009), 11. Gelderblom and Jonker, "Completing a Financial Revolution," 643.

required large-scale employment of local seamen.¹² Some of these studies have adopted a micro historical approach, exploring the Company's history in one of its Asian outposts.¹³ Accordingly, the environmental history of the Company's activities in Atlantic waters has received little attention since the advent of climate history.¹⁴ In this, scholarship of the VOC echoes that of its English competitor. For example, Philip Lawson's recent account of the rise and fall of the English East India Company contains not a single reference to "wind," and the only storms he describes are metaphorical.¹⁵

Nevertheless, some historians of the VOC have examined how weather patterns influenced the establishment and later operation of the Company. In the 1970s and 1980s, Jaap Bruijn pioneered the quantitative analysis of VOC documentary records, and the resulting statistics reflected the influence of storms on Company shipwrecks. In 2003, Femme Gaastra, who had been part of this earlier initiative, outlined how VOC fleet schedules were set, in part, by the threat of winter storms in the North Sea, and the annual reality of the Indian monsoon. Gaastra echoed Bruijn in writing that prevailing winds in the Atlantic and Indian oceans shaped the development of standardized trade routes between Asia and the Dutch Republic. In 2010, Robert Parthesius repeated Gaastra's conclusions, and again described relationships between VOC shipwrecks and storms. However, despite the research pursued by Bruijn, Gaastra,

¹² Leonard Blussé, "No Boats to China. The Dutch East India Company and the Changing Pattern of the China Sea Trade, 1635-1690." *Modern Asian Studies* 30:1 (1996): 52. M. van Rossum, "De intra-Aziatische vaart: Schepen, 'de Aziatische zeeman' en ondergang van de VOC?", *Tijdschrift voor Sociale en Economische Geschiedenis* 8:3 (2011): 32. Ryūto Shimada, *The Intra-Asian Trade in Japanese Copper by the Dutch East India Company During the Eighteenth Century*. (Leiden: Brill, 2006), 8. M. Vink, "'The World's Oldest Trade': Dutch Slavery and Slave Trade in the Indian Ocean in the Seventeenth Century." *Journal of World History* 14:2 (2003): 135.

¹³ These trends mirror broader developments in the scholarship of early modern European imperialism. Bhawan Ruangsilp, *Dutch East India Company Merchants at the Court of Ayutthaya: Dutch Perceptions of the Thai Kingdom, Ca. 1604-1765*. (Leiden: Brill, 2007), 21. J. S. Furnivall, *Netherlands India: A Study of Plural Economy*. (Cambridge: Cambridge University Press, 2010), 23. Andrade, "The Company's Chinese Pirates," 420.

¹⁴ Richard Grove has written perhaps the finest environmental histories of European commercial imperialism in Asian waters. Richard Grove, "Indigenous Knowledge and the Significance of South-West India for Portuguese and Dutch Constructions of Tropical Nature." *Modern Asian Studies* 30:1 (1996): 122.

¹⁵ Philip Lawson, *The East India Company: A History*. (Oxford: Routledge, 2014), 144.

Parthesius, and others, no study has yet connected the activities of the VOC to the climatic fluctuations of the Little Ice Age.¹⁶

This chapter begins by reconstructing how early modern climatic fluctuations, which influenced the frequency of storms in the North Sea region, ultimately affected VOC shipwrecks and mortality rates in the seventeenth and early eighteenth centuries. Correspondence written in Asia and Europe sheds new light on these relationships, but the most important sources are day registers that are here examined in unprecedented detail. Day registers, which survive in large quantities, provide abundant data regarding the major characteristics of Company journeys, but do not record the precise geographic location of vessels at sea, or the weather their crews experienced. However, such information is given by the hour in VOC ship logbooks. The chapter therefore continues by quantifying seventeenth- and eighteenth-century VOC logbook measurements of wind direction and daily distance travelled. Finally, the chapter concludes with a comprehensive re-examination of day register data in light of ship logbook observations that suggest a link between changing North Sea weather patterns and average VOC journey duration.

Climatic Shifts and Storms in VOC Correspondence and Day Registers

In 1610, VOC commander Hendrik Brouwer instructed his crew to avoid the then-typical course that passed by Madagascar and Mauritius to reach the spice islands of Indonesia. Instead, the mariners charted a route that crossed the breadth of the Indian Ocean from the Cape of Good Hope in southern Africa to the west coast of Australia, before curving north towards Indonesia.

¹⁶ Jaap R. Bruijn, "Between Batavia and the Cape: Shipping Patterns of the Dutch East India Company." *Journal of Southeast Asian Studies*, 11:2 (1980): 260. Gaastra, *The Dutch East India Company*, 114. Robert Parthesius, *Dutch Ships in Tropical Waters: The Development of the Dutch East India Company (VOC) Shipping Network in Asia 1595-1660*. Amsterdam: Amsterdam University Press, 2010), 52.

While superficially longer than the usual course to the Indies, this route avoided the contrary winds and storms of higher latitudes and instead harnessed the “roaring forties,” a persistent band of high-velocity westerlies at 40° S in the Indian and Atlantic Oceans. Consequently, Brouwer and his crew spent less time at sea, and in 1616 the Heren XVII approved his newly charted course as mandatory for all VOC vessels.¹⁷ After some experimentation, the course of ships from Europe to Asia was formally laid down in the Company’s “sailing orders.” VOC vessels were to sail through the English Channel or, in time of war, along “the back way” around Scotland and Ireland. From there, ships were instructed to bear south, passing west of the Bay of Biscay. After crossing the equator, captains followed a precisely marked *wagenspoor* (“cart track”) to avoid being drawn into the Gulf of Guinea to the east, or, to the west, into a collision course with ships travelling north. Subsequently, vessels were required to anchor at the Cape of Good Hope to resupply, and from there they would follow Brouwer’s route to Indonesia (Map 2.1).¹⁸

In the decades that immediately followed the establishment of the VOC, vessels departing for Asia were organized into two “fleets:” the Christmas Fleet, which ostensibly set sail in December, and the Easter Fleet, which generally departed around April. When the English Channel was at peace, these “fleets” were not convoys but, instead, isolated vessels that were part of a biannual exodus from many Dutch ports. If harbour ice permitted departure, outbound vessels in the Christmas Fleet were forced to brave conditions in the North Sea region that were stormy in both warmer and cooler climates, but provisioning and staffing the ships in early winter was easier than it would be in the spring. Moreover, vessels in the Christmas Fleet could arrive in the Indian Ocean just before the end of the summer monsoon, which was accompanied

¹⁷ Harm Stevens, *Dutch Enterprise and the VOC*, 9.

¹⁸ The risk of being shipwrecked on Australia’s western coast was real, but in the VOC’s history only six vessels were lost there. Gaastra, *The Dutch East India Company*, 114.

by winds that, in turn, facilitated travel from Batavia to the Company's other factories in Asia. After 1636, additional vessels were organized into a third, "Fairs," fleet, which departed in September and October and could more consistently harness the winds of the monsoon. By the eighteenth century, so many ships departed the Republic for Asia that the idea of separate fleets was obsolete.¹⁹

Logistics in Asia forced most vessels departing from Batavia to leave between November and January, and none of these ships ever arrived in Dutch ports later than November of the following winter. That was still too late for the Heren XVII, who organized the Company's autumn auction when all expected inbound vessels had arrived. Arrivals later than October required a second auction, which drove down prices, but despite repeated instructions from the Heren XVII to dispatch ships earlier in the year, changes to the rhythm of the Company's intra-Asian operations were never deemed feasible by the governors general of Batavia. Even in times of peace, the richly-laden VOC ships returning to the Republic were typically organized into convoys and, despite their substantial armament, awaited by escorting warships in the North Sea region.²⁰

For most outbound and inbound VOC vessels, the passage through the Northeastern Atlantic was the part of their journey that was most influential to its success or failure. As the VOC's power waxed in Asia, it was in the waters off Europe that VOC ships were most vulnerable to enemy action. Meanwhile, ice likely delayed outbound vessels in the harbours of England, Scandinavia, and the Dutch Republic, while storms were especially common in the

¹⁹ Gaastra, *The Dutch East India Company*, 111.

²⁰ *Generale missiven van gouverneurs-generaal en raden aan heren XVII der Verenigde Oostindische Compagnie*, Vol. 3, ed. W. P.H. Coolhaas. (The Hague: Martinus Nijhoff, 1980), 314. Pieter Van Dam, *Beschryvinge van de Oostindische Compagnie Vol. 3.*, ed. F. W. Stapel. (The Hague: Martinus Nijhoff, 1927; orig. 1701), 499. Femme Gaastra, *Bewind en beleid bij de VOC: de financiële en commerciële politiek bij de bewindhebbers, 1672-1702*. (Zutphen, 1989), 49.

seasons during which Company vessels typically arrived and departed. The North Sea lies in a zone between the Icelandic Low and Azores High where depressions normally move east and winds consequently blow overwhelmingly from the west, particularly during moderate or warm climatic regimes. However, ship logbooks, diary entries and correspondence have revealed that, in the North Sea region, the colder temperatures and more frequent storms of the Maunder Minimum were probably accompanied by a rise in the prevalence of easterly winds (Introduction, Chapter 4). Like storms, these easterlies were particularly frequent in the months when most Company vessels returned to or sailed from the Republic.²¹

Jaap Bruijn has employed VOC day register information to calculate that fewer than 3% of outbound and 5% of inbound VOC ships were lost due to storms or enemy action. However, that still amounted to 144 vessels, and the financial, material, and human toll of even a single shipwreck could be immense.²² In order to shed new light on these statistics, and the ways in which Company voyages may have been influenced by changes in prevailing weather, this chapter introduces ship journey reconstructions compiled from a more comprehensive analysis of 6,000 VOC day registers. Historians have developed databases that standardize register information, most notably through an initiative supported by the Huygens Institute for the History of the Netherlands. However, the interpreted data has not yet been analyzed to yield precise measurements of VOC journey duration or rate of completion. Indeed, the standardized results have not been interpreted using a rigorous methodology for removing insufficiently continuous or inadequately precise data. Accordingly, it has not been possible to reliably identify

²¹ Wheeler, "Understanding Seventeenth-Century Ships' Logbooks," 16. Wheeler et al., "Atmospheric circulation and storminess derived from Royal Navy logbooks," 13. Frank Siegmund and Corinna Schrum, "Decadal changes in the wind forcing over the North Sea." *Climate Research* 18:39-45 (2001): 44. Korevaar, *North Sea Climate*, 65. "Northeast England: Climate," Met Office, accessed February 2, 2013, <http://www.metoffice.gov.uk/climate/uk/ne>. "Eastern England: Climate," Met Office, accessed February 2, 2013, <http://www.metoffice.gov.uk/climate/uk/ee>. Bruijn, "Shipping Patterns of the Dutch East India Company," 261.

²² Bruijn, "The Dutch East India Company as Shipowner, 1602-1796," 134. Bruijn, "Shipping Patterns of the Dutch East India Company," 261. Parthesius, *Dutch Ships in Tropical Waters*, 52.

connections between VOC journey characteristics and the climatic trends that have been reconstructed with great detail for the northeastern Atlantic.²³

In this chapter, VOC day register information has been carefully filtered to yield information that is of value for historical climatologists. For example, statistics of total journey times presented in this chapter do not include data recorded for the rare vessels that did not journey along the approximate geography of the cart track, or for ships on voyages that were not described to the day. The statistics also exclude journeys of ships that remained in a particular location for longer than a few months, for reasons that were definitely or, in rare occasions, probably for purposes beyond resupply.²⁴

Far more problematic was the need to compensate for secondary ports visited by VOC ships sailing to or from Asia, which multiplied as the Company's reach lengthened in the course of the seventeenth century. Because of delays that accumulated when a ship lingered in or approached a port, secondary destinations could distort statistics measuring both journey times and rates of mortality. More importantly, the locations of secondary destinations did not always conform precisely to the geography of the cart track, undermining attempts to compare ship speeds and rates of journey completion along the same route. Consequently, statistics here compiled from day registers do not include journeys in which secondary destinations were visited, unless one of two conditions was met. First, the balance of evidence must suggest that meteorological conditions necessitated resupply or contributed to a delay at a secondary port, although this does not include cases where a vessel was forced to return to its port of origin

²³ Bruijn, "Shipping Patterns of the Dutch East India Company," 261.

²⁴ "Database VOC Schepen." *De VOC Site*, accessed 24 June, 2013, <http://www.vocsite.nl/schepen/lijst.html>. Bruijn, *Dutch Asiatic Shipping in the 17th and 18th Centuries*, 261.

before departing a second time.²⁵ Alternatively, the secondary destination must have been clearly positioned along the cart track, it must have been described with geographic precision, and, of course, the time spent at the secondary point must have been recorded to the day.²⁶ Ultimately, nearly 2,000 VOC outbound and inbound entries, dating from 1598 to 1709, remained after irrelevant or imprecise day register information was screened from this statistical analysis.

Only after 1625 did day registers record the number of shipwrecks and deaths on journeys from the Republic to the Cape, and along the whole length of the passage from the Republic to Asia. Despite the resulting omission of most of the Grindelwald Fluctuation, register data reveals that the average mortality rate was typically high aboard Dutch East Indiamen (Figure 2.2). This substantial death rate undermines Bruijn's claim that employment in the VOC was relatively safe, owing to the rarity of Company shipwrecks. In fact, for journeys departing Asia or the Republic, most registers describe several deaths in each week, and, often, each day of the passage. Many of these deaths were attributed either to disease or sailors falling overboard, and both of these conditions could be worsened by the trauma of a storm at sea. Not surprisingly, the destruction of a ship could lead to a surge in deaths, particularly when all hands were lost upon a lee shore. The rate of mortality recorded in day registers generally peaked sharply during years of abundant shipwrecks, and a significant portion of deaths occurred in the Atlantic Ocean,

²⁵ In such cases, the relationship between meteorological conditions and the return to port was too often unclear, and even when the meteorological stimulus was obvious at sea, delays after the return to port could rarely be convincingly linked to the influence of weather. For example, a leaky hull could force a return to port, yet the reasons for the leak were not always outlined explicitly in day registers. A storm could have stressed the hull and contributed to the leak, yet it was just one of a number of likely culprits.

²⁶ The secondary locations included within day register statistics: Ascension island; St. Helena; Sao Tiago; Cape Verde; São Tomé; Saldanha Bay; Sao Vincente; Sierra Leone; Isle of Wight; Falmouth; Portland; the Shetland Islands; Plymouth; Torbay; Mauritius (only for statistics of all outbound voyages, because Mauritius is roughly 1,000 kilometres outside of the Cart Track to Batavia but on the Cart Track to India); Tuticorin (again, off the Cart Track to Batavia but on the Cart Track for India from October to March); Ceylon (for Indian destinations along the Cart Track), Madagascar (again, for Indian destinations only); Cape Lopez; the Faeroe Islands; Annabon; Tercera; Rio Sester; Luanda and Cape Capus. The superficially vague destinations of Ireland, Dasseneiland and Norway were included because these really refer to specific ports that can be pinpointed with accuracy. The secondary destinations excluded from the day register statistics were England (far too vague); the Downs (similarly, too vague); St. Thomas; Sao Paulo; Bresont; Sumatra, and any Dutch port.

during voyages from the Republic to the Cape. Day registers, which did not mention daily weather, nonetheless explicitly described how storms stimulated many of the disasters that contributed heavily to increases in average mortality.²⁷

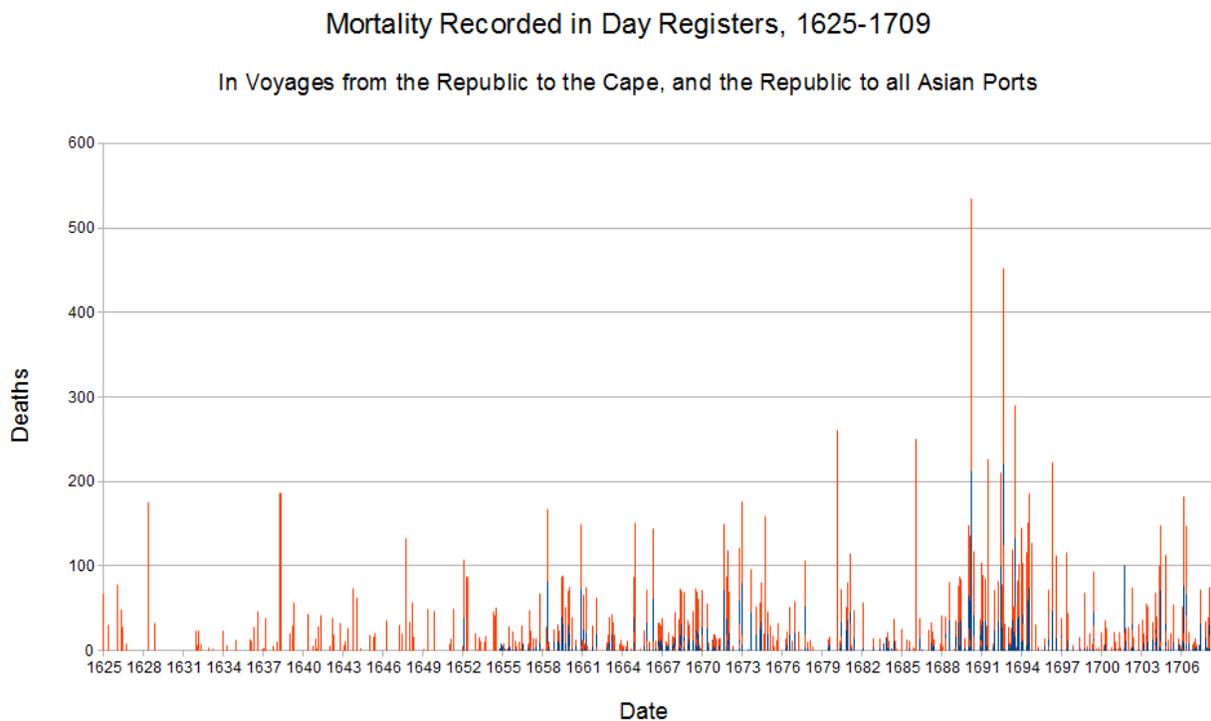


Fig. 2.2. Mortality recorded in day registers for vessels travelling from the Republic to the Cape (blue), and from the Republic to Asia (orange), 1625-1709.

Register data confirm that failed journeys accounted for only a small percentage of total voyages from the Republic to the Indian Ocean, although such catastrophes could be tremendously costly. However, the registers also reveal that failed journeys, usually owing to shipwreck, were significantly more common during the minima of the Little Ice Age than they were during the period's relative maxima (Figure 2.3). More than half of these wrecks occurred in the North Sea region. Disasters at sea peaked during the last years of the Grindelwald

²⁷ "Database VOC Schepen." *De VOC Site*. Bruijn, *Dutch Asiatic Shipping in the 17th and 18th Centuries*. Bruijn, "Shipping Patterns of the Dutch East India Company," 261.

Fluctuation in the late 1620s, the first decades of the Maunder Minimum in the 1660s and 70s, and in particular during the early 1690s. The sharp decline in shipwrecks during the rapid growth of the VOC in the 1630s and especially the 40s demonstrates that the rise in wrecks later in the decade was not merely a product of the Company's expansion.²⁸

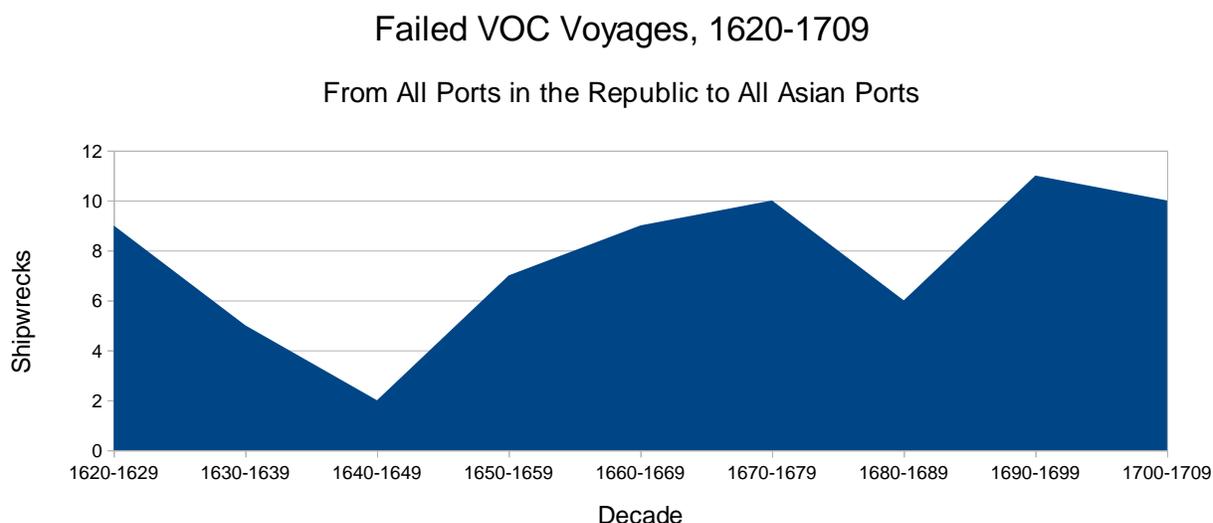


Fig. 2.3. Uncompleted VOC voyages, usually owing to shipwreck, in day registers describing traffic from the Republic to Asia, 1620-1709.

Letters sent to the Heren XVII from the Company's leadership in Batavia abound with reports of storms, which often necessitated costly repairs. The Huygens Institute has compiled the abundant letters from Batavia into thirteen published volumes, each containing material written in approximately one or two decades. The correspondence of the Company's leading merchants and politicians is often continuous, reliable, and consequently relevant for historical climatology. In letters written from 1610 to 1638 and published within the first volume, storms

²⁸ Outbound statistics are used here because a greater portion of day registers describing outbound journeys from all ports in the Republic to all ports in Asia were sufficiently precise to be included in these statistics. Moreover, inbound voyages were similarly affected by the kind of catastrophic storms that ended, rather than accelerated or delayed, ship voyages. "Database VOC Schepen." *De VOC Site*. Bruijn, *Dutch Asiatic Shipping in the 17th and 18th Centuries*. Bruijn, "Shipping Patterns of the Dutch East India Company," 261.

were discussed, on average, once every 2.3 pages (Figure 2.4). Spanning nearly thirty years, the period incorporates the late Grindelwald Fluctuation together with the warmer and, in some regions, more tranquil decade that followed. Average annual references to storms increased slightly in subsequent decades before rising sharply in the decade between 1675 and 1685. However, average yearly storm references fell significantly in the final decade of the seventeenth century, before increasing to their highest recorded level during the late Maunder Minimum. Storms were mentioned in 46 letters written between 1713 and 1724, but thereafter storms were mentioned in only four letters written from 1725 to 1737.²⁹

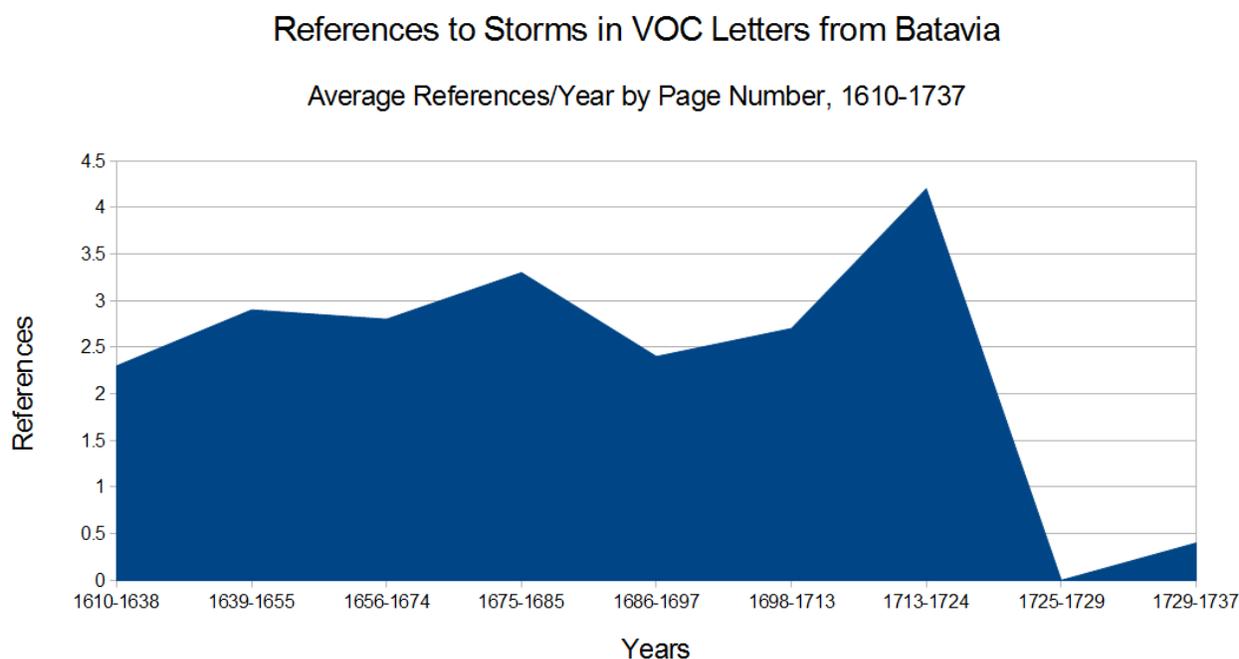


Fig. 2.4. Page numbers per year in which storms were mentioned within VOC correspondence sent from Batavia to Amsterdam. Page numbers were taken from nine volumes published by the Huygens Institute for the History of the Netherlands. Each volume covers between four and 18 years.

A quantitative analysis of storm references in letters sent from Batavia inevitably reduces a qualitative diversity of meteorological information to produce simplified statistics. Not all of

²⁹ *Generale missiven van gouverneurs-generaal en raden aan heren XVII, Volumes 1-9*, ed. Coolhaas.

the storms described by the governors general and councils in Batavia affected vessels in the Atlantic Ocean, nor did all beset East Indiamen sailing to or from the Republic. Storms that caused minor damage generally escaped mention, especially when that damage could be repaired at a port along the cart track. Still, references to storms in letters from Batavia do seem to have increased during the Maunder Minimum, despite a puzzling decline in the last years of the seventeenth century, when shipwrecks and mortality both increased sharply. That reduction in storm references may have been caused by a decline in descriptions of violent weather in Asia, which was naturally affected differently by contemporary climatic fluctuation than the northeastern Atlantic. However, because so many VOC shipwrecks occurred in the North Sea and northeastern Atlantic, storm references in letters were probably strongly influenced by the frequency and severity of gales in that region. Consequently, they were generally more abundant during the Maunder Minimum.³⁰

At the other pole of the VOC's trading empire, many East Indiamen were too large to enter Amsterdam's shallow harbour without the assistance of tugboats and external floatation tanks called "camels." Accordingly, most East Indiamen loaded and unloaded at Texel. Correspondence and diaries written within the Dutch Republic reveal that shipwrecks off Texel were more common during the Maunder Minimum than they were before or after, despite the presence of significant statistical outliers (Figure 2.5). Most of these shipwrecks were stimulated by storms, yet very few were attributed to Company East Indiamen. In 1625 the VOC vessel *Alkmaar* was destroyed in a gale near Texel, and in 1639 two VOC ships sunk off the same island, of which one was an East Indiaman. Another Company vessel was lost in the following year, while the *Lelie*, an East Indiaman, foundered in 1654. Other wrecks in subsequent decades were part of convoys and some were bound to Asia, but in surviving sources none of these lost

³⁰ *Generale missiven van gouverneurs-generaal en raden aan heren XVII, Volumes 1-9*, ed. Coolhaas.

vessels was explicitly assigned to the VOC. Of course, company ships did sink along the cart track, and many foundered in the northeastern Atlantic. Both shipwrecks and average journey mortality accordingly increased during the Maunder Minimum and decreased thereafter. The loss of an East Indiaman, rare even during the nadir of the Maunder Minimum, was far more costly in lives and wealth than the calamities that befell flutes and other smaller ships. Nevertheless, a statistical analysis of day registers, diaries, and correspondence suggests that the seaworthy East Indiamen could usually survive all but the most severe gales.³¹

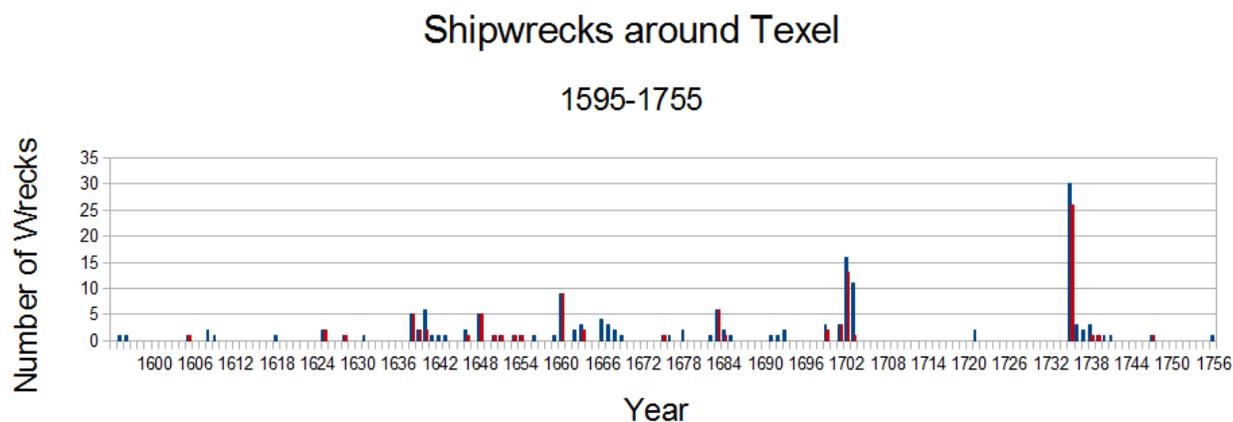


Fig. 2.5. Total shipwrecks (blue) and shipwrecks during storms (red) recorded off Texel between 1595 and 1756.

Of course, correspondence sent during the Maunder Minimum can also offer qualitative insights into relationships between VOC voyages and the intermingled influences of increased easterly winds and more frequent storms during the Maunder Minimum in the Northeastern Atlantic. On 20 April 1671, Adriaen van der Goes informed his brother that four French East Indiamen were ruined in a storm shortly after leaving port. Eight years earlier, Van der Goes had described how four ships, these belonging to the VOC, were sunk in a storm off the coast of Madagascar. Both disasters likely occurred near a lee shore. For much of their voyages, however,

³¹ “Wrecks in Documents.” *Maritiem programma Nederland, Rijksdienst voor het Cultureel Erfgoed*. Accessed 24 June 2013, http://www.maritiemprogramma.nl/WID_00.htm. Parthesius, *Dutch Ships in Tropical Waters*, 52.

East Indiamen sailed in deep water, far from the coast, and when provided with space to maneuver the large, seaworthy vessels were rarely sunk by gales.³²

In January and February 1707, grand pensionary Anthonie Heinsius received a series of letters from another Van der Goes aboard the vessel *De Beschermmer* (“The Protector”). Between 1702 and 1720, Heinsius received thousands of letters from Dutch officials across Europe, and Van der Goes was one of these men.³³ On 6 January, Van der Goes reported that his vessel had been delayed for two weeks off the port of Goeree in southern Holland, owing to westerly winds.³⁴ Given the Republic’s participation in the War of the Spanish Succession, when Van der Goes finally set sail his vessel quickly joined other ships passing through the English Channel. On 27 January *De Beschermmer* was off Portsmouth, a port in southern England that was on an arm of the Channel. However, its voyage was again postponed when westerly winds in the Downs, a roadstead on the east coast of England, slowed the arrival of the rest of its convoy from Texel. Shortly thereafter Van der Goes and his crew were anchored near St. Helens, off the south coast of England, to await the long-expected convoy, yet hard, southwesterly winds soon forced *De Beschermmer* back to Portland. Despite the disruptive westerlies, Van der Goes actually recorded an unusual abundance of easterlies in January, and he insisted that he could have harnessed these to be at Lisbon on 27 January, had he not been detained by convoy duty.³⁵ Van

³² Adriaen van der Goes, “Hage, den 30 Maert 1663,” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, C.J. Gonnet (ed). (Amsterdam: Johannes Müller, 1899), 179. Van der Goes, “Hage, den xx April 1671,” *Briefwisseling tusschen de gebroeders van der Goes*, 203.

³³ In total, Heinsius sent and received some 24,000 letters! “De briefwisseling van Anthonie Heinsius 1702-1720.” Accessed March 8 2014, <http://resources.huygens.knaw.nl/heinsiusrepublicpoliticswarfinance>.

³⁴ Van der Goes reported “contrary” winds, but given the geography of Goeree in relation to the Channel these likely blew from the west. Van der Goes, “Van VAN DER GOES, 6 januari 1707.” *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VI: 1707.* A.J. Venendaal Jr. (ed), (’s-Gravenhage: Martinus Mijhoff, 1984), 9.

³⁵ “Indien ick hadde moge doorzeyle, ick twijfele niet of soude Lissebon hebbe bereyckyt met de oostewindt wearmede van voor de Goeree ben vertrocke den 2 deeser en tot den 12en heeft gewaeyt.” Van der Goes, “Van VAN DER GOES, 27 januari 1707.” *De Briefwisseling van Anthonie Heinsius*, 45.

der Goes wrote that he hoped for a resumption of easterly winds, as the convoying ships from the Admiralty of West Friesland were not provisioned for more than six months.³⁶

In fact, the ships from Texel arrived off St. Helens on the day after Van der Goes sent his letter, and with them returned the easterlies of previous weeks. In a letter sent on 10 February, Van der Goes reported that the convoy made good progress for two days following its long-awaited union. Thereafter, however, three days of still conditions slowed the fleet until a ferocious gale brought with it rain, snow, and a driving wind from the south. Most of the convoy had been scattered, and with a resumption of hard, westerly winds many ships were blown back to Portland and Portsmouth. Much of the fleet was slowly reassembled, despite lingering rain, hail, and hard winds, but several ships suffered severe damage to masts and rigging. In the immediate aftermath of the storm, only the warships and East Indiamen escaped dispersion, and their likely participation in the subsequent reconstitution of the fleet suggests that they suffered only minimal damage.³⁷

The letters sent by Van der Goes demonstrate the complexity of the relationship between outbound VOC ship voyages and weather typical of the Maunder Minimum in the North Sea region. Van der Goes explicitly explained that easterly winds quickened southbound voyages in the Northeastern Atlantic, but his reports of problematic westerlies underscore yet again that the seemingly random variability of weather must be considered in any analysis of climate as a structure capable of affecting human activity over both the short and longue durée. Moreover, the potential benefits of persistent easterlies were squandered because military necessities, stimulated by political imperatives and shaped by the agency of individual mariners, merchants, and politicians, forced Van der Goes to await a fleet from Texel. A spate of westerlies further

³⁶ Van der Goes, "Van VAN DER GOES, 27 januari 1707." *De Briefwisseling van Anthonie Heinsius*, 46.

³⁷ Van der Goes, "Van VAN DER GOES, 10 februari 1707." *De Briefwisseling van Anthonie Heinsius*, 71.

delayed the second half of the convoy until the advantageous weather had long since passed. The influence of the storm was similarly complex. As the convoy sailed far from a lee shore, few ships were lost, and indeed the seaworthy East Indiamen were apparently more resilient to hard winds than the smaller merchantmen that accompanied them. Nonetheless, the gale compounded delays caused by convoy requirements and westerly winds, not only because it scattered the fleet, but because its southerly winds blew many smaller flutes north, towards ports they had departed days earlier. An intercepting enemy armada would have likely suffered similar damage and dispersal, yet, given the limited supplies carried aboard the convoying warships, the gale not only slowed but imperiled the progress of the VOC vessels. Ultimately, complex human and environmental influences mediated the destructiveness of storms for crews aboard East Indiamen. Overall, the course and seaworthiness of these large vessels meant that they were rarely wrecked by storms. Nevertheless, in the North Sea region such disasters, and accompanying rates of mortality, were more common during the frequent and severe gales that accompanied the Maunder Minimum.

Changes in Prevailing Wind and Storm Frequency Reflected in VOC Ship Logbooks

Ship logbooks can provide further insight into relationships between VOC voyages and the meteorological expressions of Little Ice Age climatic oscillations in the Northeastern Atlantic. Logs compiled aboard VOC ships described weather events at sea on most days of a vessel's voyage. By contrast, letters were rarely sent directly from Company ships at sea. The few that were written at sea typically supplement correspondence from warships during naval operations, and are hardly representative of conditions experienced in typical VOC journeys. The

value of logbooks for reconstructing past weather is a reflection of both the strengths and limitations of nautical technology in the seventeenth and eighteenth centuries. The invention of the octant and the sextant meant that after the mid-seventeenth century latitude could be judged with reasonable accuracy, yet longitude was another matter. Until 1767, longitude was calculated by “dead reckoning,” a technique that incorporated the ship’s speed, measured by log-line, and its course, determined by compass. Corrections were made upon encountering landmarks of known longitude. In a vacuum these variables would have been sufficient to determine a vessel’s position, but a further correction was necessary to account for leeway in the ship’s course, in which the most important influence was wind. Estimating the effect exerted by wind intensity and direction was a mathematically sophisticated but inexact science; nevertheless, the safety of the ship depended on it. Consequently, the relatively continuous, detailed observations in logbooks usually recorded more, and more precise, meteorological data than was provided within day registers or correspondence (Figure 2.6).³⁸

³⁸ Wheeler, “British Naval Logbooks from the Late Seventeenth Century,” 136.

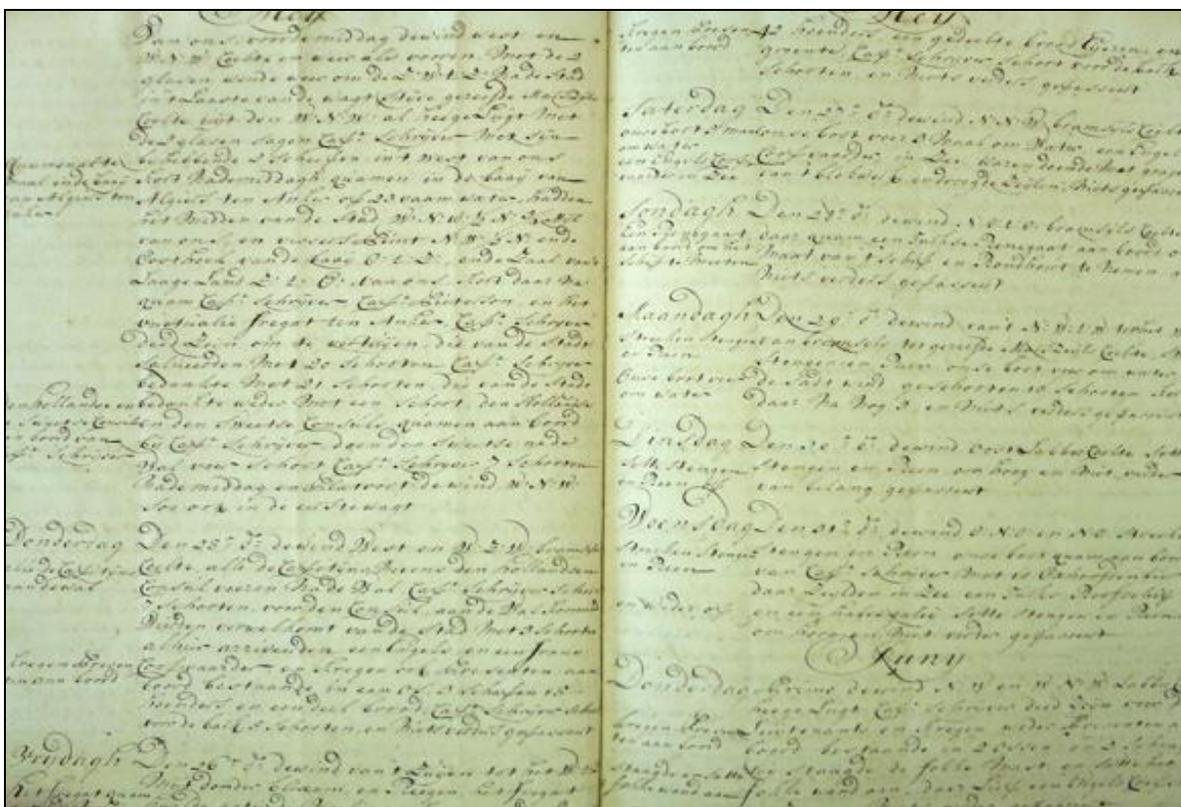


Fig. 2.6. An example of a Dutch ship logbook kept, featuring a particularly clear script. Jan Liefing, “Journaal Gehouden op 's Landschip Matenes, onder bevel van den kapitein J. Liefing, gedurende zijn reis naar de Middellandsche zee en de kust van Marokko. 1730 Maart 14 - 1730 October 27.” Admiralteitscolleges, 1586-1795. Reference code: 1.02.46, Inventory number: 1134, Nationaal Archief (The Hague, Netherlands).

The earliest logbook that chronicled a voyage to Asia while recording weather in the Atlantic provides an account of a journey undertaken in 1601, by three vessels under the command of Joris van Spilberghen. Financed by De Moucheron, the expedition just predated the establishment of the VOC, and its mariners were first among the sailors of the Republic to arrive at the wealthy island of Ceylon, modern-day Sri Lanka and later a major Dutch possession. On 5 May, the vessels under Spilberghen departed Zeeland with a favourable north-easterly wind, yet four days later a southerly storm forced the expedition into the haven of Dartmouth. According to the ship logbook, one of the ships had sprung a leak in the storm, and salt water flooded its reserves of bread. New provisions were brought aboard as the fleet waited for the wind to

subside, but it was not until 15 May that the vessels could leave port. The expedition passed Plymouth that evening, and as no further setbacks hampered its voyage in the Northeastern Atlantic the logbook omits any account of the succeeding weeks, until the fleet's arrival at Cape Verde off the western coast of Africa on 10 June.³⁹

The report of the expedition to Ceylon confirms that easterly winds were beneficial to ships sailing south from the Republic, and suggests, like the letters sent to Heinsius, that storms could delay, if not necessarily imperil, the largest merchantmen bound for Asia. Still, although the logbook provides examples of the potential consequences of weather rendered more likely during Little Ice Age minima, its fragmentary account is not as continuous as surviving logbooks that document later voyages to Asia. For example, the logs kept aboard the *Wapen van Hoorn* ("Coat of Arms of Hoorn") in 1627 recorded daily distance travelled and morning wind direction on virtually every day from the ship's departure from the Republic on 19 March until its arrival at Cape Verde on 12 April.⁴⁰ Written in one of the final years of the Grindelwald Fluctuation, fully 82% of the logbook's morning measurements described some variation of easterly winds, while winds that blew from the west were described in just 9% of observations. By contrast, westerlies in the Channel prevail today in all months, and would be expected in 60% of entries. Nevertheless, although conditions similar to those that influenced a surge in easterlies in the late-seventeenth century likely prevailed during the first minimum of the Little Ice Age, increased easterly winds cannot yet be linked to Grindelwald Fluctuation. Moreover, beyond the English Channel the southward extent of the shift in the frequency of easterlies that accompanied the

³⁹ "'T historiae journal, van tgene ghpaseert is van whegen dry schepen, ghenamt den Ram, Schaep ende het Lam, ghevaren wt zeelandt vander stad Camp-Vere naar d'Oost-Indiën, onder t'beleyt van Joris van Spilberghen, Generael anno 1601," in *De reis van Joris van Spilbergen naar Ceylon, Atjeh en Bantam 1601-1604*. (S'Gravenhage: Martinus Nijhoff, 1933), 1. R. Rajpal Kumar De Silva, *Illustrations and Views of Dutch Ceylon 1602-1796: A Comprehensive Work of Pictorial Reference with Selected Eye-Witness Accounts*. (Brill Archive, 1988), 20.

⁴⁰ In many ship logbooks, morning entries were more continuous and, for meteorological data, more detailed than evening entries.

later Maunder Minimum remains uncertain. Still, although the logbook of the *Wapen van Hoorn* did not record wind velocity, its observations nevertheless suggest that easterlies, and particularly north-easterly winds, could accelerate the speed of a vessel travelling south from the Republic (Figure 2.7). On days accompanied by some deviation of easterly wind, the *Wapen van Hoorn* travelled, on average, 29.4 German Miles (roughly 220 kilometres) per day, while in the few days marked by westerlies the ship covered just 22.5 German Miles (approximately 169 kilometres).⁴¹

Wapen van Hoorn, 1627

Daily Distance Covered and Wind Directions, 20 March - 11 April

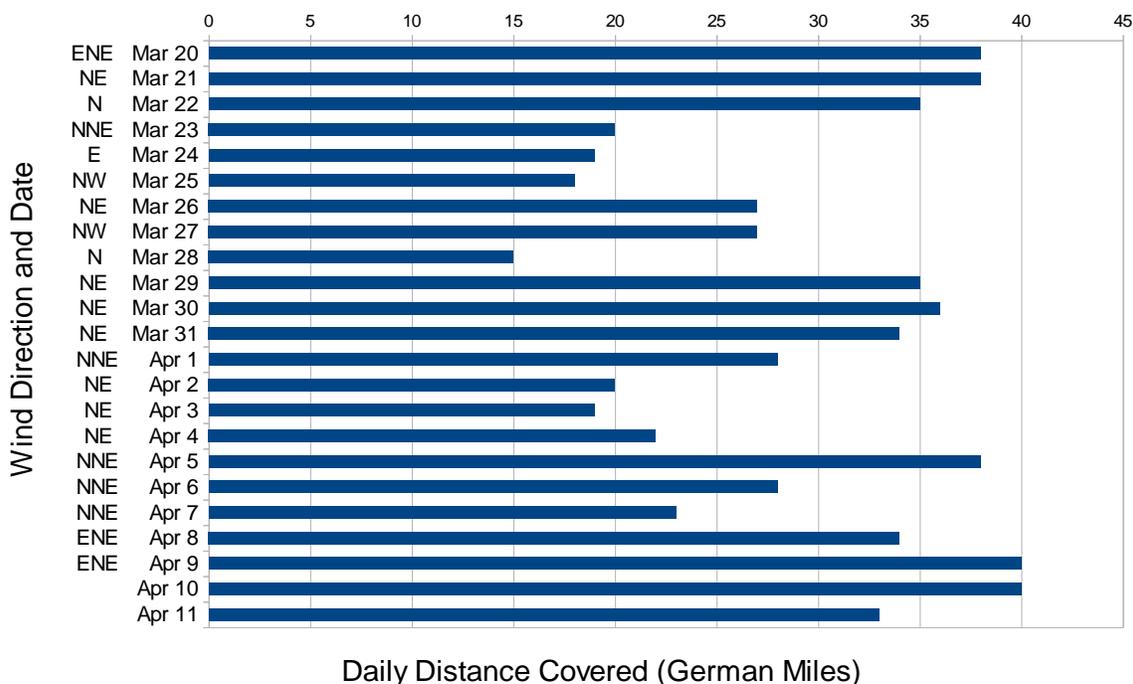
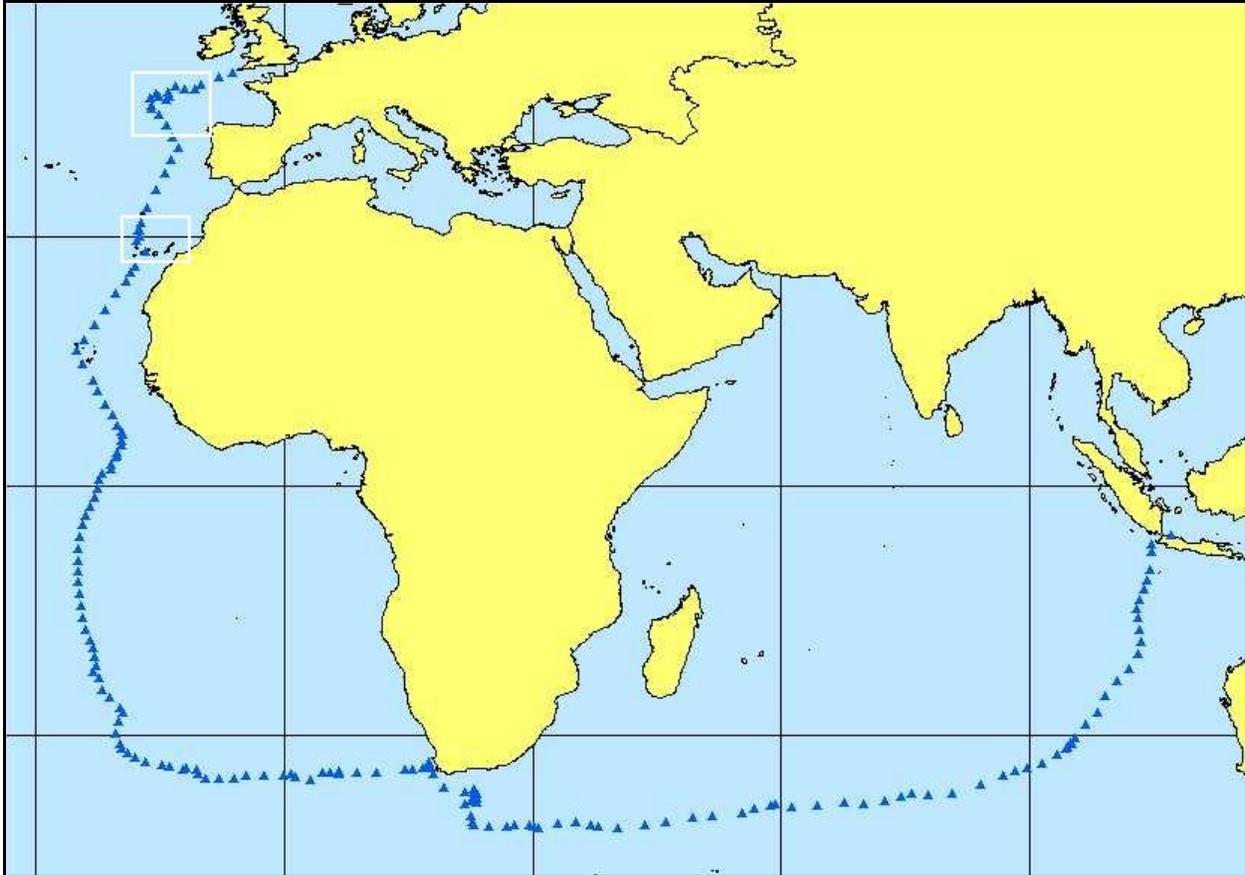


Fig. 2.7. Daily distance covered, in German miles, and morning observations of wind direction in the first 24 days of the voyage of the *Wapen van Hoorn*. In the X Axis, an E refers to an easterly, a W to a westerly, an N to a northerly, and an S to a southerly. “NNE” therefore refers to a wind issuing from the north-northeast. An early modern measurement, a German mile was equivalent to 7532.5 metres in the modern metric scale. Omitted values correspond to gaps in ship logbook measurement.

⁴¹ “Journal vant schip Wapen van Hoorn op sijn 3de voyagie . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands).

Few sufficiently continuous ship logbooks survive to document meteorological conditions in the Northeastern Atlantic in the slightly warmer decades that interrupted the nadir of the Little Ice Age. In the first year of the Maunder Minimum, however, a particularly large East Indiaman left Rotterdam for Batavia, and its *opperstuurman* or navigator, Gerritszoon Boos, kept a meticulous log of its voyage.⁴² Although the hulking *Maarseveen* departed Rotterdam on 9 October 1662, the first entry in its logbook was written six days later, after the southbound ship had already cleared the English Channel. The first day of the vessel's voyage was fairly typical of conditions experienced during the following two weeks. The prevailing winds were not only calm, but also, by blowing from the south, were generally contrary to the course desired by the ship's navigator and captain. By 23 October the wind had shifted to the Southwest – directly contrary to the ship's intended course – and on 24 October the breeze nearly ceased altogether. That day the ship moved a mere 0.25 German miles – a remarkably low number – and when the wind returned on 25 October it again blew from the southwest. For the 14 days from the start of the voyage until 29 October the *Maarseveen* travelled just 162 German Miles, or 11.6 for the average day. This signifies a lengthy delay considering that the average distance travelled by the *Maarseveen* in its first 1.5 months (two weeks in October and the whole of November) was 18.3 German miles. Nor did the vessel travel in a straight (if slower) line during its first two weeks. Instead, the *Maarseveen* dithered near the Celtic Sea, a delay likely caused by contrary winds that not only slowed forward progress but were too calm to tack against (Map 2.2).

⁴² Herman Ketting, *Leven, werk en rebellie aan boord van Oost-Indiëvaarders (1595-±1650)*. (Amsterdam: Het Spinhuis, 2005), 57.



Map 2.2. Journey of the *Maarseveen*. Blue triangles reflect where each entry in the logbook of the *Maarseveen* was written during the ship's journey to Batavia in 1662. Delays in the vessel's passage through the Northeastern Atlantic are highlighted. "Cliwoc Data Position Plots: Maarseveen (CLIWOC Meta Data)." Accessed 24 June 2013, http://www.knmi.nl/cliwoc/cliwocmeta_maarseveen.htm.

On 29 October the southwesterly winds stiffened, and over the course of the day the *Maarseveen* tacked against them to travel 19 German miles. On the following day the *Maarseveen* travelled 21 German miles, now bearing east towards the Canary Islands, and the course outlined in the VOC's Sailing Orders. On 2 November the ship passed west of Lisbon, and now, for the first time, the wind blew from the North. The *Maarseveen* accelerated, covering 27 German miles on 3 November and 33 for the next two days as winds continued to originate from the North-east. By 6 November, the vessel had travelled 226.5 German miles since its delay ended on October 29, averaging some 25.2 German miles for every day. In just seven days of

favourable weather, the ship had covered 33% more miles than it had in its first two weeks, and these were all in the right direction.⁴³

As it closed on the Canary Islands on 7 November 1662, the *Maarseveen* entered another stretch of troublesome weather. On the 7th and 8th winds remained favourable from the North, but now also blew from the west, while their velocity declined dramatically. In calm conditions on 8 November and most of 9 November, the ship travelled only 5 German miles, although the light breeze gradually shifted to issue from the southwest. On 10 November the *Maarseveen* journeyed only 9 German miles, and winds originated from the west-southwest. On 11 November the winds turned again, now blowing favourably from the Northeast, but all indications are that, with the notable exception of 13 November, the wind's strength remained weak. By 15 November the vessel was in the middle of the Canary Islands, but in the eight days since 7 November it had travelled a mere 112.5 German miles, averaging just 12.5 German miles a day. Once again calm, contrary winds had taken their toll.⁴⁴

One month after the *Maarseveen*'s first recorded log the ship's pace quickened once more, as strong winds from the Northeast propelled the vessel down through the cart track and towards the equator. The journey slowed again beginning on November 26; in fact, on 2 December the wind was "*doodstil*" – dead calm – while the ship remained virtually stationary. Overall, from 15 October to 30 November the *Maarseveen* travelled over 840 German miles, approximately 6,300 kilometres, from the mouth of the English Channel to a position just west of Guinea. The ship's progress confirms that changes in the direction and velocity of wind were the most important influences on the course and speed of a seventeenth-century vessel. When the

⁴³ Gerritsz Boos, *Maarseveen* logs, records 69243 – 69251, 29 October – 6 November. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

⁴⁴ *Ibid.* Logs from other vessels indicate the *Maarseveen* was not required to slow down as it passed through the Canary Islands.

wind was high and blew from the north, east, or especially the northeast, the *Maarseveen* could travel over thirty times faster than it did in weak and contrary winds from the southwest (Figure 2.8). Easterly winds were likely more common in the North Sea region during the Maunder Minimum, and indeed Gerritszoon Boos observed especially plentiful easterlies in the first weeks of his journey. The frequency of easterlies may have also increased south of the North Sea region, although the logbook of the *Maarseveen* recorded relatively few easterlies after the vessel sailed beyond 46°N, a latitude parallel to the southern coast of France. Overall, Boos described easterlies in 57% of his morning logbook entries, while descriptions of westerly winds accompanied the other 43% of morning meteorological observations.⁴⁵

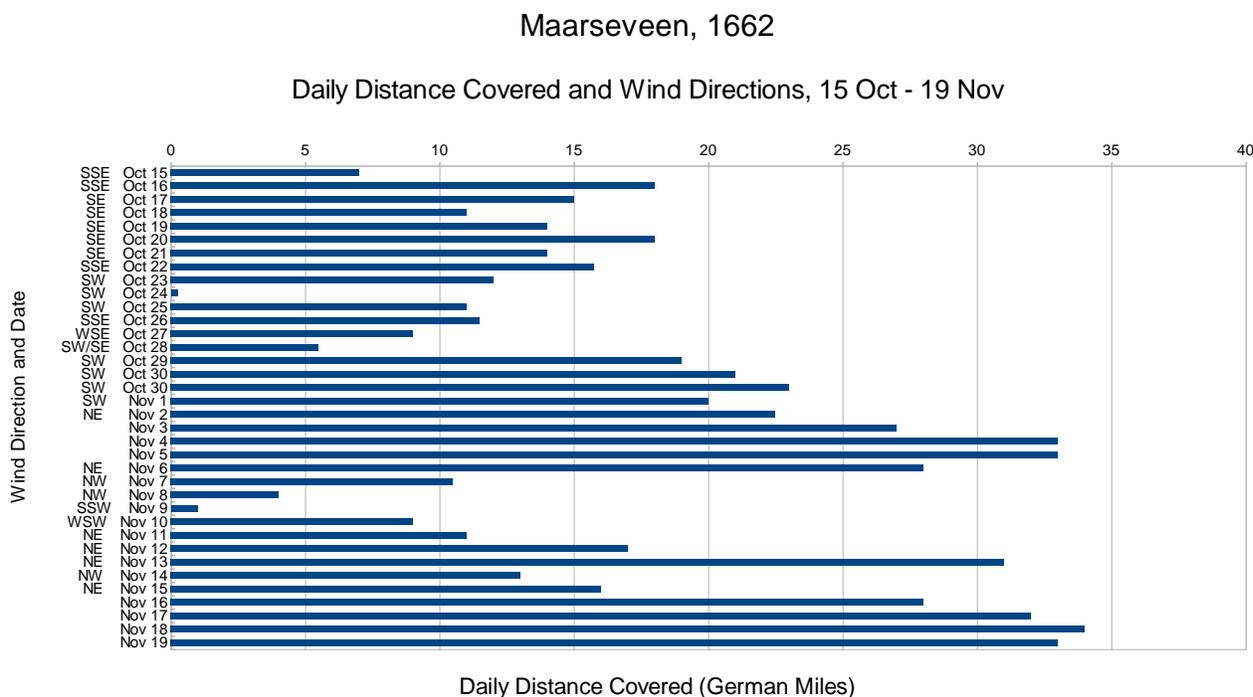
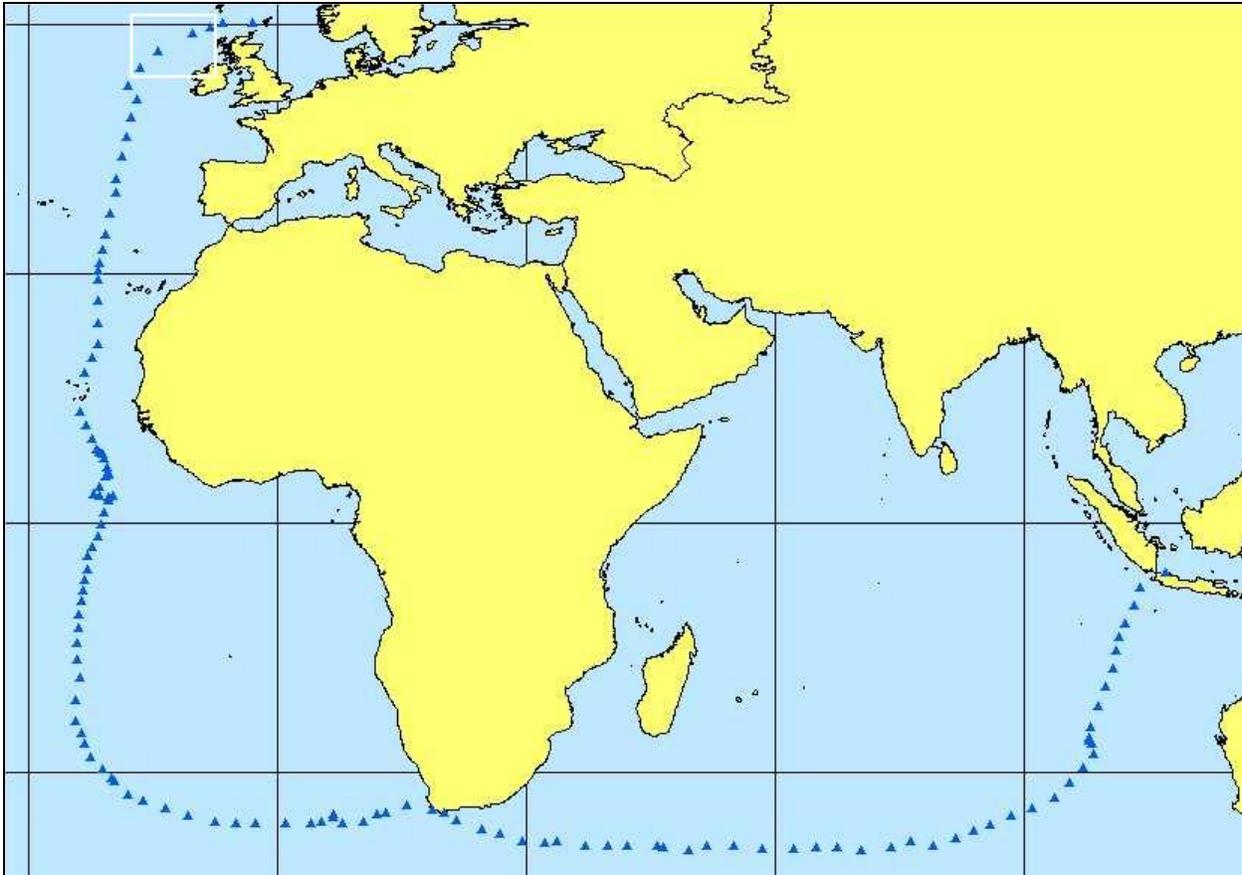


Fig. 2.8. Daily distance covered, in German miles, and daily observations of wind direction in the first 36 days of the voyage of the *Maarseveen*.

⁴⁵ Gerritsz Boos, *Maarseveen* logs, records 69261 – 69277, 16 November – 2 December. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

Fifteen years after the *Maarseveen* left port, a vessel of similar size departed Texel for Batavia. The *Maarseveen* was lost in battle shortly after returning from Asia, but in 1662 it had set sail while the Republic was at peace. The *Afrika*, however, embarked on its journey on 12 April 1677, in the final year of a long conflict between the Republic and France. Consequently it travelled in convoy along the “back way” north of Scotland and Ireland, which lengthened its voyage to Batavia by approximately 2,000 kilometres. Like logbooks kept by other officers, the log of *opperstuurman* Adriaen Jongekoe did not record estimated longitude in the vicinity of familiar landmarks, but his observations of latitude nevertheless reflect the *Afrika*'s progress through the North Sea in the first ten days of its journey. Moreover, Jongekoe faithfully described meteorological conditions during this period, and his measurements reveal that the convoy experienced winds from the east or southeast on 70% of days before a longitude was recorded.⁴⁶

⁴⁶ Adriaen Jongekoe, *Afrika* logs, records 11248 – 11257, 12 April – 21 April. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.



Map 2.3. Journey of the *Afrika*. Blue triangles reflect where each entry in the logbook of the *Afrika* was written during the ship's journey to Batavia in 1677. The rapid progress made during the storm of April 25-26 is highlighted. The first ten days of the *Afrika*'s journey are omitted from this map, owing to the absence of longitude measurements given in the ship's logbook. "Cliwoc Data Position Plots: Afrika (CLIWOC Meta Data)." Accessed 24 June 2013, http://www.knmi.nl/cliwoc/cliwocmeta_afrika.htm.

On 21 April, Jongekoe's first measurement of longitude placed his vessel off the northern coast of Scotland, where it sailed in a north-easterly wind (Map 2.3). In the course of the following day, the *Afrika* crossed an impressive 28 German miles, powered by strong winds from the north-northeast. However, on 23 April the *Afrika* covered just 11 German miles in a contrary if variable wind from the west-southwest. The wind shifted again to blow from the southeast for much of 24 April, and by evening it had stiffened while veering to issue from the east-northeast. The *Afrika* crossed 20 German miles in the favourable wind, but strong gusts soon strengthened into a ferocious gale. The storm raged throughout the next day, but the logbook of the *Afrika*,

rather than describing damage and mortality, instead recorded that favourable winds from the northeast propelled the vessel a remarkable 46 German miles, or nearly 350 kilometres, to the west. On 25 April the *Afrika* traversed over four degrees of longitude, and covered more distance in a day than any East Indiaman examined in this chapter. On 26 April strong winds continued to blow from the north, and although the storm had mostly subsided the *Afrika* nevertheless travelled 34 German miles on the day. Overall, for the sixteen days in April during which the distance travelled was either recorded or decipherable the *Afrika* crossed a total of 375 German miles, averaging a swift 23.4 miles every day. In just over two weeks the ship had avoided the peril of French interception and covered nearly 3,000 kilometres to reach 46.3 °N 18.3 °W, west of Porto, Portugal, on 30 April.⁴⁷

Jongekoe described easterly winds in 68% of his morning logbook entries, yet the first leg of the *Afrika*'s journey was perhaps most significantly influenced by a storm that strengthened favourable winds from the northeast for at least three days. Gales and easterly winds were more common in the North Sea region during the Maunder Minimum than they were before or after. Moreover, Hubert Lamb has also suggested that a regional rise in the frequency of severe storms with winds from the north may have accompanied the late Little Ice Age. According to Lamb, of ten catastrophic North Sea storms between 1703 and 1860, nearly half blew from the north. By contrast, Lamb's analysis indicated that, from 1860 to 1989, northerly winds accompanied just 23% of severe storms. Lamb's sample size was small, and his methodology was, at times, hampered by an uncritical consideration of documentary evidence. Nevertheless, it is possible that the meteorological conditions experienced by the mariners aboard the *Afrika* in the first leg of its journey were precisely those rendered more frequent in the

⁴⁷ Adriaen Jongekoe, *Afrika* logs, records 11248 – 11266, 12 April – 30 April. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>. Unger, "Introduction," in *Cogs, Caravels and Galleons*, 27.

colder decades of the Maunder Minimum. The easterly wind and north-easterly storm, in turn, greatly accelerated the vessel's voyage. Despite its 2,000-kilometre detour, the *Afrika* reached the relatively southerly latitude of 46°N in precisely half the time of the *Maarseveen*, which was itself engaged in a relatively quick journey (Figure 2.9). Moreover, despite its ferocity the gale of 25 April did not seem to have severely damaged or, indeed, imperilled the *Afrika*. The ship was far from shore, and although the wind direction of the storm was fortuitous, it was unlikely that any gale could expose the vessel to a lee shore. Several men fell overboard and drowned during the first weeks of the ship's voyage, but such tragedies were hardly unusual during a voyage to Asia.⁴⁸

⁴⁸ Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 30.

Afrika, 1677

Daily Distance Covered and Wind Directions, 13 April - 30 April

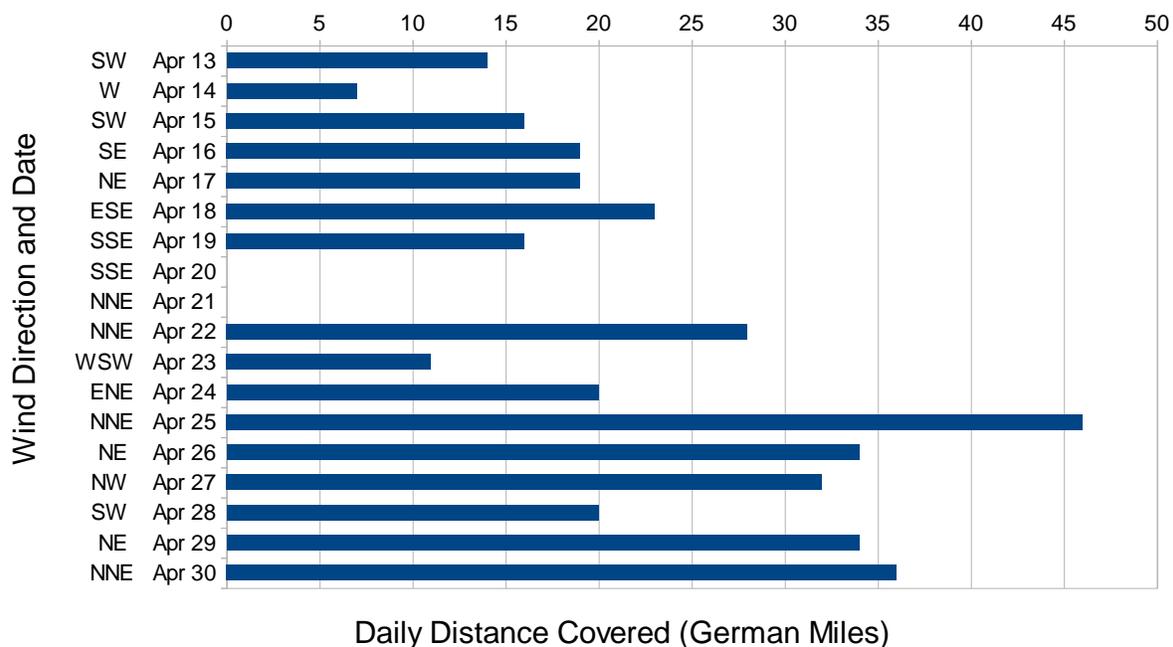


Fig 2.9. Daily distance covered, in German miles, and daily observations of wind direction in the first 18 days of the voyage of the *Afrika*. The influence of the storm of 25 April is clearly demonstrated.

The influence of more common easterlies was reflected with particular clarity in logbooks kept aboard two East Indiamen that sailed through the northeastern Atlantic during the nadir of the Maunder Minimum. The *Vosmaar* left Wielingen in convoy on 26 April 1696, and although it was a large East Indiaman, at 800 tons burden it could carry 400 tons less than the *Maarseveen*. Meanwhile, with a comparatively light carrying capacity of 200 tons, the *Boor* left Texel on 17 July 1699. The *Vosmaar* departed in a season that in the warmer twentieth-century climate is marked by relatively abundant easterlies, and its logbook records easterly winds on 34% of morning entries written in the Atlantic north of 40° N. Consequently, easterlies were slightly more common during the voyage of the *Vosmaar* than their annual average in the

twentieth-century climate.⁴⁹ However, during the first eighteen days of the journey of the *Boor* in the summer three years later, easterlies were measured in 44% of logbook morning observations, despite the vessel's departure in a season then, as now, characterized by abundant westerlies. These results roughly complement Wheeler's analysis of British naval ship logbooks, which reveals a sharp reduction in easterly winds in 1696, and a more moderate decline in 1699.⁵⁰

Other VOC ship logbooks written during the climax of the Maunder Minimum reflect this unusual abundance of easterly winds in the North Sea region. The log kept aboard the *Unie* from its departure on 25 December 1699 until 4 January 1700 describes easterlies in 44% of morning and 67% of evening observations. Thereafter, between 16 January and 8 February 1701 the log of the *Berkel* recorded easterlies on 49% of morning entries.⁵¹ The logbooks of the *Unie* and *Berkel* contain references to daily distance covered that are too fragmentary for statistical analysis. Even in the more complete logs kept aboard the *Vosmaar* and *Boor*, records of daily distance travelled were not as continuous as those provided in the logs of the *Wapen van Hoorn*, *Maarseveen* and *Afrika*. The relatively irregular measurements nonetheless reveal that daily distance traversed peaked in easterly winds, especially when these winds issued from the north-east (Figure 2.10a and 2.10b). Overall, the *Vosmaar* travelled a daily average of 14 German

⁴⁹ This is a generalization of weather patterns that are never stable; west-southwesterlies, for example, appear to have grown more frequent between 1988 and 1997, as mean wind velocity increased. Siegmund and Schrum, "Decadal changes in the wind forcing over the North Sea," 44. Korevaar, *North Sea Climate*, 65. "Northeast England: Climate," Met Office, accessed 2 February 2013, <http://www.metoffice.gov.uk/climate/uk/ne>. "Eastern England: Climate," Met Office, accessed 2 February 2013, <http://www.metoffice.gov.uk/climate/uk/ee>.

⁵⁰ Wheeler, "British Naval Logbooks from the Late Seventeenth Century: New climatic information from old sources," 140. Korevaar, *North Sea Climate*, 21.

⁵¹ Wheeler's investigation of British logbooks, by contrast, suggests a recovery in the frequency of westerlies in 1699 and 1700. Wheeler et al., "Atmospheric circulation and storminess derived from Royal Navy logbooks," 13.

miles, while the *Boor*, weathering more easterly winds, covered an average of 17.3 German miles per day.⁵²

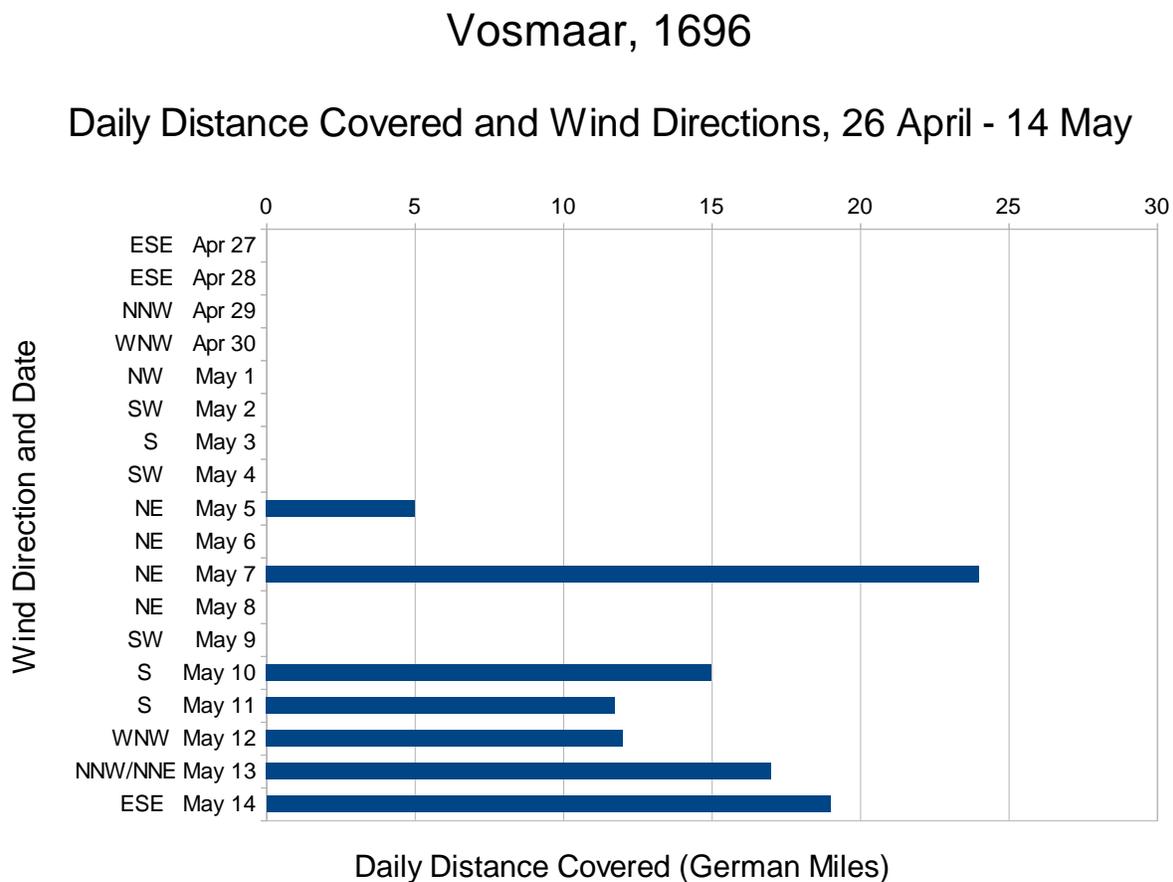


Fig. 2.10a. Daily distance covered, in German miles, and morning observations of wind direction in the first 18 days of the voyage of the *Vosmaar*.

⁵² “Journal vant schip Wapen van Hoorn op sijn 3de voyagie . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). “Journaal gehouden op het schip Vosmaar van de kamer Zeeland door schipper Jacob Lantsheer . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). “Journaal gehouden op het schip Boor door schipper Jan van Wijck . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). “Journaal gehouden op het schip Unie door schipper Jan Vrelant . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). Journaal gehouden op het schip Berkel . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands).

Boor, 1699

Daily Distance Covered and Wind Directions, 17 July - 3 August

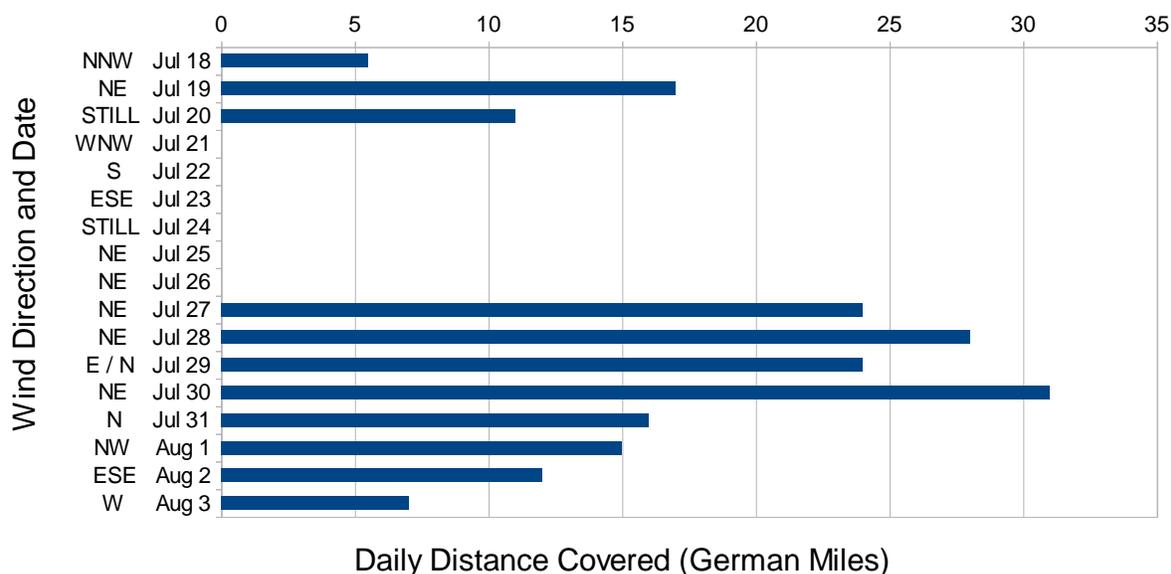


Fig. 2.10b. Daily distance covered, in German miles, and morning observations of wind direction in the first 18 days of the voyage of the *Boor*. At the end of both Figure 2.10a and 2.10b the *Vosmaar* and *Boor* had reached approximately 40° S. Daily distance travelled was far more irregularly recorded than in the previous ship logbooks.

Wind speed was not recorded in the logbook of the *Wapen van Hoorn*, yet the logs of the *Maarseveen*, *Afrika*, *Vosmaar*, and *Boor* provide sufficient meteorological data to suggest that wind direction was a more important influence than wind velocity on daily distance travelled by an East Indiaman. Most qualitative wind speed descriptions by mariners in the age of sail can be reliably converted to quantitative measurements in the modern Beaufort wind force and weather scale. These conversions reveal that the translatable wind velocities recorded on board the *Maarseveen* from its departure until its arrival at 40° N averaged Beaufort (BF) 3.1, approximately 13 kilometres/hour. Meanwhile, wind speed measured aboard the *Afrika* before

the ship passed 46° N averaged BF 3.4, nearly 16 km/h.⁵³ The *Afrika* did travel faster than the *Maarseveen* as it crossed the northeastern Atlantic, yet its greater speed was influenced not only by higher average winds, but also by those winds blowing from a favourable, easterly direction. Moreover, the logbook of the *Vosmaar* reveals that its crew experienced winds that averaged BF 3.1 (13 km/h) before the ship reached 40° N, yet the *Boor* apparently weathered average winds of just BF 1.9 (5.5 km/h). Nonetheless, in the northeastern Atlantic the pace of the *Boor* was significantly quicker than that of the *Vosmaar*. Without regular and extensive cleaning, the accumulation of barnacles on ship hulls could slow those ships over time, yet both vessels were attempting only their second journey to Asia. Furthermore, although the *Boor* was significantly smaller than the *Vosmaar*, lighter ships did not always travel faster than heavier vessels. Consequently, compared to the journey of the *Vosmaar*, the faster passage of the *Boor* through the northeastern Atlantic was likely primarily stimulated by the substantially higher volume of easterly winds recorded by its crew.⁵⁴

Reflections of the climatic minima of the Little Ice Age, the shifting variables of wind direction and velocity as an influence on VOC ship voyages can be isolated with even greater clarity through an analysis of Company voyages during a warmer climatic regime. Documentary proxies compiled by Lamb, Wheeler, and Jean Grove suggest that the frequency of westerly winds in the North Sea region rebounded in the wake of the Maunder Minimum, with a peak in late 1730s yielding to a sharp decline in the colder 1740s. Thereafter, Lamb's data indicates that

⁵³ Two descriptions provided aboard the *Afrika* referred to high winds in the days surrounding the storm of 25 April, yet these observations were too imprecise for translation.

⁵⁴ “Journal vant schip Wapen van Hoorn op sijn 3de voyagie . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). “Journaal gehouden op het schip Vosmaar van de kamer Zeeland door schipper Jacob Lantsheer . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). “Journaal gehouden op het schip Boor door schipper Jan van Wijck . . .”. Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). Adriaen Jongekoe, *Afrika* logs, records 11248 – 11266, 12 April – 30 April. Entered by Rolf de Weijert. Gerritsz Boos, *Maarseveen* logs, records 69261 – 69277, 16 November – 2 December. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

the frequency of westerlies rose in the years directly following 1750 before falling sharply after 1755, a precursor of the Dalton Minimum (1760-1850) in northern Europe. Lamb's evidence was derived from documentary sources that were compiled on land, across contemporary Britain. However, his claim that a rise in easterly winds accompanied the climatic cooling of the mid- to late-eighteenth century is supported by meteorological observations written at sea, in logbooks from the VOC vessels *Africaensche Galeij*, *Admiraal de Ruyter*, *Akerendam*, *Bos en Hoven*, *Landskroon*, *Oud Haarlem*, *Schagen*, *Scholtenburg*, *Spaarzaamheid*, and *Westerveld*.⁵⁵

These ten ships all sailed through the North Sea region between 1750 and 1775. The first fourteen days of their logbooks record their time in the vicinity of England and the English Channel, which approximately overlaps with the geography considered by Lamb, Wheeler, and Grove. For these first two weeks of their journeys, officers aboard the Company ships observed an average of 58% easterly winds, 39% westerly winds, and 3% calm winds, variable winds, or purely northerly or southerly winds. However, the three ship logbooks describing voyages in the early 1750s recorded averages of 69% westerly winds and 31% easterly winds, while the seven logbooks written in or after 1755 measured 64% easterly winds, 32% westerly winds, and 4% other (Figure 2.11). The meteorological information contained within these VOC logbooks consequently confirm earlier studies by suggesting that westerlies grew less frequent, and easterlies more frequent, across the North Sea region in the 1750s.⁵⁶

⁵⁵ Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 31. Grove, *Little Ice Ages Ancient and Modern*, 8. Wheeler et al., "Atmospheric circulation and storminess derived from Royal Navy logbooks," 13.

⁵⁶ C. Mattijssen, *Africaensche Galeij* logs, records 11389 – 11403, 6 January – 20 January. Entered by Maarten Koek. Cornelis van de Putte, *Admiraal de Ruyter* logs, records 9242 – 9256, 11 March – 25 March. Entered by Renate Meijer. Cornelis van de Stam, *Akerendam* logs, records 12689 – 12704, 5 January – 20 January. Entered by Frank Boekhorst. Cornelis van der Stam, *Bos en Hoven* logs, records 29025 – 29039, 30 March – 13 April. Entered by Rolf de Weijert. J.W. v/d Velden, *Landskroon* logs, records 65874 – 65888, 22 December – 5 January. Entered by Toni Spek-Font Pallares. Jan Siereveld, *Oud Haarlem* logs, records 85717 – 85731, 28 December – 11 January. Entered by Pauline Beckers. Jacob Leertouwer, *Schagen* logs, records 105316 – 105330, 27 August – 10 September. Entered by Frank Boekhorst. Pieter Clement, *Scholtenburg* logs, records 106280 – 106294, 26 December – 9 January. Entered by Bruni Oehlers. Willem Vrugt, *Spaarzaamheid* logs, records 109396 – 109410, 28 October – 11

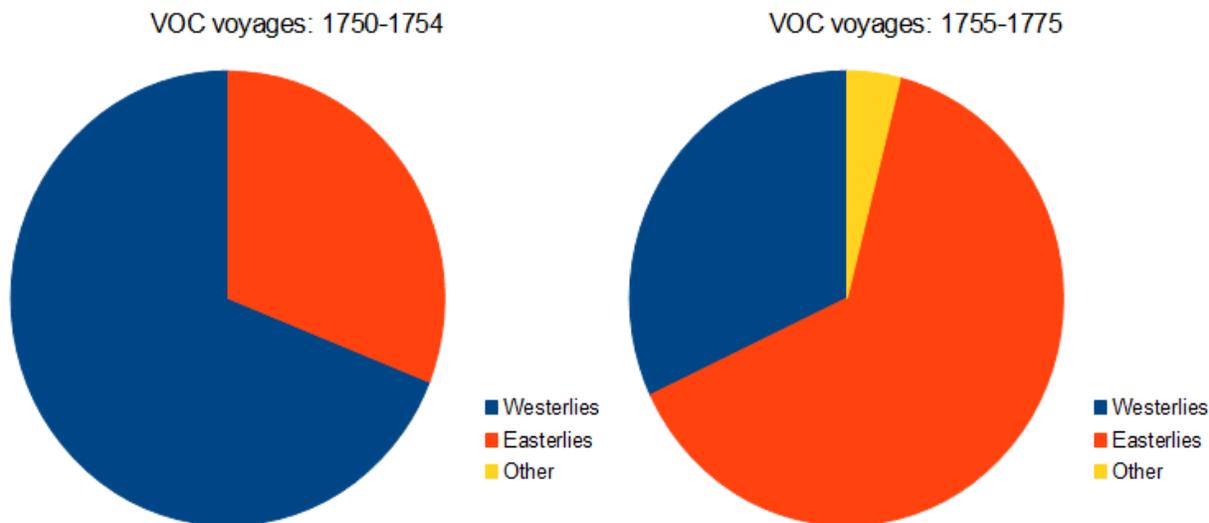


Fig. 2.11. Simplified derivations of westerly and easterly winds recorded in three ship logbooks compiled from 1750 to 1754, and seven logs written from 1755 to 1775, for outbound VOC vessels sailing along the cart track through the northeastern Atlantic.

Nevertheless, in the North Sea region, the relationship between more and less common wind directions is influenced by seasonal changes in ways that fluctuate within and between climatic regimes. That reality complicates attempts to compare VOC ship voyages between warmer and colder years. Aside from the *Boor*, the seventeenth-century vessels considered in this chapter departed in the spring or fall, seasons when easterlies are more common in the warmer climate of the twentieth century, if not as frequent as recorded in the VOC logbooks. In the 1760s the crews of the *Admiraal de Ruyter* and *Bos en Hoven*, departing the Republic in the spring, both experienced easterlies on the majority of days during their passage through the northeastern Atlantic. The measurements in their logs echoed those kept aboard the *Wapen van Hoorn* and *Afrika*, but no such parallels existed between autumn voyages in different climatic regimes. The *Spaarzaamheid* in 1751 and the *Westerveld* in 1764 both departed in the fall, and both vessels sailed against significantly more westerlies than were encountered by the crew of

November. Entered by Frank Boekhorst. Lieve van Rentergem, *Westerveld* logs, records 132726 – 132740, 25 November – 9 December. Entered by Frank Boekhorst. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

the *Maarseveen*. Meanwhile, among the eighteenth-century logs, those of the *Africaensche Galej*, *Akerendam*, *Landskroon*, *Oud Haarlem*, *Scholtenburg*, and *Vlietlust* were written during voyages that began in December or January. Westerlies dominated during the first weeks of the voyage of the *Africaensche Galej* in 1750, but, on average, the vessels that sailed during or after 1755 weathered a particularly striking abundance of easterly winds.⁵⁷ In the absence of additional wind data at seasonal resolution, these conclusions can shed little light on seasonal shifts in wind direction during the Dalton Minimum. Nevertheless, restricting the eighteenth-century comparison to only those ships that departed in the spring or fall again suggests that the abundance of easterlies recorded in VOC logbooks compiled in the northeastern Atlantic during the Maunder Minimum was both significant and unusual.⁵⁸

The logbooks of the *Africaensche Galej*, *Admiraal de Ruyter*, *Akerendam*, *Bos en Hoven*, *Landskroon*, *Oud Haarlem*, *Schagen*, *Scholtenburg*, *Spaarzaamheid*, and *Westerveld* also reveal that more abundant easterlies could quicken the voyages of VOC vessels taking the cart track south through the English Channel. The average daily distance traversed by all ten ships during the first two weeks of their voyages was 21.8 German miles. However, for the three ships sailing in the early 1750s, when westerly winds were more common, that average declined to 19.3, while for the six vessels sailing after 1755 the average increased to 22.2. The 14% shift in

⁵⁷ In particular, the logbooks of the *Oud Haarlem*, *Scholtenburg* and *Vlietlust* record easterlies on 86-100% of morning entries!

⁵⁸ C. Mattijsen, *Africaensche Galej* logs, records 11389 – 11403, 6 January – 20 January. Entered by Maarten Koek. Cornelis van de Putte, *Admiraal de Ruyter* logs, records 9242 – 9256, 11 March – 25 March. Entered by Renate Meijer. Cornelis van de Stam, *Akerendam* logs, records 12689 – 12704, 5 January – 20 January. Entered by Frank Boekhorst. Cornelis van der Stam, *Bos en Hoven* logs, records 29025 – 29039, 30 March – 13 April. Entered by Rolf de Weijert. J.W. v/d Velden, *Landskroon* logs, records 65874 – 65888, 22 December – 5 January. Entered by Toni Spek-Font Pallares. Jan Siereveld, *Oud Haarlem* logs, records 85717 – 85731, 28 December – 11 January. Entered by Pauline Beckers. Jacob Leertouwer, *Schagen* logs, records 105316 – 105330, 27 August – 10 September. Entered by Frank Boekhorst. Pieter Clement, *Scholtenburg* logs, records 106280 – 106294, 26 December – 9 January. Entered by Bruni Oehlers. Willem Vrugt, *Spaarzaamheid* logs, records 109396 – 109410, 28 October – 11 November. Entered by Frank Boekhorst. Lieve van Rentergem, *Westerveld* logs, records 132726 – 132740, 25 November – 9 December. Entered by Frank Boekhorst. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

average distance covered reflects the over 30% leap in the number of easterlies VOC ships experienced after 1755. The influence of wind direction is especially apparent when the journeys of these ten ships are categorized according to the prevailing winds experienced, rather than the year of their travels. The three ship logbooks recording westerly winds for at least half of all days during the first two weeks of their voyages listed an average speed of just 17 German miles in a day. Meanwhile, ships enjoying easterly winds for more than half of their first two weeks travelled a daily average of 24.5 German miles. Moreover, aggregate statistics can obscure how gradual shifts in prevailing wind could occasionally be expressed through extremes. For example, 93% of the winds encountered by the *Africaensche Galeij* in the first two weeks of its journey in 1750 issued from the west, and the ship travelled a daily average of just 12.1 German miles. By contrast, during the first 14 days of its travels in 1766, the *Scholtenburg* experienced easterly winds 93% of the time, and averaged a remarkable 29 German miles per day.⁵⁹

The eighteenth-century ship logbooks that help contextualize the meteorological conditions experienced by seventeenth-century crews sailing south through the English Channel cannot do the same for the journey of the *Afrika*, which travelled along a very different route. Moreover, comparing the *Afrika's* voyage to a selection of VOC ship journeys from a warmer climatic regime is complicated by circumstances that surrounded the use of the back way. After the conclusion of the war of Austrian Succession in 1748, the back way was rarely employed by

⁵⁹ C. Mattijsen, *Africaensche Galeij* logs, records 11389 – 11403, 6 January – 20 January. Entered by Maarten Koek. Cornelis van de Putte, *Admiraal de Ruyter* logs, records 9242 – 9256, 11 March – 25 March. Entered by Renate Meijer. Cornelis van de Stam, *Akerendam* logs, records 12689 – 12704, 5 January – 20 January. Entered by Frank Boekhorst. Cornelis van der Stam, *Bos en Hoven* logs, records 29025 – 29039, 30 March – 13 April. Entered by Rolf de Weijert. J.W. v/d Velden, *Landskroon* logs, records 65874 – 65888, 22 December – 5 January. Entered by Toni Spek-Font Pallares. Jan Siereveld, *Oud Haarlem* logs, records 85717 – 85731, 28 December – 11 January. Entered by Pauline Beckers. Jacob Leertouwer, *Schagen* logs, records 105316 – 105330, 27 August – 10 September. Entered by Frank Boekhorst. Pieter Clement, *Scholtenburg* logs, records 106280 – 106294, 26 December – 9 January. Entered by Bruni Oehlers. Willem Vrugt, *Spaarzaamheid* logs, records 109396 – 109410, 28 October – 11 November. Entered by Frank Boekhorst. Lieve van Rentergem, *Westerveld* logs, records 132726 – 132740, 25 November – 9 December. Entered by Frank Boekhorst. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

Company ships until the end of the eighteenth century, when the last wars of the Dutch Republic coincided with the third and final minimum of the Little Ice Age. Nevertheless, four VOC vessels did take the back way between 1750 and 1760: the *Hercules* in 1756, the *Jerusalem* in the same year, the *Sloterdijk* in 1759, and the *Noordbeveland* in 1760. The climate of the northeastern Atlantic was shifting quickly between 1750 and 1760, and the logbooks of the four vessels suggest that the high volume of easterlies recorded in the logs kept after 1755 by VOC ships travelling directly south from the Republic may have affected the northeastern Atlantic far beyond the North Sea. Still, the decade between 1750 and 1760 was, on average, warmer than the late-seventeenth century had been. Consequently, journeys taken by VOC ships in these years can suggest whether meteorological conditions during the voyage of the *Afrika* were unusual and, perhaps, influenced by a cooler climate.⁶⁰

Beyond recording an abundance of easterlies, meteorological descriptions in the eighteenth-century logbooks differ sharply from those provided in the account of the *Afrika*. In the log kept aboard the *Afrika*, 80% of entries taken north and northwest of the British Isles reported northerly winds. In 1756, however, the logbook of the *Hercules* recorded winds from the south in 100% of entries taken while the ship travelled north of Ireland and Scotland, while the *Jerusalem* experienced winds from the south on 67% of the days it spent in the same area.⁶¹ Travelling in 1759, the log of the *Sloterdijk* described winds from the south in just 40% of measurements taken north of the British Isles, but in the same region a year later the *Noordbeveland* weathered winds from the south on 60% of its days there. The *Hercules* and

⁶⁰ *Hercules* logs, records 54537 – 54546, 9 July – 18 July. Entered by Ronald Schurink. Godfried Wargijn, *Jerusalem* logs, records 61167 – 61178, 4 August – 15 August. Entered by Frank Boekhorst. Jacob Rijzik van den Briel, *Noordbeveland* logs, records 84254 – 84270, 18 May – 1 June. Entered by Florie Barnhoorn. Cornelis van der Stam, *Sloterdijk* logs, records 108144 – 108169, 23 May – 16 June. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

⁶¹ The area examined for these ship logs lies between roughly 60 °N 15 °W and 60 °N 5 °E, or as far to the east as the ship logs recorded, given that into the North Sea longitude was generally discarded.

Sloterdijk, which experienced a particular abundance of southerly winds, both sailed through the region in the summer, while the other vessels, like the *Afrika*, traversed the same waters in the spring. Nevertheless, the contrast between the many northerlies recorded during the voyage of the *Afrika* and the numerous southerlies described in the later logs is striking, although quite possibly a function of a relatively small sample size.⁶²

None of the four ship logbooks written in the 1750s recorded a single storm, let alone a storm with winds from the north. However, in 1769 the logbook kept aboard *Agatha*, a whaling vessel travelling to Svalbard, recorded three days of uninterrupted gustiness from the north as it sailed just east of the back way. Meanwhile, in the late eighteenth century, crews aboard the frigates *Dregterlandt*, *Braave*, and *Bellone* survived gales and squalls issuing from the north, as their vessels passed through the waters north of Scotland and Ireland. It is possible that a rise in the frequency of storms accompanied the coming of the Dalton Minimum in the waters north of the British Isles during the late-eighteenth century, although this shift may have been delayed relative to a regional increase in the abundance of easterly winds. Regardless, eighteenth-century ship logbooks confirm that the storm encountered by the crew of the *Afrika* was more likely during the Maunder or Dalton Minima than it was during the warmer, decade-scale climatic regimes that interrupted the nadir of the Little Ice Age.⁶³

⁶² Adriaen Jongekoe, *Afrika* logs, records 11248 – 11266, 12 April – 30 April. Entered by Rolf de Weijert. *Hercules* logs, records 54537 – 54546, 9 July – 18 July. Entered by Ronald Schurink. Godfried Wargijn, *Jerusalem* logs, records 61167 – 61178, 4 August – 15 August. Entered by Frank Boekhorst. Jacob Rijzik van den Briel, *Noordbeveland* logs, records 84254 – 84270, 18 May – 1 June. Entered by Florie Barnhoorn. Cornelis van der Stam, *Sloterdijk* logs, records 108144 – 108169, 23 May – 16 June. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

⁶³ Adam Ooms, *Agatha* logs, records 11656 - 11676, 3 August – 23 August. Entered by Frank Boekhorst. CLIWOC Database. Jacobus Arkenbout, *Dregterlandt* logs, records 40721-40818, 20 April - 2 August. Entered by Pim Vente. J. Zoeteman, *Braave* logs, records 29252-29381, 24 February - 6 August. Entered by Simone Pathuis. H.C. Albers, *Bellone* logs, records 27427 – 27555, 24 February – 7 August. Entered by Simone Pathuis. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

The logbooks of the *Hercules*, *Jerusalem*, *Sloterdijk*, and *Noordbeveland* were written in ships inbound from Asia to the Republic. Consequently they can provide a comparison for the weather experienced on board the *Afrika*, but not for the influence of those meteorological conditions on daily distance travelled by outbound ships along the back way during the Maunder Minimum. Nevertheless, few logbooks kept aboard VOC ships returning from Asia survive from the seventeenth century, and eighteenth-century logbooks therefore provide the best glimpses into how inbound vessels were affected by changes in wind direction and intensity. During their journey around the British Isles, the *Hercules*, *Jerusalem*, *Sloterdijk*, and *Noordbeveland* travelled a relatively sluggish daily average distance of 14.2 German miles, perhaps slowed by the paucity of high, squally winds. Regardless, for vessels inbound along the back way, as for outbound ships travelling down the Channel, the most significant meteorological condition affecting travel through the northeastern Atlantic appears to have been wind direction.

Northerlies and southerlies, however, were far more influential than easterlies or westerlies in contributing to daily distance travelled aboard the *Hercules*, *Jerusalem*, *Sloterdijk*, and *Noordbeveland*. In particular, southerly winds appear to have accelerated ships returning to the Republic, perhaps because the time inbound ships sailed north while traversing the back way around the British Isles far exceeded the duration of their southerly course through the North Sea. The *Sloterdijk*, for example, experienced mostly northerly winds, and travelled a daily average of 11.2 German miles, while the *Hercules* journeyed 17.5 miles a day with winds entirely from the south. By contrast, there was minimal correlation between daily distance covered and the frequency of northerlies or southerlies during the voyages of the ten outbound

ships used as a comparison for the voyages of the *Wapen van Hoorn*, *Maarseveen*, *Vosmaar*, and *Boor*.⁶⁴

For most inbound East Indiamen in times of peace, the cart track off Europe swung far to the west of its location for outbound voyages (Map 2.1). The wind directions that accelerated outbound vessels therefore did not influence returning ships in a directly opposite fashion. In the last weeks of their journeys, some inbound ships actually sailed southeast before swinging north at the entrance to the English Channel, while other vessels bore further to the northeast.

Nevertheless, all ships sailed far to the west before turning to the east, a turn taken to harness persistent trade winds from the west in the heart of the northern Atlantic. The climatic shifts that probably stimulated an increase in the frequency of easterlies in the North Sea region and, perhaps, parts of the northeastern Atlantic accordingly did not affect the prevailing winds of the broader northern Atlantic, and indeed there is no scientific evidence for such a widespread transition in early modern Atlantic wind patterns.⁶⁵

Unfortunately, only two ship logbooks written before 1780 survive to document the journeys of VOC ships returning from Asia, and the low sample size prohibits definitive conclusions. Still, although the logbook of the *Akerendam* in 1754 recorded far more westerlies than easterlies, the more fragmentary log kept aboard the *Alkemade* in 1775 nevertheless reveals that easterlies could be numerous across the Atlantic. Perhaps because inbound VOC ships nearing the Republic could sail in many directions and still travel closer to their home ports, the logbooks suggest that wind velocity was more important than wind direction for returning

⁶⁴ Entered by Rolf de Weijert. *Hercules* logs, records 54537 – 54546, 9 July – 18 July. Entered by Ronald Schurink. Godfried Wargijn, *Jerusalem* logs, records 61167 – 61178, 4 August – 15 August. Entered by Frank Boekhorst. Jacob Rijzik van den Briel, *Noordbeveland* logs, records 84254 – 84270, 18 May – 1 June. Entered by Florie Barnhoorn. Cornelis van der Stam, *Sloterdijk* logs, records 108144 – 108169, 23 May – 16 June. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

⁶⁵ Bruijn, *Dutch Asiatic Shipping in the 17th and 18th Centuries*, Vol I, 24.

vessels. For example, on 31 April the *Akerendam* covered 25.5 German miles in brisk southwesterly winds, but on 1 May the ship traversed 28.5 German miles in a stiff breeze from the north-northeast. The ship covered 16.5 German miles as northerly winds moderated on the following day, and just 12.5 German miles on 3 May, in calm conditions.⁶⁶

During the Maunder Minimum, and perhaps during the other minima of the Little Ice Age, a rise in easterly winds in the North Sea region likely increased the velocity of VOC ships travelling to Asia, whether along the back way or south through the English Channel. More frequent storms during these minima, while occasionally damaging to East Indiamen and their convoys, probably accelerated outbound VOC vessels in the North Sea region, particularly because an unusual percentage appear to have blown from the north and, possibly, the east. Some of the meteorological transitions associated with early modern climatic trends likely affected ship journeys beyond the North Sea and English Channel, although the geographical extent of the changes remains uncertain, and across much of the northern Atlantic the westerly trade winds appear to have prevailed throughout the Little Ice Age. These trade winds benefitted VOC ships returning from Asia, although inbound journeys in the northern Atlantic were likely less affected by shifts in prevailing wind direction than changes in its average velocity. No study has yet measured early modern shifts in average wind velocity across the northern Atlantic, or even in the North Sea, yet it is possible that inbound voyages were, in general, accelerated by the same storms that frequently hastened ships departing the Republic. Overall, an analysis of individual ship logbooks suggests that outbound ship voyages were significantly influenced by the weather that accompanied the Maunder Minimum, while inbound journeys were more ambiguously affected.

⁶⁶ Cornelis van de Stam, *Akerendam* logs, records 12672-12685, 22 April-5 May. Entered by Frank Boekhorst. Pieter Grijp, *Alkemade* logs, records 14282-14295, 9 June-22 June. Entered by Rolf de Weijert. CLIWOC Database. Accessed 24 June 2013, <http://www.knmi.nl/cliwoc>.

Beyond the Northeastern Atlantic: Climate, Weather, and Dutch Trade with Asia

Additional ship logbooks and, most importantly, day registers can help reveal how VOC journeys beyond the northeastern Atlantic were influenced by its weather and climate. After all, meteorological shifts in the northeastern Atlantic may have been balanced by changes elsewhere along the cart track. Moreover, the acceleration of a ship voyage owing to a gale in the North Sea region might have been undermined by a necessarily lengthy stay at, for example, the Cape of Good Hope to repair storm damage. Aside from gales, daily weather was not explicitly mentioned in Company day registers, yet meteorological influences, recorded in ship logbooks, were reflected in day registers through reports of shipwrecks or, more commonly, dates of arrival into ports along the cart track.⁶⁷

The 6,000 VOC day registers examined to reconstruct relationships between storms, shipwrecks, and mortality were also investigated to yield comprehensive statistics that chart shifts in VOC journey times from the Company's establishment until the final years of the Maunder Minimum. Reconstructions of storms and mortality compiled using day registers could incorporate journeys from all havens in the Republic to all ports in Asia. However, because the settlements owned by the VOC were so far apart, statistics measuring journey times concentrated on inbound and outbound voyages between Texel and Batavia, the Company's most common sites of arrival and departure.⁶⁸ Day registers describing journeys between these ports reveal that the average total journey duration of 794 precisely documented Dutch voyages from Texel to

⁶⁷ Bruijn, *Dutch Asiatic Shipping in the 17th and 18th Centuries*, Vol I, 24.

⁶⁸ Several sites very near Batavia substituted for Batavia in these reconstructions, especially for early voyages of the VOC and its precursor companies. Bantam, Bali and Jacatra were included as substitutes for Batavia, yet the more distant sites of Aceh and Johore were not.

Batavia fluctuated significantly from the first expeditions of the precursor companies until the last years of the Maunder Minimum (Figure 2.12). The total length of an individual voyage could be many times longer than the preceding voyage, even within the same decade. The most significant long-term trend was a decline in average total journey times from the first decades of Dutch trade with Asia until the 1630s, followed by a gradual if fitful increase from the last decade of the seventeenth century that continued into the eighteenth century. The lengthy average duration of voyages during the Grindelwald Fluctuation was probably a reflection of both the pioneering nature of those journeys, and the lack of standardization that accompanied the first decades of Dutch trade in Asia.

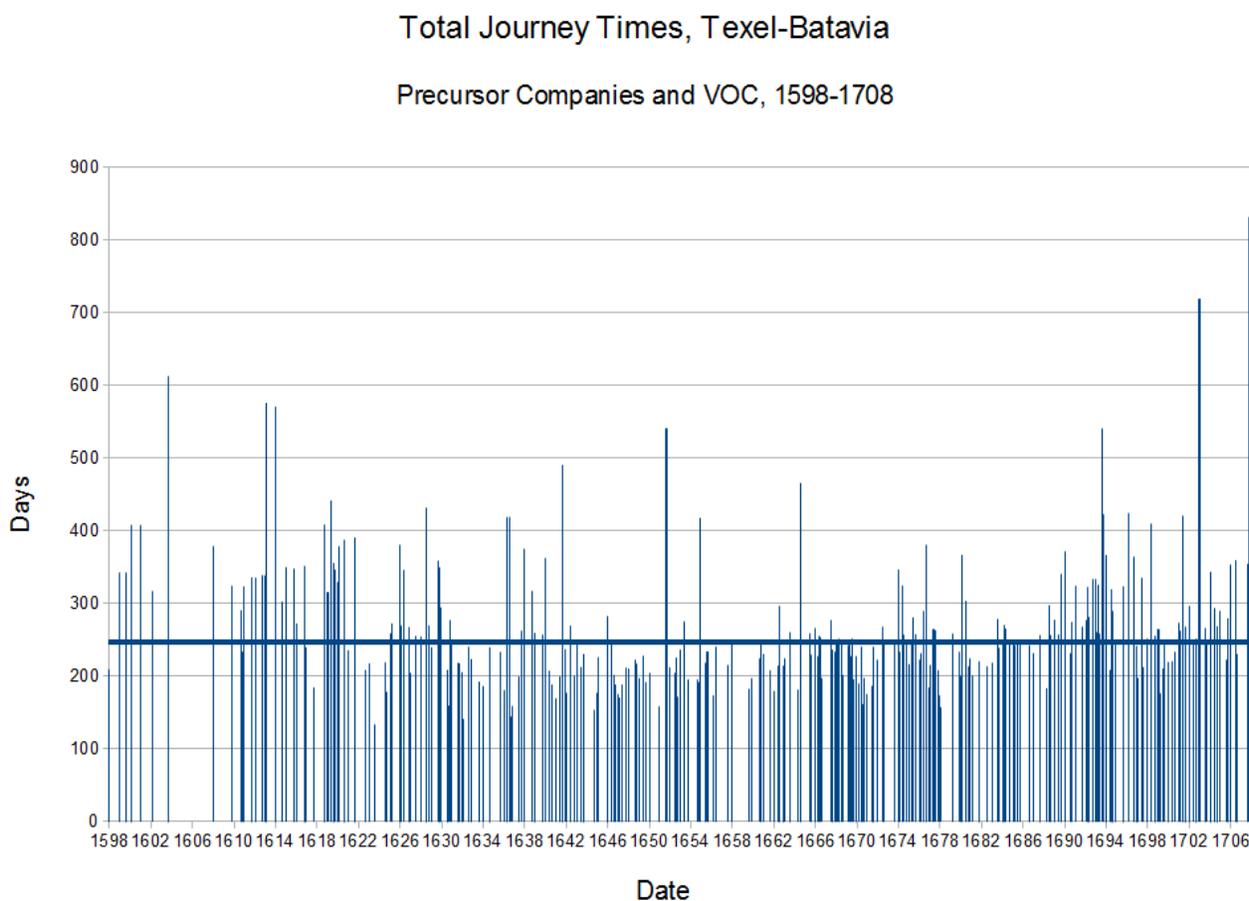


Fig. 2.12. Total journey times, in days, for ships sailing from Texel to Batavia between 1598 and 1708. Gaps in the graph reflect years in which day registers and ship logbooks were not recorded with sufficient precision. A mean value line has been inserted.

After the conclusion of the Grindelwald Fluctuation in 1629, variation in the day register statistics was most strikingly expressed in extreme voyages like the 415 and 490-day passages of the *Haan* and *Heemstede* in 1642, or the remarkable 131-day journey of the *Zwarte Beer* just two years later. Following the first decades of Dutch trade in Asia, the number of exceptionally long voyages peaked in the 1630s and early 1640s, the early 1650s, and from the late 1690s until 1708. These extreme voyages were not isolated from the broader trends reflected in the day register statistics, but rather symptomatic of shifts in median journey times. Minima in median journey times appear to have occurred in the early 1630s, the mid to late 1640s, the middle of the 1650s until the early 1660s, and the 1680s. In particular, both median and average journey times were relatively stable and comparatively low from the early 1650s until the early 1690s, a period that was better documented than early, less constant minima.⁶⁹

Long after VOC voyages were standardized, total journey times were subject to cultural, economic, political, and environmental influences that interacted with human agency and extended far beyond meteorological and, in turn, climatic stimuli. Of course, historical data invariably reflect a constellation of influences, but some of these influences can be extracted from an analysis of Company voyages to Asia. Among the most important were days spent at the Cape of Good Hope and secondary ports along the cart track, which naturally extended total journey times. Day register statistics demonstrate that for ships travelling between Texel and Batavia, the average number of days occupied at secondary destinations increased dramatically after approximately 1650 (Figure 2.13a). Moreover, both average age and average tonnage of

⁶⁹ *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Volume II, Outward-bound voyages from the Netherlands to Asia and the Cape (1595-1794)*, ed. J.R Bruijn et al. (The Hague: Martinus Nijhoff, 1979), 1-459. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

VOC ships rose gradually between 1598 and 1708, and larger ships encrusted with barnacles sailed more slowly than smaller, cleaner vessels (Figures 2.13b and 2.13c).⁷⁰

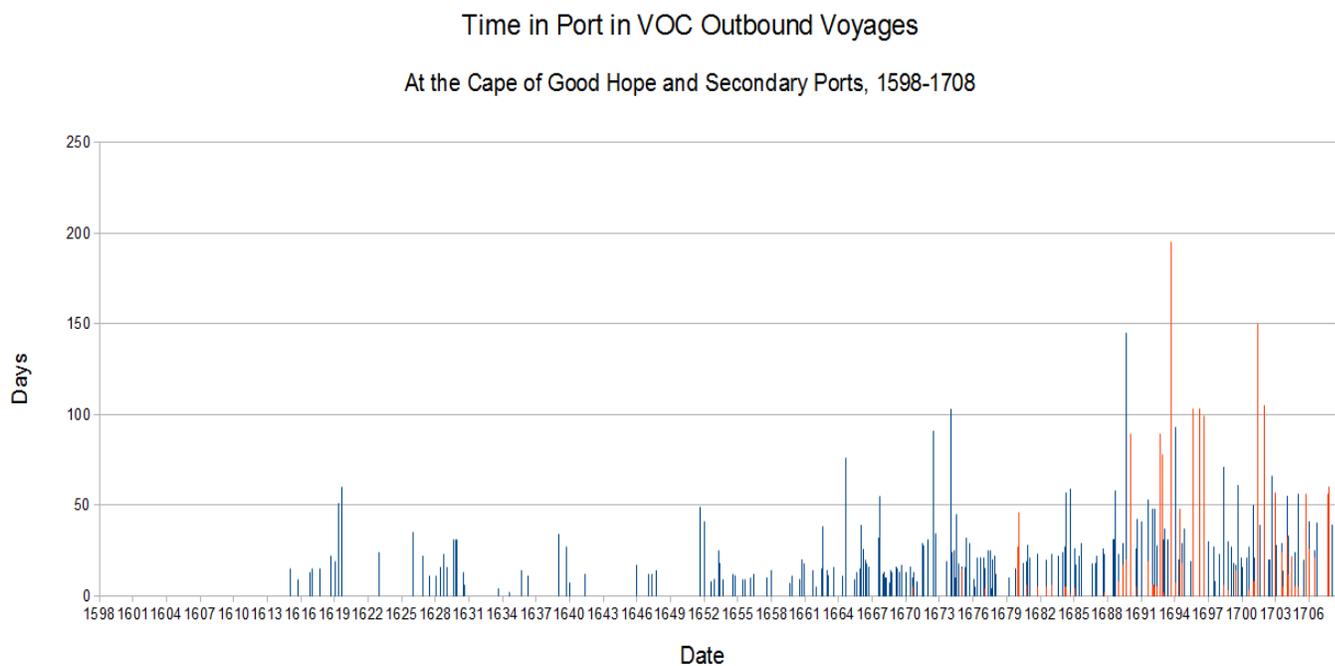


Fig. 2.13a. Time, in days, that VOC vessels travelling from Texel to Batavia spent at the Cape of Good Hope (blue) and applicable secondary destinations (orange) between 1598 and 1708. Ships that stopped at no secondary ports en route to Batavia are not listed.

⁷⁰ *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Volume II*, ed. J.R Bruijn et al., 1-459. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

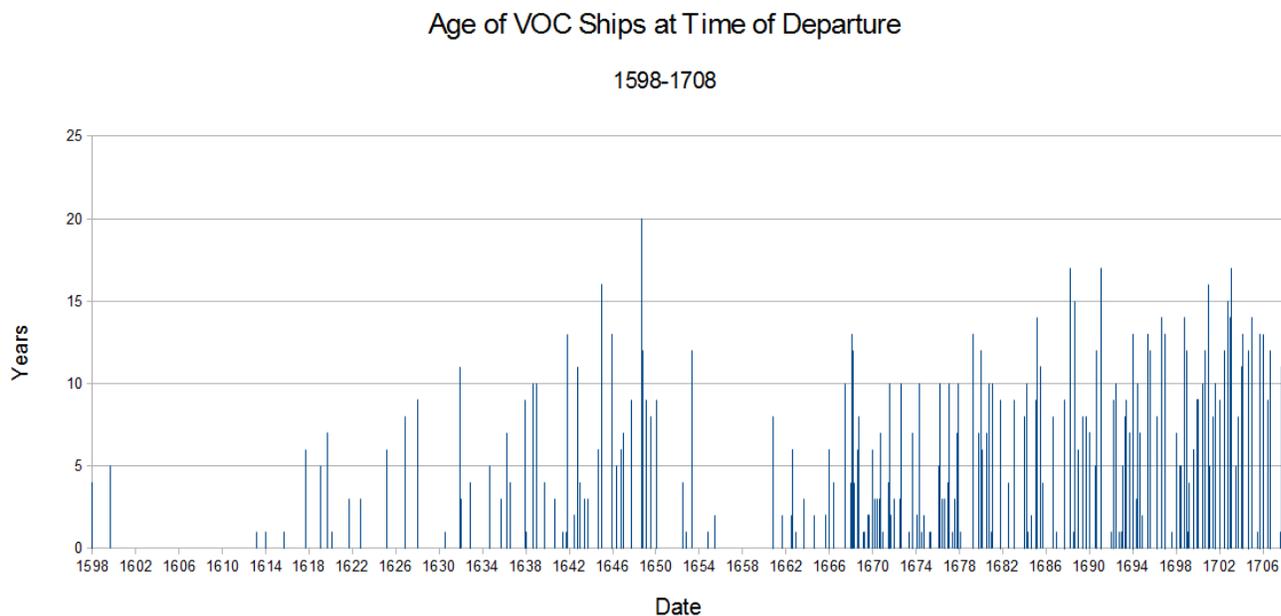


Fig. 2.13b. Age, in years, of VOC vessels departing Texel for Batavia, 1598-1708. Gaps correspond to years in which day registers did not record the date of ship construction.

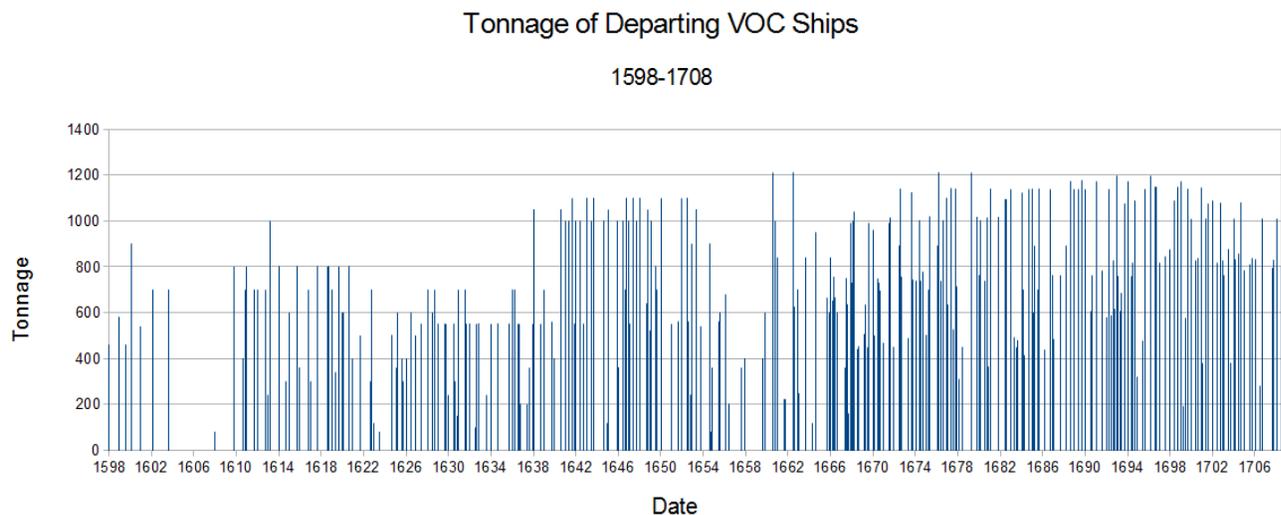


Fig. 2.13c. Tonnage of VOC vessels sailing from Texel to Batavia between 1598 and 1708. Gaps correspond to years in which day registers did not record tonnage.

The increase in ship size and age was likely not sufficient to effect a significant rise in average journey time. Indeed, the lack of apparent connections between ship age and journey duration also suggests that technological developments did not significantly quicken the speed of

VOC voyages. Far more significant was the rise in average time occupied at the Cape and additional secondary ports along the cart track in the late seventeenth and early eighteenth centuries. It is possible that delays in secondary destinations were, at times, stimulated by repairs necessitated by storms, although, again, gales were less likely to severely damage East Indiamen than smaller flutes and yachts. Ultimately, at least some of the rise in the average total journey duration from Texel to Batavia in the latter decades of the examined period reflected decisions taken by VOC personnel, rather than the unavoidable influence of changing meteorological conditions.

By subtracting the number of days in which Dutch vessels sailing to Asia remained in secondary ports along the cart track from the total duration of each voyage, it is possible to uncover the approximate time each VOC vessel remained at sea (Figure 2.14). Once at sea, Company crews naturally endeavoured to minimize the duration of the passage to their next port of call, and the resulting statistics consequently highlight the influence of variables outside the control of VOC personnel. The sea time reconstruction reveals a decline in the number of extremely lengthy voyages after the early 1660s, despite the exceptionally long journeys of the *Drie Kronen* in 1703 and the *Beverwaard* in 1708. Moreover, after the first decades of Dutch trade to Asia, relatively long average journey times now appear to have been common in the middle of the 1630s, the early 1640s, the middle of the 1670s, the early 1690s, and the first years of the eighteenth century.⁷¹

⁷¹ *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Volume II*, ed. J.R. Bruijn et al., 1-459. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

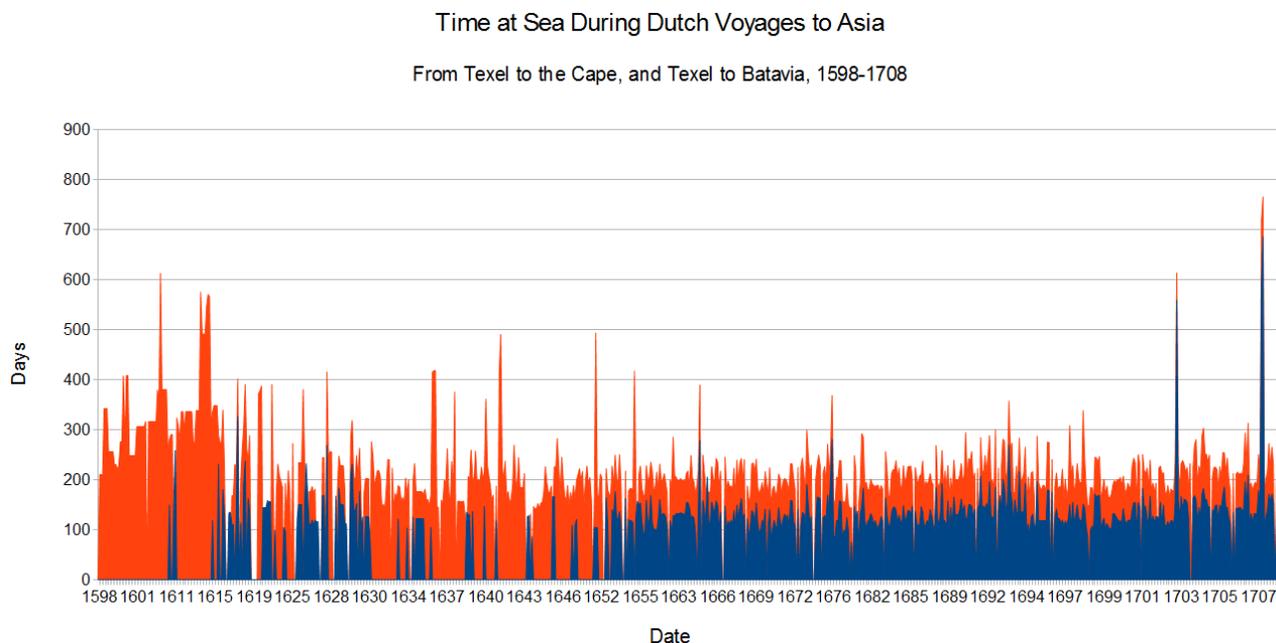


Fig. 2.14. Time spent at sea from Texel to the Cape of Good Hope (blue), and Texel to Batavia (orange), for Dutch ships sailing from Texel to Batavia between 1598 and 1708.

Graphing the time spent at sea from Texel to the Cape alongside the total time at sea for the entire passage from Texel to Batavia demonstrates that variations in the duration of the journey to Asia were closely correlated to fluctuations in the length of voyages in the Atlantic. In other words, the part of most voyages to Batavia for which interdisciplinary researchers have most reliably compiled climate reconstructions, and in which prevailing winds may have been particularly subject to change, was also especially influential to total VOC journey times. On the other hand, the day register statistics of total days spent at sea for Dutch vessels sailing from Texel to Batavia also confirm that some of the rise in total journey times towards the end of the period was stimulated by greater time spent at secondary ports along the cart track. Still, significant variability in journey times is reflected in the sea time graph, with even minor fluctuations in average voyage duration reflecting additional weeks or even months at sea that were costly in both human and material terms.

The Republic was at war for much of the period between 1598 and 1708, and in some years, during most wars, VOC vessels were required to take the lengthy back way around the British Isles. Most East Indiamen were also forced to travel in large convoys, which travelled only as fast as their slowest vessels, and suffered delays if scattered by storms. In fact, it is surprising that delays in days spent at sea by VOC ships were not more severe during the three Anglo-Dutch Wars of the seventeenth century, the war with France that lingered from 1672 to 1678, the War of the Grand Alliance from 1688 to 1697, and the War of the Spanish Succession from 1701 to 1714. Fortunately, the sea time reconstruction can be refined by eliminating years in which the Republic was embroiled in naval wars that affected the seas directly west of the European mainland, although the Dutch were so frequently at war that the results are reduced to six relatively isolated periods (Figure 2.15). Nevertheless, the results reveal a gradual decline in the time VOC vessels remained at sea, both in their journey from Texel to the Cape, and in their overall voyages to Batavia.⁷²

⁷² *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Volume II*, ed. J.R. Bruijn et al., 1-459. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

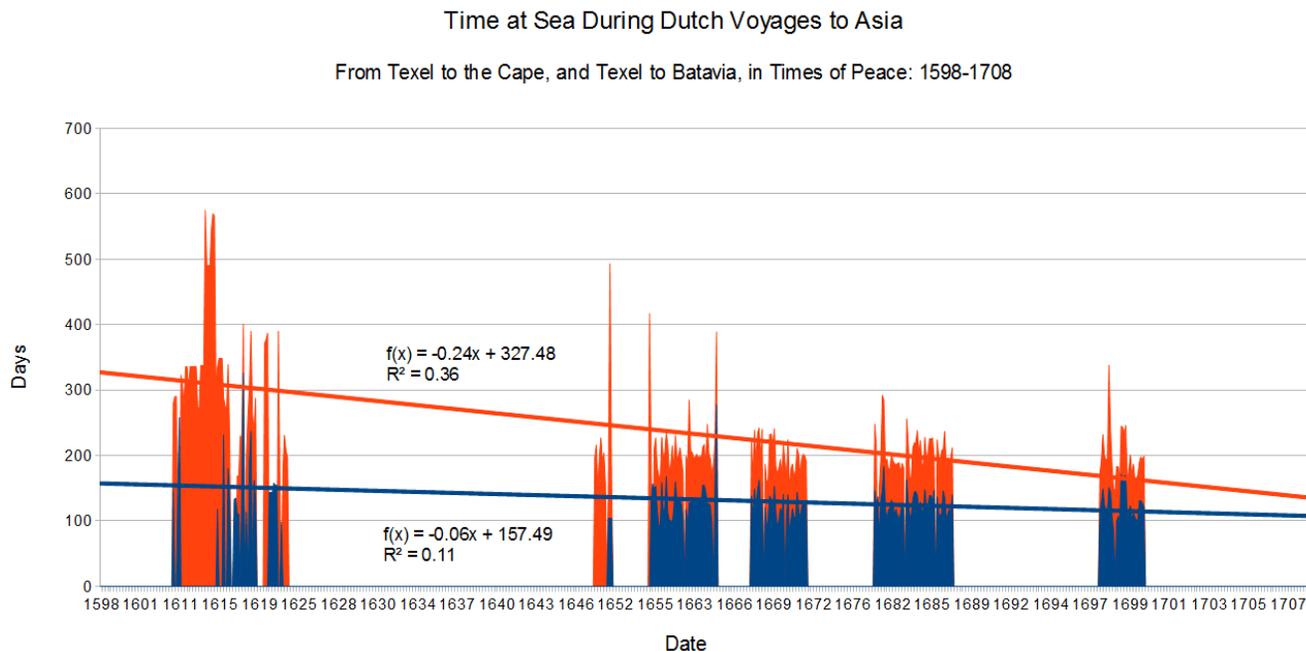


Fig. 2.15. Time spent at sea for Dutch vessels sailing from Texel to the Cape of Good Hope (blue), and Texel to Batavia (orange), in years of peace between 1598 and 1708. To emphasize the general trend, a linear regression analysis has been applied to both results. Average time at sea decreased by more than a third during the period.

The 355 day registers incorporated within a reconstruction of inbound VOC journeys from Batavia to Texel reflect a very different trend (Figure 2.16). More – and more precise – registers recorded voyages from Texel to Batavia, in part because many ships constructed in the shipyards of the Republic were used in the thriving intra-Asian trade. Ships leaving for Batavia consequently outnumbered those returning to Texel, and statistics of inbound journeys are less continuous than those that document outbound voyages. Still, the inbound register reconstruction contains sufficient data for a comparison with outbound register statistics. A quantitative analysis of the registers reveals that the average voyage from Batavia to Texel did not take as long as the passage from Texel to Batavia. Moreover, extremely short or lengthy voyages were less common for inbound than for outbound ships, although for vessels on both journeys they declined in frequency after the late 1650s. Despite that trend, however, the length of average voyages from

Batavia to Texel increased by approximately 10% from the expeditions of the precursor companies until the final decades of the Maunder Minimum.⁷³

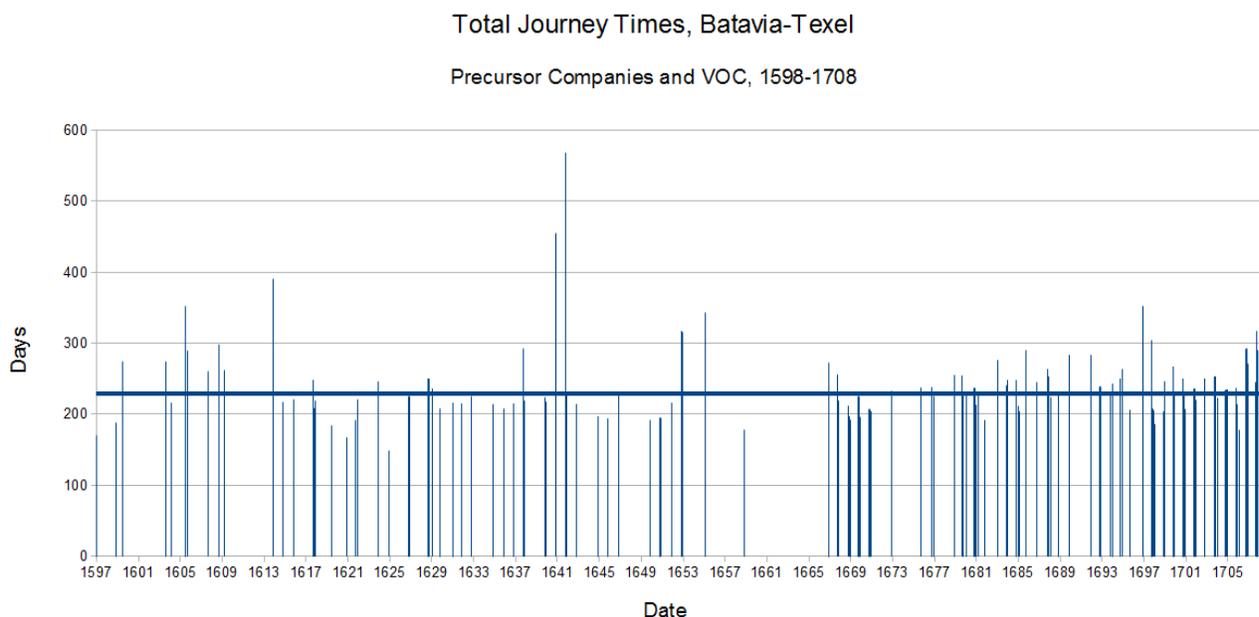


Fig. 2.16. Total journey times for vessels sailing from Batavia to Texel, 1597-1708. Gaps reflect years for which sufficiently precise or continuous registers were not available. A mean value line has been inserted.

The same shifts in average ship size and age that did not significantly influence outbound voyages also did not greatly affect gradual changes in inbound journey duration. On the other hand, changes in time spent at secondary destinations along the cart track did affect voyages to Texel as significantly as they influenced journeys from Texel. For inbound voyages, however, the trend in average duration spent at secondary ports and the Cape of Good Hope differed sharply from that reflected in outbound journey statistics (Figure 2.17). Ships travelling to Texel frequently called at secondary ports in the early seventeenth century, before the Cape was routinely employed, and the duration of their stays in these ports occasionally occupied a

⁷³ *Dutch-Asiatic Shipping in the 17th and 18th Centuries, Volume III: Homeward-bound voyages from the Asia and the Cape to the Netherlands (1597-1795)*, ed. J.R. Bruijn et al. (The Hague: Martinus Nijhoff, 1979), 1-343. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

sizeable portion of their total journey time. Secondary ports aside from the Cape sharply declined in popularity after the 1640s, and they were rarely used for the rest of the period. Meanwhile, the Cape of Good Hope emerged as the primary port of resupply. Despite significant decadal fluctuations in the average duration of delays there, the time spent by inbound ships at the Cape generally increased in the late seventeenth and early eighteenth centuries. Overall, shifts in the time spent by returning ships at secondary destinations, including the Cape, are easily visible in a reconstruction of total inbound journey time (Figures 2.16 and 2.17).⁷⁴

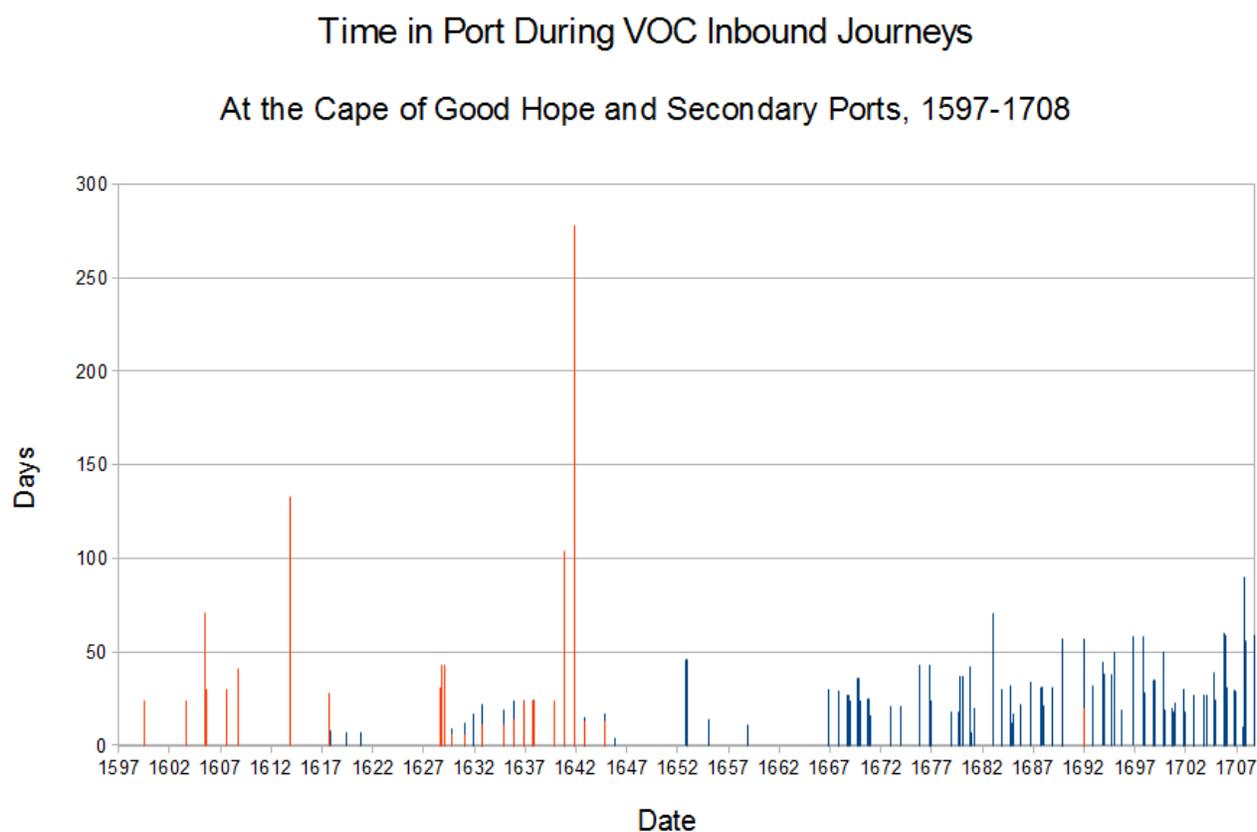


Fig. 2.17. Time, in days, that VOC vessels travelling from Batavia to Texel spent at the Cape of Good Hope (blue) and applicable secondary destinations (orange) from 1597 to 1708. Ships that stopped at no secondary ports en route to Texel are not listed.

⁷⁴ *Dutch-Asiatic Shipping in the 17th and 18th Centuries, Volume III*, ed. Bruijn et al., 1-343. “Database VOC Schepen.” De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

The typical journey from Batavia to Texel was longer in the late-seventeenth and early-eighteenth centuries than it had been in the first decades of the seventeenth century. After time spent at secondary destinations is subtracted from total journey duration, day register statistics appear to reveal that the average time spent at sea for VOC ships travelling from Batavia to Texel declined slightly over the course of the seventeenth century, but that decline was really stimulated by several voyages of exceptional length during the 1640s and early 1650s (Figure 2.18). For most ships travelling to Batavia, significantly more time was spent in the Atlantic than was passed in the Indian Ocean. For vessels bound for Texel, however, far more time was employed in the Indian Ocean. In fact, during many journeys the time spent at sea for the entire passage was three times longer than the duration of the voyage across the Atlantic alone. Relatively swift homebound journeys through the Atlantic were likely stimulated by the trade winds of the Atlantic, which blew from the southeast in southerly latitudes, and from the southwest north of the equator, excepting the North Sea region and, possibly, the southeastern Atlantic during the Maunder Minimum. Longer journeys in the Indian Ocean, in turn, were likely influenced by the prevailing westerlies of the roaring forties. Consequently, during the Maunder Minimum it is unlikely that changes in the direction and intensity of prevailing winds in the North Sea region were balanced by shifts in wind direction across other regions along the cart track.⁷⁵

⁷⁵ Bruijn et al., *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Introductory Volume*, 19. *Dutch-Asiatic Shipping in the 17th and 18th Centuries, Volume III*, ed. Bruijn et al., 1-343. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijt.html>.

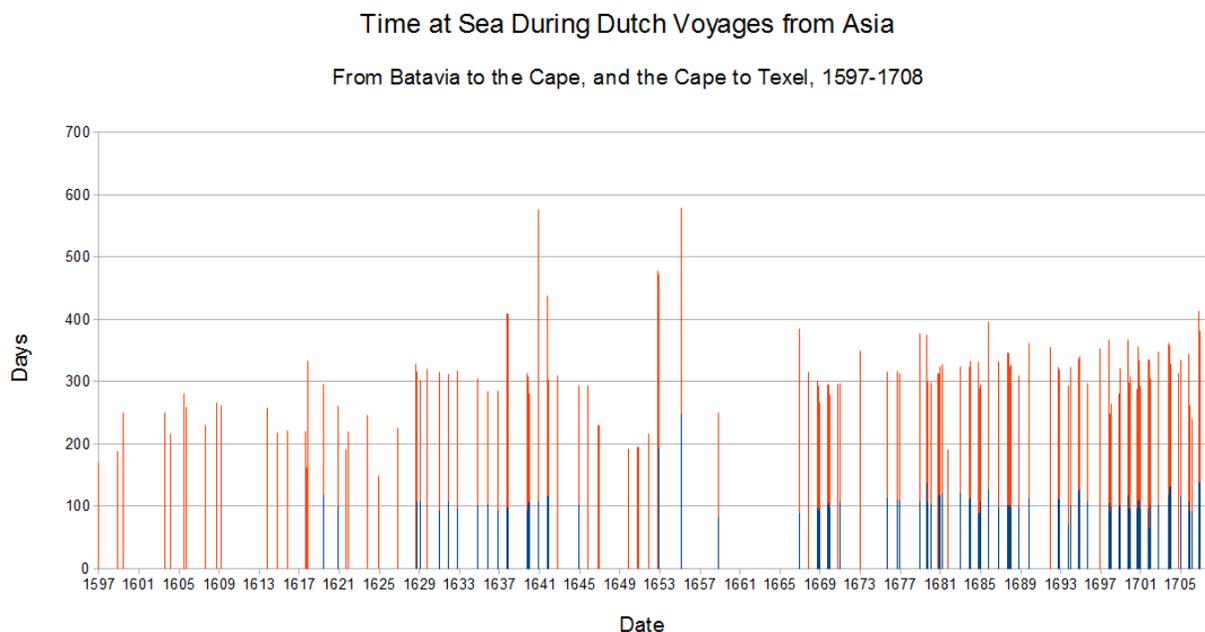


Fig. 2.18. Time spent at sea from Batavia to the Cape of Good Hope (blue), and Batavia to Texel (orange), for Dutch ships sailing from Batavia to Texel between 1597 and 1708.

Of course, returning East Indiamen, like outbound vessels, were required to take the longer back way during the Republic's frequent wars. Unfortunately, the sample size of inbound day registers kept during times of peace was significantly smaller than the outbound registers. Still, eliminating day registers written during years of war from the reconstruction of inbound times at sea reveals that total journey duration peaked in the 1680s before declining slightly in the final years of the seventeenth century. Time spent in the Atlantic slowly rose during the entire period, reaching a corresponding climax in the 1680s. Both trends, however, were slight, with the shift in average journey times accounting for approximately 5% of average voyage duration between 1597 and 1708 (Figure 2.19).⁷⁶

⁷⁶ *Dutch-Asiatic Shipping in the 17th and 18th Centuries, Volume III*, ed. Bruijn et al., 1-343. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijst.html>.

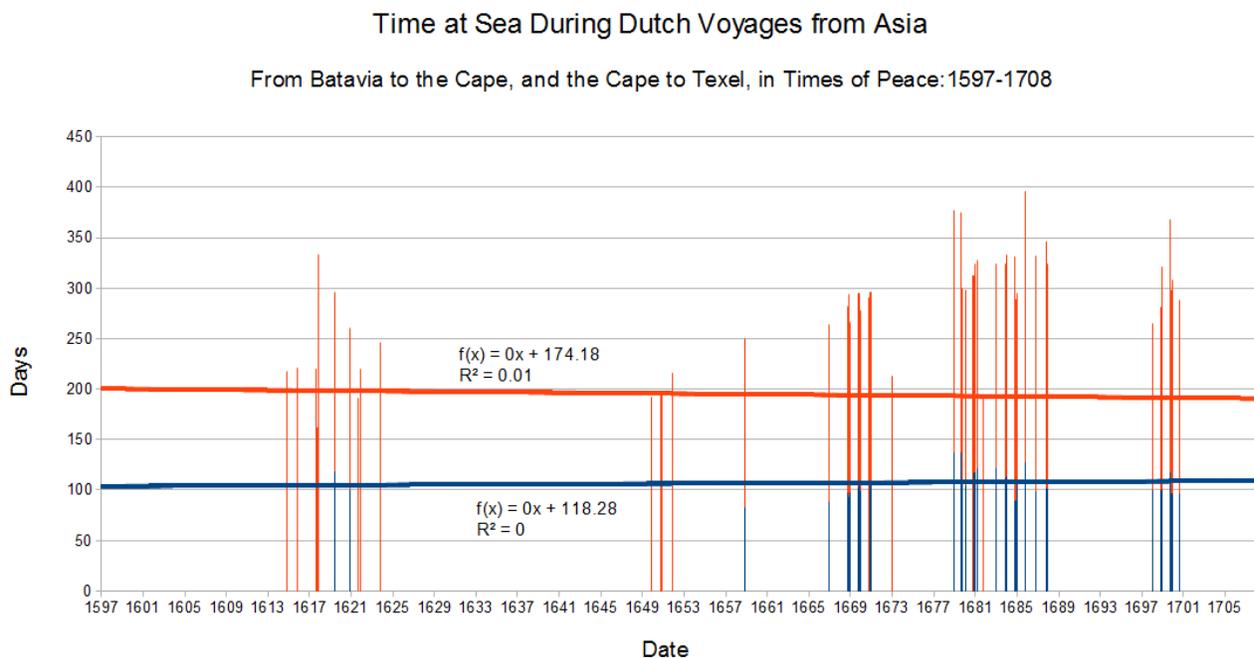


Fig. 2.19. Time spent at sea for Dutch vessels sailing from Batavia to the Cape of Good Hope (blue), and Batavia to Texel (orange), in years of peace between 1597 and 1708. To emphasize the general trend, a linear regression analysis has been applied to both results.

For crews aboard VOC vessels, journey duration was a matter of life, death, and profit. Time spent at sea was time exposed to storms and enemy combatants in unsanitary and typically disease-ridden conditions. Annual mortality peaked during storms and wars, both of which were particularly frequent during the Maunder Minimum. On the other hand, annual mortality also increased in years that coincided with unusually long voyages to or from Batavia. If the risk of death was not motivation enough for a speedy passage to Batavia, the *Heren XVII* offered substantial bounties for outbound journeys completed within six months. These bounties were a testament to the uneven importance of outbound and inbound journey duration for the functioning of the Company's commercial networks.⁷⁷

⁷⁷ Bruijn et al., *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Introductory Volume*, 103. *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Volume II*, ed. J.R Bruijn, 1-459. "Database VOC Schepen." De VOC Site, accessed 24 June 2013, <http://www.vocsite.nl/schepen/lijt.html>.

The VOC occupied a larger share of the Dutch economy as the Republic declined relative to other European powers in the final decades of the seventeenth century. However, even as the Company's revenues rose its profits declined, and its bloated infrastructure in Asia struggled to remain competitive against English and Scandinavian East India companies that increasingly traded coffee, tea, and other commodities more lucrative than spices. As the VOC entered the terminal decades of its lengthy decline, its Governor General in Batavia, Gustaaf Willem van Imhoff, submitted a lengthy recipe for reform to the Heren XVII. Written in 1741, his "considerations" recommended increased bounties for rapid passage to Batavia, and subsequent proposals written in the following year also suggested new ship designs and improved training for Company mariners. These urgent suggestions were doubtless inspired in part by the success of competing East India Companies. They also responded to a series of disastrous shipwrecks off the Cape of Good Hope, stimulated by the poor training of mariners in ferocious storms that cannot, at present, be linked to early modern climatic fluctuation.⁷⁸

The peril posed by competition and disastrous storms may have overwhelmed the less spectacular influence of gradual changes in average weather, and indeed such shifts might not have been readily discernible to VOC personnel. Still, the Heren and their subordinates could access an unprecedented wealth of meticulously quantified material that charted meteorological conditions. Moreover, they could consult long-serving veterans of the passage to Asia, whose experience could span decades of climatic transition. Consequently, by slowing the passage of outbound ships through the northeastern Atlantic, unusually common westerly winds in the North Sea region during the warmer interval between the Maunder and Dalton minima may have

⁷⁸ Gustaaf Willem van Imhoff, "Consideratiën over den tegenwoordigen staat van de Nederlandsche O.I.C." Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (Den Haag, Netherlands). Peter Stearns, "The Essence of Commodification: Caffeine Dependencies in the Early Modern World," *Journal of Social History* 35 (2001): 269. Bruijn et al., *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Introductory Volume*, 103. Blussé, *No Boats to China*, 53.

contributed to Imhoff's considerations, even if the contribution was not consciously recognized. Ultimately, Imhoff's recommendations were only the most detailed entry in a long, fraught history of VOC governors general debating the duration of VOC voyages with their hypothetical masters in the Republic. Often weather and certainly climate remained implicit in the arguments that repeated themselves across the long history of the early modern world's most valuable company. Negotiations concerned dates of departure and the speed of transit, although the Company's leaders were aware that such structures were heavily influenced by meteorological conditions. When juxtaposed with surviving ship logbooks and day registers, their correspondence suggests that the weather accompanying climatic fluctuation during the Little Ice Age prompted urgent discussion and response at all levels of the Company's vast infrastructure.⁷⁹

Conclusions: Trends, Consequences, and Reactions

Weather patterns that grew more common during Little Ice Age minima and maxima influenced VOC ship journeys, but this relationship was not straightforward. The exceptional length of outbound voyages during the final decades of the Grindelwald Fluctuation was probably stimulated primarily by economic, political, and cultural influences that encouraged exploration and discouraged comparatively short, standardized voyages at the dawn of Dutch commerce with Asia. However, contemporary expeditions to the Cape were also lengthier than they would be later in the seventeenth century, and passage through the Atlantic was far less subject to the demands of discovery and conquest. The cause of the relative length of these Atlantic voyages is uncertain. Changes in the Company's techniques and technologies from its

⁷⁹ Van Imhoff, "Consideratiën over den tegenwoordigen staat van de Nederlandsche O.I.C."

first years until the early eighteenth century were likely insufficient to significantly affect journey time. Moreover, voyages returning to Texel were comparatively short during the early seventeenth century, suggesting that the stimulus that lengthened outbound journeys through the Atlantic also shortened inbound passages across the same waters.

Despite the meteorological conditions reported in the logbook of the *Wapen van Hoorn*, the pattern of prevailing wind in the northeastern Atlantic might have been different during the late Grindelwald Fluctuation than it was in the Maunder Minimum. More common westerlies may have slowed departing vessels while accelerating returning ships, but such a trend would be at odds with Lamb's analysis of prevailing winds across seventeenth-century England. Unfortunately, efforts to develop firm conclusions regarding changes in patterns of prevailing wind across the northeastern Atlantic in the sixteenth and early seventeenth centuries are undermined by the dearth of sufficiently numerous and continuous high-resolution sources that record contemporary wind direction.⁸⁰

More of these sources survive from the late seventeenth and eighteenth centuries. They reveal that the onset of the Maunder Minimum was most importantly expressed for VOC mariners through a rise in the frequency of easterly winds and, perhaps, high-velocity northerly winds. These winds influenced outbound and inbound voyages on a scale dramatically reflected in ship logbooks and, somewhat less vividly, day register statistics. Despite relatively small sample sizes, logbooks kept aboard ships sailing in the northeastern Atlantic strongly support previous studies by indicating that easterly winds were indeed unusually common during the Maunder Minimum. They also suggest that outbound vessels harnessing these winds usually travelled far more quickly through the Atlantic than ships struggling against westerlies.

⁸⁰ Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 31.

Far fewer logbooks of sufficient precision survive to record characteristics of inbound ship journeys, but relevant eighteenth-century logs suggest that returning ships travelling along the back way were affected by different winds than those that influenced vessels sailing south of the British Isles. For inbound vessels taking the back way, the balance between southerly and northerly winds was probably the most important contributor to daily distance travelled, while returning vessels travelling along the peacetime route through the English Channel were likely particularly subject to wind velocity. Neither changes in the frequency of northerly and southerly winds, nor shifts in average wind velocity, can currently be attributed to the influence of Little Ice Age minima or maxima in the northeastern Atlantic. Still, in the North Sea region high winds blowing at or above 34 knots were more frequent during the Maunder Minimum, and inbound vessels might have harnessed these to their benefit.⁸¹

As comparatively low-resolution sources that provide largely indirect meteorological data, day registers contain evidence that is mediated by more variables than complicate the relatively straightforward relationships between weather, observer, and ship recorded in logbooks. Nevertheless, when filtered for known socioeconomic influences, day registers reveal that the average time spent at sea for ships sailing from Texel to Batavia decreased substantially during the Maunder Minimum. The registers also demonstrate that this gradual shift was at times masked by random variation, but nevertheless primarily reflected changes in the time ships took to cross the Atlantic. Moreover, the register reconstructions indicate that outlier voyages of extreme length, which generally signalled dramatically increased time at sea, were much less common during the heart of the Maunder Minimum than they were before or after. Day registers consequently suggest that relationships between changes in prevailing weather in the

⁸¹ Wheeler et. al., "Atmospheric circulation and storminess derived from Royal Navy logbooks," 18.

northeastern Atlantic and daily distance covered by outbound ships, recorded in logbooks, affected the duration of the entire passage to Batavia.

Day registers recording voyages from Batavia to Texel reveal that interactions between climate, weather, and inbound journeys were more ambiguous than they were for outbound passages. For vessels returning to Texel, extremely long or short “outlier” voyages were less common than they were for outbound ships, but in both reconstructions extreme journeys were less common after the onset of the Maunder Minimum. Screening for socioeconomic influences reveals that average time passed at sea may have increased for inbound ships during the Maunder Minimum, but this did not reflect a significant shift in the time ships spent in Atlantic waters. Moreover, the general trend in 110 years of inbound VOC journeys was relatively stable. A slight overall decrease in total journey time contrasted with an equally marginal increase in the average passage through the Atlantic. It may be that more frequent easterly winds and, perhaps, more common northerly winds slowed returning vessels, even if high velocity winds that could be harnessed were also more abundant. Still, the relatively low resolution data provided within day registers undermine any attempt to develop firm conclusions from such a slight trend, particularly given the absence of abundant and continuous ship logbook information.

Ultimately, in the northeastern Atlantic changes to prevailing wind direction and velocity accompanied the climatic minima and maxima of the Little Ice Age in the seventeenth century. These changes influenced both the speed and the bearing of VOC ships at sea, affecting their passage through the Atlantic in ways that influenced long-term shifts in average total journey duration. For outbound ships the transition to the colder climate of the Maunder Minimum was particularly significant. In the final decades of the seventeenth century an unusual abundance of high, easterly and, possibly, northerly winds reduced average journey times for vessels departing

Texel, and although more ships succumbed to storms such calamities remained rare. On the other hand, during the Little Ice Age cold decades in the north Atlantic likely influenced the strength of the Asian summer monsoon, lessening regional precipitation and, in particular, the average force of prevailing southwest winds. These southwest winds were critical for the redistribution of goods brought to Batavia by ships travelling in the Christmas and Fairs fleets.⁸²

Different elements of the VOC's vast trading empire were differently affected by the weather that accompanied the climatic oscillations of the Little Ice Age. However, changes to distinct aspects of the Company's commercial network did not counteract one another to nullify the influence of climatic fluctuation. Departing and returning vessels carried different goods, and sailed to different ports for different purposes. Outbound ships typically carried silver, information and instructions, essential prerequisites for sustaining the Company's trade in Asia and defending its monopoly from other European powers. Inbound ships, on the other hand, transported the profits of the commerce enabled by their outbound counterparts. Consequently, changes to outbound travel times were more influential to the success of the VOC's commercial operations than shifts in inbound journey duration. Information about regional prices or newly hostile entities was most effective if it arrived quickly, and could be entirely irrelevant if delayed. Precious metals could be employed most effectively if used with the most current market information to maximize profit. Moreover, rapid passage along the cart track allowed outbound vessels belonging to the Christmas Fleet to arrive in Batavia before the conclusion of the summer monsoon. Prevailing southwest winds might have been weaker during the minima of the Little Ice Age, yet they could still be employed to stimulate the Company's intra-Asian trade if vessels from Batavia arrived on time. Accordingly, the weather that accompanied the Maunder

⁸² Anil K. Gupta et al., "Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean." *Nature* 421 (2003): 356.

Minimum in the North Sea region, and perhaps the broader North-eastern Atlantic, could have provided important commercial and military advantages to the VOC. Because the Dutch long dominated the commerce with and within Asia, this could have benefitted the Republic's economy in the context of late seventeenth-century Europe.⁸³

Ultimately, shifts in prevailing weather were one influence among the many that shaped early modern waterborne traffic between Europe to Asia. For example, during the life of the VOC, changes in prescribed routes, and the increased availability of way stations along the cart track, reflected economic and political imperatives that affected ship voyages at least as much as contemporary climatic shifts. The effect of these developments is readily visible in a reconstruction of both outbound and inbound VOC journey times, even though changes in ship size, and especially ship age, do not appear to have greatly impacted voyages from Texel to Batavia. As it was in the Arctic, in the Atlantic the climatic shifts of the Little Ice Age affected mobility across the world known to the Dutch, but their influence was mediated by cultural, social, and economic structures that were, in turn, shaped by personal agency.

⁸³ Gaastra, *The Dutch East India Company*, 111. Jacobs, *In Pursuit of Pepper and Tea*, 60.

Chapter 3

Supplying the Metropole in the Little Ice Age: Mobility Within, and Near, the Dutch Republic

For the merchants and mariners of the Dutch Republic, neither journeys of exploration nor the exploitation of discovered realms would have been possible without the wealth and expertise gleaned from commerce in European waters. For much of the Republic's history, the most important intra-European trade was with the cities that bordered the Baltic, which emerged as the vital link in a single-season triangle trade that included ports in the Low Countries, France and Iberia. Dutch merchants ultimately wrested the mastery of this lucrative trade from the Hanseatic League or Hanse, a mercantile confederation of German towns that had gradually solidified around Lübeck in the first decades of the thirteenth century. For nearly two centuries the Hanse competed with Baltic powers and, eventually, Dutch towns for control of Baltic commerce, as economic disputes frequently erupted into open warfare.¹

At last representatives of Holland, Zeeland, and Friesland obtained major regional trading privileges in 1443, after Dutch raids and blockades in the Baltic supported the new king of Denmark in a war against the Hanse. Despite the relentless political machinations of the Hanseatic League and the enduring threat of piracy, by 1497 Dutch ships already accounted for the vast majority of merchant vessels entering the Baltic. Unlike their Hanseatic competitors, Dutch merchants could deploy the shipping capacity of off-season herring busses. Many seamen

¹ David Nichols perceptively writes that “the much-discussed shift of economic pre-eminence from the Mediterranean to the Atlantic economies in the sixteenth and seventeenth centuries was preceded and made possible by the development of an economic region through a dense network of trading ties that developed after the late thirteenth century in the areas of Germanic speech bordering the Baltic and North Seas.” David Nicholas, *The Northern Lands: Germanic Europe, c. 1250-c. 1500*. (Chichester: John Wiley & Sons Ltd., 2009), xi, 319. Charles E. Hill, *The Danish Sound Dues and the Command of the Baltic*. (Durham: Duke University Press, 1926), 10. Louis Sicking, *Neptune and the Netherlands: State, Economy, and War at Sea in the Renaissance*. (Leiden: Brill, 2004), 209. Aksel E. Christensen, *Dutch Trade to the Baltic about 1600: Studies in the Sound Toll Register and Dutch Shipping Records*. (Copenhagen: Einar Munksgaard, 1941), 18, 271.

from the towns of Holland sought employment in colder months, and the large busses could therefore be easily crewed with low-cost labour. Moreover, the already large and flexible Dutch merchant fleet benefitted from easy access to herring, salt, textiles, and other goods highly valued in Baltic ports, which in turn supplied timber, metals, and especially grain.²

Events surrounding the rise of an independent Republic in the Low Countries perpetuated the advantages that had already allowed Dutch traders to dominate Baltic commerce in the first years of the sixteenth century. The influx of wealthy merchants from the southern Low Countries contributed to Amsterdam's emergence as the preeminent European entrepôt, and financed the expansion of Dutch industry. The subsequent surge in high-value, low-volume commodities and finished goods produced within the Republic flowed into Baltic ports, which supplied increasingly diverse bulk goods in return. In 1595, a series of technological improvements executed by shipwrights culminated in the development of the flute, a specialized merchant vessel that further reduced labour costs by requiring minimal crews. By now, Baltic commerce was referred to as the *moeder negocie*, or “mother of all trades,” not only owing to its scale, but because its profits and commodities were crucial to the broader health of the Dutch economy.³ Indeed, at the Republic's zenith in 1650 some 4,000 Dutch flutes sailed into the Baltic, accounting for 95% of all ships hauling goods between the region and the rest of Europe. Grain remained the most significant commodity returned to a Republic where commercialized

² De Vries and Van der Woude, *The First Modern Economy*, 351. Hill, *The Danish Sound Dues and the Command of the Baltic*, 20. Milja van Tielhof, *De Hollandse graanhandel, 1470-1570: koren op de Amsterdamse molen*. PhD Diss, Universiteit Leiden 1995).

³ In 1666 the Baltic trade accounted for as much as 75% of the capital active on the Amsterdam bourse. In the Republic, the trade was also called the “vital nerve” or “soul” of commerce. Barbour, *Capitalism in Amsterdam in the 17th Century*, 27. Christensen, *Dutch Trade to the Baltic about 1600*, 20.

agricultural production was attuned to external markets and insufficient for the local requirements of a highly urbanized population.⁴

Unlike their colleagues plying more glamorous yet less essential trades to distant ports, the mariners and merchants who sustained the Baltic trades found little benefit in the weather that accompanied the coldest decades of the Little Ice Age. For the many employees of the VOC, more common storms and shifting patterns of prevailing wind during the Maunder Minimum provided more advantages than disadvantages. For explorers seeking a Northeast Passage, the influence of meteorological conditions typical of Little Ice Age minima hampered efforts to reach Asia, but encouraged new and eventually very profitable discoveries in the Arctic. The environmental manifestations of climatic fluctuation that most influenced Baltic commerce were the same as those that mattered most for explorers in the Arctic. Ice and storms could guide voyages of exploration to lucrative new discoveries, even if such discoveries were unanticipated. Sailors plying Baltic trades, on the other hand, knew that the successful completion of their journeys depended on their arrival at a particular destination.

During the minima of the Little Ice Age, sea ice that expanded rapidly in frigid winters and melted slowly in cool springs prohibited the progress of Baltic merchant vessels, while more common storms threatened lives and livelihoods. Unlike East Indiamen, flutes bound for Baltic cities frequently restocked in northern ports where sudden freezing could prohibit departure, and sailed across waters that could be entirely sealed by sea ice. Gales, moreover, were often deadly to crews aboard vessels that sailed near lee shores but were far less seaworthy than larger VOC ships. The consequences of storms and ice were rarely straightforward, and affected more than those directly involved in each Baltic voyage or, more broadly, the flow of commodities between

⁴ Maarten Prak, *Gouden Eeuw*, 105. Price, *Dutch society*, 70. De Vries and Van der Woude, *The First Modern Economy*, 357. Sicking, *Neptune and the Netherlands*, 6. Milja van Tielhof, *The Mother of All Trades: The Baltic Grain Trade in Amsterdam from the Late 16th to the Early 19th Century*. (Leiden: Brill, 2012), 7.

European ports. Delays influenced by the telltale weather of Little Ice Age minima could encourage legal wrangling, complicate diplomatic relations, and interfere with the success of armies in the field.

Historians of the Dutch Republic continue to debate the relative modernity of the Dutch economy and the importance of its different commercial enterprises between the sixteenth and nineteenth centuries.⁵ Recently, they have explored the complex economic, cultural, and political processes behind the changing spatial dynamics of Baltic commerce. New studies have also considered interactions between the Republic's rich knowledge culture and the sophisticated commercial practice of its merchants, in the Baltic and elsewhere.⁶ Overall, many historians of renaissance and early modern Baltic "bulk" trade have referred to the influence of weather, but very few have mentioned the Little Ice Age. For example, in his comprehensive survey of the commercial and military history of the Low Countries before the establishment of the Republic, Louis Sicking in 2004 briefly described how favourable winds affected voyages to and from the Republic, but he did not link such winds to broader climatic trends. In his 2006 study of Amsterdam's entrepôt economy, Clé Lesger mentioned weather only while listing alternative meeting sites for early modern merchants. In these short passages he also ignored the influence of the Little Ice Age. Jan Luiten van Zanden did not refer to weather at all in his earlier survey of the Dutch economy between 1350 and 1850, or indeed in his subsequent studies of economic developments before, during, and after the Republic's Golden Age.⁷

⁵ Van Zanden, "The 'revolt of the early modernists,'" 632. Davids, *The Rise and Decline of Dutch Technological Leadership Vol. I*, 17.

⁶ Werner F. Y. Scheltjens, "The Changing Geography of Demand for Dutch Maritime Transport in the Eighteenth Century." *Histoire & mesure* 27:2 (2012): 3. Clé Lesger, *Handel in Amsterdam ten tijde van de Opstand*, 190.

⁷ Sicking, *Neptune and the Netherlands*, 322. Clé Lesger, *The Rise of the Amsterdam Market and Information Exchange: Merchants, Commercial Expansion and Change in the Spatial Economy of the Low Countries, C. 1550-1630*. (Farnham: Ashgate Publishing Ltd., 2006), 245. J. L. van Zanden, *Arbeid tijdens het handelskapitalisme: Opkomst en neergang van de Hollandse economie 1350-1850*. (Hilversum: Uitgeverij Verloren, 1991) 11. Joerg

Still, early modern climatic fluctuations have not escaped the notice of all Dutch historians of the Baltic economy. Ad van der Woude and Jan de Vries briefly acknowledged that "climatic shocks" coincided with the early modern expansion of Dutch commercial networks. Moreover, in her detailed analysis of the Baltic grain trade, published in 2003, Milja van Tielhof included a case study of Dutch merchant Willem de Clercq in the early nineteenth century. As part of this case study, Van Tielhof explained how annual fluctuations in weather, associated with the last great minimum of the Little Ice Age, influenced grain prices and, in turn, the profitability of De Clercq's business in the Baltic. Nevertheless, historians of the Dutch Republic at its height have generally ignored relationships between climatic fluctuations and Dutch commerce in the Baltic, particularly as they were expressed in the voyages conducted by the Republic's seamen.⁸

This chapter begins with a statistical reconstruction of Dutch shipping through the Baltic during the Little Ice Age. It then explores correspondence written by Dutch citizens in the Baltic during the final years of the Maunder Minimum, which reflect the full complexity of relationships between weather and human activity in the region. It continues by examining how changes in average wind direction and velocity that accompanied Little Ice Age minima may have influenced Dutch voyages to and from the Baltic. It also investigates the possible relationship between climatic fluctuations, cold winters, the price of grain, and the profitability of the Baltic grain trade. Next, it introduces the Dutch transportation system in the metropole itself, within the borders of a Republic that was divided between a low-lying, watery west and a hillier, drier east. Using correspondence, diary entries, and toll accounts, it describes how different kinds of standardized travel through the canals of the coastal provinces were differently

Baten and Jan Luiten van Zanden, "Book production and the onset of modern economic growth." *Journal of Economic Growth* 13 (2008): 217.

⁸ Van Tielhof, *The Mother of All Trades*, 298. De Vries and Van der Woude, 199.

affected by weather that accompanied Little Ice Age minima and maxima. Finally, it concludes with an analysis of travel on roads and by boat, humbler modes of mobility that were affected by contemporary climatic fluctuations in distinct ways.

Climatic Fluctuation and Sea Ice Extent in the Sound Toll Registers

Shortly after 1420, the fortress that would later be expanded to become Kronborg castle was constructed near Copenhagen in the Sound, a narrow passage that affords easiest access to the Baltic from the sea area of the Kattegat, which in turn connects to Skagerrak and the North Sea (Map 3.1).⁹ Dues for passing ships were under consideration as early as 1423, and by the command of King Erik they were first implemented six years later, much to the consternation of the Hanseatic towns. The Sound's development as a vital strategic corridor for Baltic commerce coincided with the failure of regional herring fisheries that had contributed greatly to Danish prosperity. Subsequently the Sound tolls emerged as a principal source of income for the Danish crown, and the state's professed control of its vital shipping corridor was central to Denmark's influence within Europe.¹⁰

⁹ "Kattegat" or "Cat Gate" was so named by medieval mariners because the passage afforded by the sea lane into the Baltic was so narrow that even a cat would have difficulty fitting through.

¹⁰ The Sound tolls accounted for as much as 10% of the income of the Danish state. J.W. Veluwenkamp, "Sound Toll Registers: Concise source criticism," 1. Accessed 10 August 2013, <http://www.soundtoll.nl/images/files/STRpdf.pdf>. Hill, *The Danish Sound Dues and the Command of the Baltic*, 11. Nicholas, *The Northern Lands*, 56.



Map 3.1. The tollhouse of Elsinore (highlighted), and nearby Kronborg castle, in 1588. Inset: general location of the Sound (highlighted) in a map of Western Europe published in 1630. Bottom left: Kronborg castle. Originally compiled by Jan Jansson, the map was coloured sometime after its publication. Jan Jansson, “Nova Europae Descriptio,” in *Atlantis maioris appendix*. Amsterdam: Ioannis Ianzonii, 1630. Georg Braun and Franz Hogenberg, *Civitates Orbis Terrarum Vol. IV*. Cologne, 1588.

Dues exacted on vessels passing through the Sound were meticulously recorded by officials in the tollhouse of Elsinore, in registers that provide critical information about the characteristics of voyages, ships, and crews. Remarkably, registers recording 1.8 million passages have survived for approximately three hundred years between 1497 and 1857, and they have emerged as an invaluable primary source collection for economic historians of early modern Europe. In a recent initiative supported by the University of Groningen and Tresoar, the Frisian Historical and Literary Centre at Leeuwarden, the Sound toll registers stored at the

Danish National Archives are being digitalized and made freely available online alongside powerful interpretive tools. Because the resulting data is quantified, standardized, continuous, and readily comparable to climatic reconstructions, the Sound toll registers can shed new light on the relationship between Baltic commerce and weather typical of Little Ice Age minima.¹¹

Admittedly, the information compiled within the registers also has limitations that are compounded by a lack of surviving ship logbooks relevant to the Baltic trades. The relatively small flutes that serviced the Baltic were not equipped by a centralized organization, nor were they individually crucial to the Republic's economic prosperity. Consequently, in the Baltic trades ship logbooks were either not kept or not preserved. Entries in the Sound toll registers recorded ports of departure alongside intended destinations, but dates of departure were not provided, and journey times to the Sound are therefore impossible to plot using the registers. Moreover, the toll accounts provide no information of damage sustained in the voyage to the Sound, and there is no mention of failed journeys. The many ships and crews that foundered in storms or succumbed to piracy are not listed in any sufficiently continuous source, so mortality in Baltic commerce cannot be measured. Worse, the Sound toll registers compiled prior to 1634 have not yet been quantified in ways that readily enable statistical analysis. Nevertheless, the stability of Dutch maritime culture and technology during the Golden Age enables broad conclusions regarding the relationship between weather, climate, and shipping in earlier decades.¹²

¹¹ "The Sound Toll Registers," Sound Toll Registers Online, accessed 2 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>. See also: Nina Ellinger Bang, *Tabeller over Skibsfart og Varetransport gennen Øresund 1497-1660, Vol. I-III*. Copenhagen: Gyldendalske Boghandel, 1906-1933.

¹² The Sound Toll registers written before 1634 will soon be entered into the database now available for records composed after 1634. That will enable statistical analysis in the format here presented of daily Sound Toll passages during the decades of the Grindelwald Fluctuation. In light of the pending entry of these documents into a standardized database, and the scope of the documents already entered into that database, the Sound Toll registers compiled prior to 1634 have not here been interpreted. Ultimately, it is highly unlikely that Dutch shipping in the

On the other hand, the Sound Toll registers do allow the reliable reconstruction of shifts in the flow of seaborne traffic into and out of the Baltic.¹³ Other routes granted access to the Baltic through the labyrinth of Danish islands, but these were hardly navigable and very rarely attempted. Roads could be used, yet travel by land was not practical for the large-scale transport of commodities. Some captains attempted to avoid the dues altogether, but the odds were slim that any could escape the notice of Kronborg castle and the patrolling guard ship nearby (Map 3.1). Ultimately, because most Baltic trade during the Golden Age of the Republic was carried aboard Dutch ships that were not based in the Baltic, the tolls faithfully record the annual heartbeat of regional commerce.¹⁴

The Sound toll registers reveal that changes in the monthly quantity of dues paid by passing captains accompanied particularly warm and cold winters during the Maunder Minimum (1662-1718) and the warmer decades that preceded the Dalton Minimum (1760-1850). Of course, the variability of weather and the recurrence of El Niño, La Niña, and other forcing agents beyond those that contributed to gradual climatic shifts, ensured that balmy winters and warm summers could occur during the coldest phases of the Little Ice Age. By far the warmest winter of the Maunder Minimum affected the Dutch Republic and the Baltic in 1685/86, and the following summer was also hotter than the twentieth-century average. The winter temperature in 1686/87 matched the twentieth-century average, rendering 1686 a remarkably warm year in the context of the Maunder Minimum. Not surprisingly, shipping through the Sound followed its usual pattern of high volume during the summer and low volume in the winter. Even weather in

decades before 1634 responded differently to changes in the amount of sea ice in the Sound than it did in the century after 1634. Veluwenkamp, "Sound Toll Registers: Concise source criticism," 2. Jan Glete, *Warfare at Sea, 1500-1650*. (New York: Routledge, 2000), 29. Christensen, *Dutch Trade to the Baltic about 1600*, 23, 25.

¹³ Fluctuations in Baltic traffic could, in turn, be related to Danish finances and perhaps the fortunes of the Danish economy, and indeed other Baltic economies, but that is outside the scope of this study.

¹⁴ Veluwenkamp, "Sound Toll Registers: Concise source criticism," 2.

unusually warm winters could imperil ships plying the Baltic trades. However, the curve generated in a line graph by the quantity of passing ships during a regular distribution of traffic through the Sound was relatively shallow, because after its brief winter hiatus shipping already resumed at substantial rates in late February, and continued at high volume until the last week of December (Figure 3.1).¹⁵

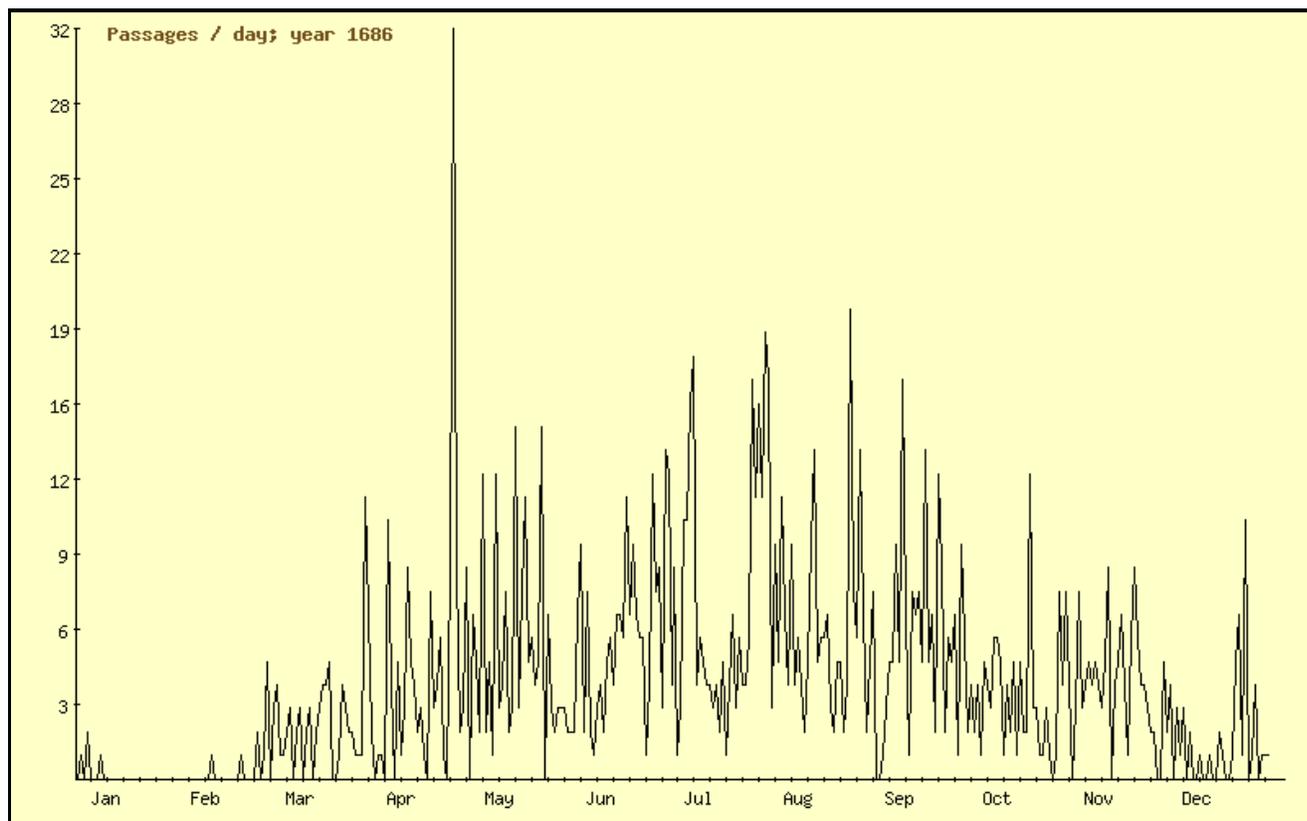


Fig. 3.1. Daily passages through the Sound in 1686. These and other graphs were compiled using statistical tools available through the Sound Toll Registers Online database.

Nine years later, the Baltic region suffered through one of the coldest winters of the Maunder Minimum, and the subsequent summer was the coolest since the “year without

¹⁵ Van Engelen, Buisman and Ijnsen, “A Millennium of Weather, Winds and Water in the Low Countries,” 112. “The Sound Toll Database,” Sound Toll Registers Online, accessed 3 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>.

summer” in 1628. However, temperatures during the following winter paralleled the twentieth-century average. The Sound toll registers reflect a complete cessation of shipping during the frigid winter of 1694/95, with an aborted resumption in late March and sustained traffic beginning only in April. Unusually extensive sea ice, stimulated by sustained freezing, was almost certainly the primary culprit for the interruption in Baltic shipping. In January and February, rivers across Europe from the Thames to the Elbe were frozen, and in Holland the most significant stretch of sub-zero temperatures persisted for three straight weeks between 20 January and 10 February. In major harbours during cold winters, sailors in icebreakers and labourers on foot struggled to prevent the accumulation of ice, and taxes were subsequently levied on ship owners. In extreme conditions typical of Little Ice Age minima, thick sea ice along the coast of the Republic could extend beyond the Zuider Zee and accumulated along the North Sea shore, while the Baltic was largely closed due to sea ice. Large-scale Baltic commerce was impossible while the ice lingered (Figure 3.2).¹⁶

Overall, in 1695 the volume of tolls recorded in the Sound toll registers was significantly higher than it had been in 1686, and on two summer days more than 130 captains paid their dues at the tollhouse of Elsinore. Economic, cultural, and political stimuli influenced the yearly volume of Baltic trade, but the complete interruption of regional commerce during the previous winter might have contributed to the unusually high volume of summer shipping. Voyages that were delayed in the winter were likely not aborted but rather postponed, because timber, grain, metals, and other Baltic goods were necessary commodities in a Republic that, without them,

¹⁶ Van Engelen, Buisman and Ijnsen, “A Millennium of Weather, Winds and Water in the Low Countries,” 112. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675-1750*, 213. Claas Arisz. Caescoper, “Jornael 1695.” *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad), 129. Staten van ontvangst van het klompwachtsgeld. 1680 – 1794. Reference code: 502. Gemeente Amsterdam Stadsarchief (Amsterdam, Netherlands). Glaser and Koslowski, “Variations in reconstructed ice winter severity in the western Baltic from 1501 to 1995,” 184. Glaser, *Klimageschichte Mitteleuropas*, 52. Van Dam, Petra J. E. M., “Water, Steam, Ice. Environmental Perspectives on Historical Transitions of Water in Northwestern Europe. *Nova Acta Leopoldina* 98:360 (2009): 37.

could neither feed its own population nor support its industries and networks of trade.

Ultimately, the Sound toll registers reveal that substantial traffic continued through the Sound in the milder winter of late 1695, and dues did not cease until midway through December.¹⁷

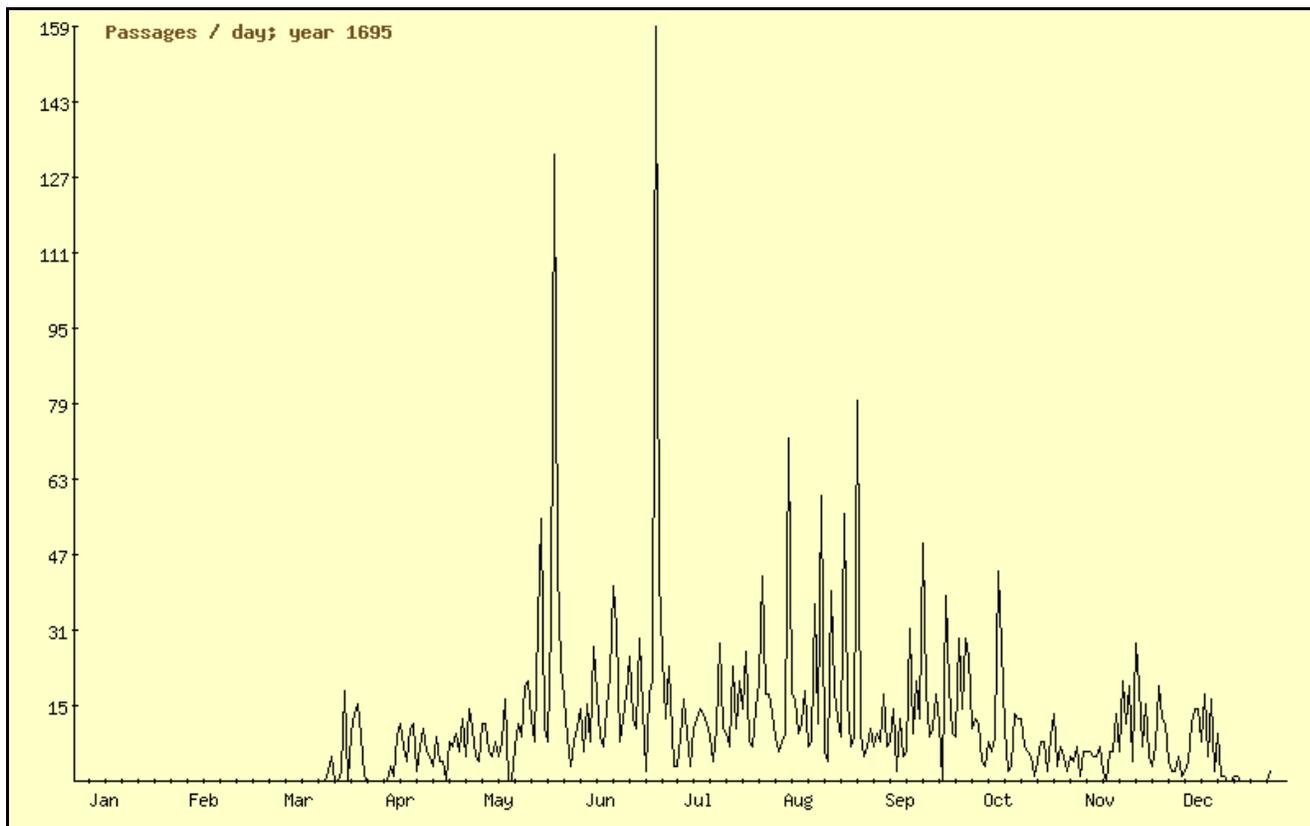


Fig. 3.2. Daily passages through the Sound in 1695.

Abnormally low winter traffic through the Sound and unusually late resumption of Baltic commerce accompanied all particularly cold regional winters during the Maunder Minimum (Figure 3.3). The winters of 1697/98 and 1708/09 were just as icy as the winter of 1694/95, and in these years traffic ceased entirely during the season. Even colder was the winter of 1683/84,

¹⁷ “The Sound Toll Database,” Sound Toll Registers Online, accessed 3 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>. Van der Goes, “Hage, den 27 February 1670.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II.*, 113.

perhaps the chilliest of the Little Ice Age, and the flow of vessels through the Sound was similarly halted. While frigid, the winter of 1673/74 was not quite as cold. However, it lingered long into the spring, and shipping was even slower to resume than it was in 1683/84. In all four winters, traffic through the Sound was entirely halted for at least two months.¹⁸

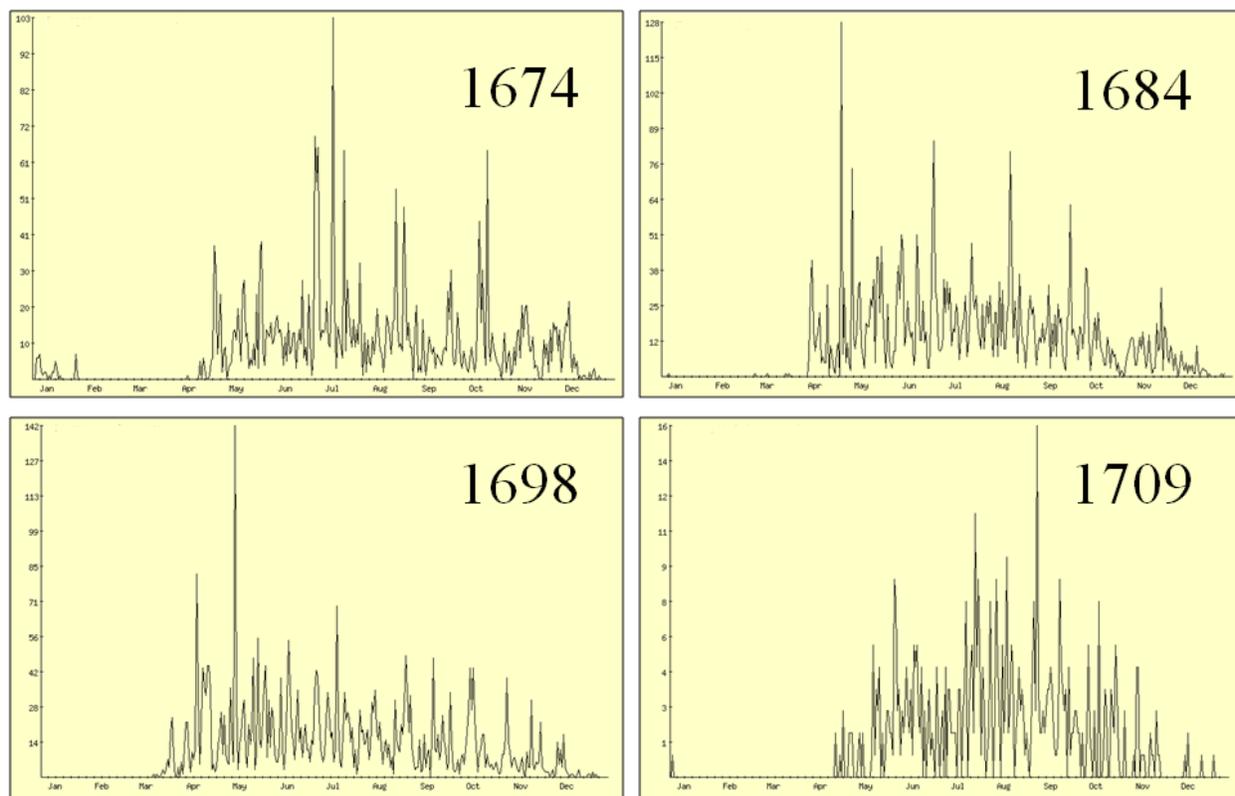


Fig. 3.3. Traffic through the Sound during particularly cold years in the Maunder Minimum (1662-1720).

By contrast, Baltic commerce persisted in warm and comparatively ice-free winters before and after the Maunder Minimum, albeit at substantially lower volume than in spring, summer and fall (Figure 3.4). For example, in the mild winter of 1723/24 a steady trickle of ships passed through the Sound in February, and in similar conditions thirteen years later 12 ships paid

¹⁸ “The Sound Toll Database,” Sound Toll Registers Online, accessed 3 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>.

their dues in January. Indeed, passages through the Sound did not cease for more than a few weeks during the moderate winters of 1636/37, 1660/61, 1723/24, and 1736/37, whereas in the frigid winter of 1708/9, for example, shipping had been halted for nearly four months. More importantly, shipping resumed to peak volume much earlier in the year during mild winters than it did in cold winters. If traffic did not reach high volumes until April or even May during cold winters, it approached peak volume as soon as early March in mild winters.¹⁹

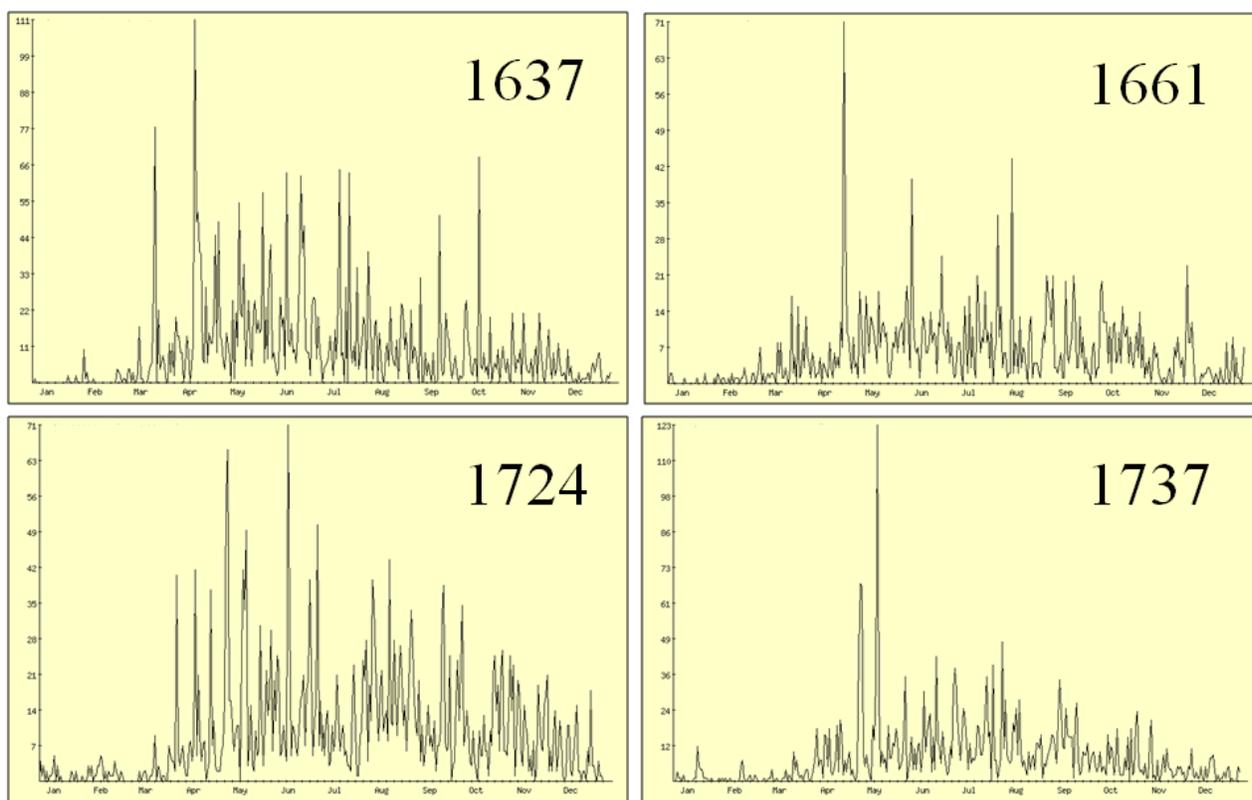


Fig. 3.4. Traffic through the Sound during comparatively warm years before and after the Maunder Minimum.

Severe winters and moderate winters influenced Baltic passages through the Sound in distinctive patterns, and the characteristics of cold or warm winters could differ in ways that had

¹⁹ “The Sound Toll Database,” Sound Toll Registers Online, accessed 3 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>.

important ramifications for Baltic commerce. For example, the winter of 1708/9 was both particularly cold and uncommonly long, with below-average temperatures persisting long into spring. Shipping ceased entirely for consecutive months, with the collection of dues at Elsinore only resuming midway through April. On the other hand, the generally frigid winter of 1697/98 was interrupted by weeks of thawing, and the last stretch of below-freezing conditions relented on 9 March. Consequently, traffic through the Sound resumed halfway through March, although its volume was relatively low until April. Ultimately, the Sound Tolls reveal that travel through the Sound was strongly affected by the changes in sea ice extent that accompanied the climatic fluctuations of the Little Ice Age.²⁰

Correspondence, Baltic Trade, and the Consequences of Sea Ice during the Little Ice Age

Quantitative reconstructions can highlight shared historical patterns and suggest correlation, but only qualitative sources can establish how different trends influenced one another. In the absence of ship logbooks, correspondence sent between the Republic and the Baltic provides the best evidence for the existence of a relationship between Baltic trade and prolonged or unusually extensive sea ice during the minima of the Little Ice Age. The letters sent to grand pensionary Heinsius by Dutch diplomats in the Baltic during the last years of the Maunder Minimum include especially detailed accounts of the complex ramifications of extensive regional ice cover in cold winters.²¹

On 11 January during the frigid winter of 1708/09, a letter to Heinsius from “Van Vrijbergen” described freezing across the Baltic so severe that ink froze in the pen,

²⁰ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. V, 255, 267, and 352.

²¹ Maria Bogucka, “Amsterdam and the Baltic in the First Half of the Seventeenth Century.” *The Economic History Review* 26:3 (1973): 435.

correspondence ceased, and people refused to leave their homes. A day later, “Goes”²² reported that the post from Hamburg was much delayed by the cold. He also revealed that 67 Dutch merchant vessels bound for the Republic were entrapped by ice in the Sound. On 14 January, correspondence from “Hulft” mentioned that “severe and violent frost” in the Baltic was preventing supplies from reaching allied troops fighting the ongoing War of the Spanish Succession. Stimulated by abnormally cold winter weather in the final decades of the Maunder Minimum, unusually extensive sea ice in 1708/09 undermined the Republic’s essential northern European networks of information, trade, and military supply. Not only was Baltic commerce halted through the Sound, but the allied position in the Baltic was temporarily paralyzed.²³

Nevertheless, on 15 January Goes wrote again to inform Heinsius that the grinding cold had diminished enough to allow most of the Republic’s merchantmen to retreat into Copenhagen’s harbour for overwintering. However, on 18 January the Sound had been sealed by ice that reached 73 centimetres thick, and an enormous ice field occupied the Kattegat. Indeed on 26 January Goes reported that *inijzen*, the process of extricating vessels from the ice and returning them to the relative safety of a harbour, was proceeding more slowly than expected. According to Goes, difficulties in the work were compounded by the disunity and insubordination of the Dutch captains, who were apparently not used to following orders. Goes did not mention whether some civilian captains refused Danish help, insisted on attempting a passage through the ice, or in other ways hampered *inijzen*. Regardless, undertones of class tension surfaced in the correspondence between Heinsius and Goes, who operated at the top of

²² Therefore not one of the Van der Goes brothers, whose correspondence is otherwise an important source in this dissertation. He was also not the Van der Goes who wrote from *De Beschermmer* in 1707 (Chapter 2).

²³ Van Vrijbergen, “Van Van Vrijbergen, 11 Januari 1709,” *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 188. Goes, “Van Goes, 12 Januari 1709,” *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 188. Hulft, “Van Hulft, 14 Januari 1709,” *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 191.

the Republic's social strata, as sailors ostensibly under the direction of the States-General confronted the peril imposed by the ice. However, such undertones did not surface regularly. On 2 February, Goes wrote only that *inijzen* continued, and a week later he reported that the last of the Dutch flutes had been safely escorted into Copenhagen's harbour.²⁴

On 10 March, "Hop" wrote from Ghent to report that traffic between the city and Zeeland had resumed, although with north-easterly winds the Leie remained frozen, and no ships had yet arrived from Holland. In fact, the ports of Amsterdam and the Republic's other northern commercial centres in its dominant province remained closed owing to ice. Indeed, on 30 March Heinsius received a letter from the Admiralty of Amsterdam, the wealthiest of the five admiralties that together outfitted the Dutch navy and supported its operations by collecting harbour tolls. The Admiralty grimly informed Heinsius that the collection of harbour duties ceased completely for four months in the severe winter Europe had just experienced. That was devastating, for without this income the Admiralties lacked both immediate cash reserves and ready credit to equip and supply the ships necessary for winning the ongoing war against France. "We can assure you," the letter concluded, "that this [Admiralty] was never in such dire need of coin as it is now."²⁵

Meanwhile, correspondence from Goes hinted that some merchant captains may have been correct to resist *inijzen*. On 12 March, Goes mentioned that Danish officials had dismissed

²⁴ Goes, "Van Goes, 15 Januari 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 192. Goes, "Van Goes, 26 Januari 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 211. Goes, "Van Goes, 2 Februari 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 232. Goes, "Van Goes, 9 Februari 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 249. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675-1750*, 344.

²⁵ "Wij konden U Weled. verseecken dat dit College noyt in soo grote necessiteyt van penningen is geweest als tegenwoordig." Admiraliteit van Amsterdam, "Van de Admiraliteit van Amsterdam, 30 Maart 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 395. Hop, "Van Hop, 10 Maart 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 325.

an earlier contract signed with Dutch captains, and now sought a higher payment for bringing the merchant fleet into Copenhagen's harbour. On 24 March, Goes wrote that negotiations were continuing between the parties, but in a detailed letter written on 13 April Goes reported that the dispute had moved no closer to resolution. Goes now revealed that in January the Copenhagen sailors' guild had either been incapable or unwilling to close a contract with the Dutch captains in the face of the extreme cold and ice. Consequently, the Dutch mariners agreed to a contract with a Danish naval officer, which bound them to pay 26 *rijksdaalders* for every ship brought into harbour by Danish sailors.²⁶ The total amount payable was supposed to be 1,742 *rijksdaalders*, yet the Danish officer now demanded 6,317 *rijksdaalders* because the ice was so thick and the cold so severe that the *inijzen* was much more expensive than anticipated. The Dutch captains refused to amend their original contract, Dutch proposals for mediation were dismissed, and Danish ministers had little taste for the involvement of the States-General.²⁷

Only on 23 April did Goes declare that the sea around Copenhagen was again open for shipping, although Dutch crews still awaited the resolution of the contractual dispute before they could depart for the Republic. Four days later an exasperated Goes wrote that he had offered to pay the difference between the original and revised fees, yet apparently distrustful Danish ministers had declined his proposal. On 30 April Goes reported that there was still no movement on the *inijzen* negotiations, and again blamed the intransigence of Dutch captains who were unwilling to listen to his counsel until it was too late. Nearly five months after the Dutch merchant fleet was first rescued from the ice on the Sound, Goes wrote on 11 May that both parties remained deadlocked, with the Danish officer insisting that no contract had ever been

²⁶ The *rijksdaalder* or "national dollar" was the currency of the Dutch Republic.

²⁷ Goes, "Van Goes, 12 Maart 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 333. Goes, "Van Goes, 24 Maart 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 369. Goes, "Van Goes, 13 April 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 436.

drafted. On the other hand, Dutch captains were now raising funds through merchants to cover the outstanding payment, and on 18 May a large convoy that included seven warships arrived from the Republic. Under the protection of the warships, on 25 May the approximately 70 ships that constituted the long-delayed merchant fleet finally departed for their home ports.

Unfortunately, there is no indication in the Heinsius correspondence of how the dispute was ultimately resolved.²⁸

Sea ice was a regular occurrence even when Baltic winter temperatures matched the twentieth-century average. For example, in December during the moderate winter of 1709/10, Hamburg merchant vessels bound for the Republic and laden with grain were seized by Danish troops. Sea ice had trapped the ships in Altona, a Danish harbour near Hamburg, and accordingly their crews were unable to escape. Representatives of the States-General protested to Danish authorities, who unconvincingly insisted that the Republic would be compensated for its lost imports.²⁹ Still, in the correspondence between Heinsius and his Baltic agents, reports of sea ice and its consequences were greatly diminished during the winter of 1709/10, compared to the year before. Moreover, the letters Heinsius received in the frigid winter of 1708/09 reveal the cascading ramifications for Baltic commerce of particularly severe winter freezing along the shores of northern European waters. Not only did unusually expansive ice contribute to the

²⁸ Goes, "Van Goes, 23 April 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 458. Goes, "Van Goes, 27 April 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 472. Goes, "Van Goes, 30 April 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 479. Goes, "Van Goes, 11 Mei 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 506. Goes, "Van Goes, 18 Mei 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 522. Goes, "Van Goes, 21 Mei 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 527. Goes, "Van Goes, 25 Mei 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*, 536.

²⁹ Goes, "Van Goes, 7 December 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 juli 1709 – 31 december 1709*, 490. Goes, "Van Goes, 17 December 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 juli 1709 – 31 december 1709*, 512. Van Engelen, Buisman, and Ijnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112.

complete cessation of Baltic commerce, which clearly would have persisted otherwise, but it was devastating for a Dutch navy that was supported, in part, by harbour tolls.



Fig. 3.5. The frozen harbour of Hoorn, a wealthy city on the Zuider Zee, possibly painted during the Maunder Minimum (1662-1720). Jan Abrahamsz Beersraten, "IJsvermaak bij de Hoofdtoren te Hoorn," painting, c. 1651-1666, http://www.colf-kolf.nl/1450-1700/3/details/Jan_Beerstraten_na_1651.htm.

Indeed, during the coldest winters of the Little Ice Age, Admiralty revenues provided by harbour dues dropped dramatically in the Republic's northern ports, while fees collected in southern ports were hardly affected. For example, during the cool winter of 1626/27 Amsterdam received £20,494 in toll revenue in January compared to £40,643 in March. The slightly more northerly towns of Hoorn and Alkmaar collected £66 and £0 in harbour dues during January, respectively (Figure 3.5). In March, tolls earned in both towns totalled £404 and £2,794, which in turn supported the operations of the Admiralty of Westfriesland and the Noorderkwartier ("North quarter"). By contrast, in January the more southerly city of Middelburg collected £9,427 in harbour revenue for the Admiralty of Zeeland, but just £5,696 in March and £9,648 in April. Rotterdam, meanwhile, contributed to the powerful Admiralty of the Maas with £8,635 in harbour duties in January, compared to only £7,682 in March and £10,012 in April. Ultimately, in the cold winters common during the minima of the Little Ice Age, freezing and sea ice disproportionately affected trade and, in turn, the collection of Admiralty revenues in the northerly cities that formed the commercial heartland of the Dutch Republic.³⁰

Letters that were eventually received by Heinsius or his agents also reveal that communications by Dutch officials in Baltic cities, often carried by ship, could suffer lengthy delays in frigid winters as vessels were trapped in harbours and couriers were forced to employ paths on land that were treacherous in the cold weather. Although written during the relatively moderate winter of 1718/19, correspondence sent by "De Bie" nevertheless reflected the full diversity of relationships between seasonal meteorological conditions, environmental structures and Baltic transportation. On 21 February De Bie wrote to Heinsius from Hamburg, and explained the cause of delays in the traumatic first leg of a secret diplomatic voyage to secure

³⁰ Harold Edward Becht, *Statistische gegevens Betreffende den Handelsomzet van de Republiek der Vereenigde Nederlanden Gedurende de 17e Eeuw (1579-1715)*. ('s-Gravenhage, Firma I.J.C. Boucher, 1908), xii.

restitution for Dutch ships and goods seized by the new Swedish regime of Queen Regent Ulrika Eleonora. De Bie's journey over land had been hindered by flooding, and he could not cross the high water by boat because of sudden freezing. At Winsen sea ice had, in fact, blown in from the Baltic with southwesterly winds, necessitating long detours. Thereafter constantly shifting meteorological conditions, expressed through bouts of heavy rain, freezing, blizzards, and fog, each contributed something different to delays in the slow voyage to Hamburg. De Bie promised that he would consult with others for guidance on the remainder of his journey, but for the moment he was stuck in Hamburg.³¹

Fortunately, De Bie's plight in Hamburg was a matter of logistics rather than sea ice, although he did reveal in a letter sent on 23 February that the Sound had recently frozen over. In a moderate winter during the transition from the Maunder Minimum to a somewhat warmer climatic regime, sea ice in the Sound had rendered the passage unnavigable some two months later than in 1708/09. Still, the ice was enough to dissuade De Bie from travelling near Copenhagen. Instead, he resolved to take an inland boat to Lübeck with the first favourable wind, from where he hoped to travel north through the Danish islands to the town of Ystad, located east of Copenhagen and just beyond the Sound. From there he would continue to Stockholm. On 2 March, De Bie wrote again to announce that he had departed Hamburg on the 24th and arrived at Lübeck on the 25th. He had arranged transport to Ystad with the captain of a galjoot, a Dutch merchant vessel, but variable winds and a combination of rain and snow had kept the ship in port

³¹ De Bie, "Van De Bie, 21 Februari 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*. (A.J. Venendaal Jr. (ed). Den Haag: Instituut voor Nederlandse Geschiedenis, 2001), 105. Michael F. Metcalf, "Conflict as catalyst: Parliamentary innovation in eighteenth-century Sweden." *Parliaments, Estates and Representation* 8:1 (1988): 66.

until the 28th. On 1 March, the oscillating conditions yielded to steady freezing with a northwesterly wind, and departure was impossible under such circumstances.³²

As De Bie wrote, however, the wind turned to blow from the southwest, a direction favourable for vessels departing the port of Lübeck. After sending his letter, De Bie resolved to discover if the ship could set sail, and he insisted that he would ask his captain to attempt a passage either through the Sound or the more southerly and more treacherous Great Belt, should the ice allow it.³³ However, in a missive sent on 6 March De Bie revealed that he was still in Lübeck. Four days earlier the wind had evidently shifted before the ship could depart, but the wind had turned to again issue from the southwest. The skipper now intended to take to the river on the following day, and sail from there to Travemünde, a nearby port that bordered the Baltic. That news was hopeful, but De Bie had received letters from Hamburg that reported that sea ice in the Sound had delayed correspondence.³⁴

For more than three weeks De Bie did not write again. Finally, on 30 March a detailed account of hardship and failure was sent to Heinsius from Stockholm. De Bie explained how he had departed for Travemünde on 7 March, yet a Danish captain had intercepted his ship in the harbour and would not let him continue without a passport. The captain insisted on waiting for new instructions until 10 March, and because the wind had turned to blow from the north and hindered further progress, De Bie agreed. The necessary passports soon arrived and the captain gave his consent, but although the wind had shifted again to issue from the south, the ship could not get to sea until early the next morning. On the evening of 8 March, De Bie and the crew of

³² De Bie, "Van De Bie, 23 Februari 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*, 116.

³³ A curious request. Passage through the Sound would first require the ship to sail northwest amid the Danish islands, and then southeast past Copenhagen to reach Landskrona and, in turn, Ystad. De Bie's captain ultimately took the more sensible route that remained west of Denmark and avoided passing through the Sound.

³⁴ De Bie, "Van De Bie, 6 Maart 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*, 121. De Bie, "Van De Bie, 2 Maart 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*, 108.

the galjoot encountered drift ice, and upon arrival at Landskrona on the morning of the 12th they found the entire coast beset with ice. They sailed beside the ice and happened across another vessel attempting to reach Ystadt. Both ships pressed through the sea ice and, with great difficulty, reached the vicinity of the town, only to find the haven choked with an even greater quantity of ice.³⁵

De Bie reached the coast despite a contrary north-easterly breeze, but further travel north by sea was clearly impossible. Unfortunately, De Bie had been obliged to leave his carriage in Lübeck owing to the small size of the galjoot, which forced him to buy passage through the Swedish countryside on a series of post wagons and farmers' wagons. De Bie reported that the land was hard to travel through, and that the farmers were unhelpful, so that, after a "long and miserable journey," he arrived in Stockholm no earlier than 27 March. In his letter De Bie beseeched Heinsius to understand why it had taken so long to reach the city, and with reason, because the delays were ruinous. After a series of wars with its neighbours, Sweden had fallen from the ranks of Europe's great powers, Russia dominated the Baltic, and the Rijksdag had reduced the Crown to a constitutional monarchy. By 27 March, captured vessels that might have been returned to the Republic, had De Bie arrived earlier, had already been sold to repair the Crown's beleaguered finances. In a short message sent on 1 April De Bie concluded that the Republic would likely not retrieve its ships and their goods.³⁶

The letters sent by De Bie during his ill-fated journey demonstrate the full complexity of interactions between climatic trends, weather conditions, environmental frameworks, and travel

³⁵ De Bie, "Van De Bie, 30 Maart 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*, 149.

³⁶ De Bie, "Van De Bie, 30 Maart 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*, 150. De Bie, "Van De Bie, 1 April 1719," *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*, 154. N. Kent, *A Concise History of Sweden*. Michael Roberts, *The Age of Liberty: Sweden 1719-1772*. (Cambridge: Cambridge University Press, 2003), 9. Lars Magnusson, *An Economic History of Sweden*. (New York: Routledge, 2002), 3.

through the Baltic. As in other years, in the winter of 1718/18 sea ice was the most important impediment to Baltic transportation, although the extent of regional ice was far less than it had been a decade earlier. Indeed, De Bie's voyage might have been impossible or, at least, even more difficult during the winter of 1708/09, although his correspondence reveals that sea ice was an impediment to regional transportation even during comparatively moderate winters.

Moreover, the relentless meteorological variability that accompanied a winter of average severity undermined De Bie's attempts to travel by land. Flooding might have been more easily surmountable were it not accompanied by subsequent freezing, and snow might not have been as bothersome if rain and fog did not immediately follow. The same likely did not apply for Baltic commerce, as thawing of any sort was indisputably better than continued freezing. Consequently, for much of the winter of 1718/19 a trickle of vessels continued to pass through the Sound, which was, of course, entirely closed in colder years. Still, the nature of De Bie's diplomatic mission reveals how the Republic's Baltic trade intersected with the many other reasons its citizens travelled through the region. Success for De Bie would have returned substantial capital to Dutch merchants in a time of economic stagnation, and success was thwarted not only by ice but also by conditions more common under a warmer climatic regime.

For Baltic commerce, the vulnerabilities of Dutch shipping technology and practice in the face of climatic fluctuation changed little from the beginning of the Grindelwald Fluctuation until the conclusion of the Maunder Minimum. Consequently, descriptions of sea ice and its consequences provided in the Heinsius correspondence echo through letters, diaries, and chronicles compiled during the height of the Golden Age, although few of these sources were as detailed or continuous as those collected by the grand pensionary of the Republic in the first decades of the eighteenth century. Nevertheless, on 12 February during the cold winter of

1585/86 Velius, the famed chronicler of Hoorn, described how a sudden transition from moderate conditions to high winds and freezing temperatures trapped eighteen ships in ice that rapidly accumulated near the harbour. However, some citizens of Hoorn used axes to break through the ice and free most of the beleaguered vessels, which were subsequently brought into port. Frigid weather during the following winter was also typical of the Grindelwald Fluctuation. For example, as freezing temperatures lingered in March 1586, farmer Abel Eppens described how the harbour of Delfzijl was blocked by sea ice that pressed forward in persistent easterly winds, trapping the ships within.³⁷

During the lengthy and remarkably cold winter of 1620/21, the Zuider Zee froze over entirely in persistent easterly winds, and sea ice extended beyond into the North Sea. In February, a ship heavily laden with commodities was trapped in ice between the northwestern coast of Friesland and the island of Terschelling. The vessel's cargo was carried in wagons across the frozen Zuider Zee to Amsterdam, Hoorn, and Enkhuizen. Pieter van Winsem, a lawyer at the Court of Friesland, reported that another merchant vessel was frozen in the ice at the same location, and would have to be unloaded. Meanwhile, Jan Hanszoon, a citizen of Harlingen, was trapped with his crew amid the sea ice as his ship approached Vlieland, one of the islands that divided the North Sea from the Zuider Zee. With staff in hand, Hanszoon, and presumably his crew, travelled by foot to the town of Harlingen. According to the scholar Pier Winsemius, "no one had ever heard of" such a deed. Even in the southerly city of Middelburg citizens struggled to break the ice that had sealed their harbour.³⁸

³⁷ Th. Velius, *Kroniek van Hoorn Band 2: 1560-1629*, ed. Jan Plekker and Rob Resoort. (Hoorn: Publicatiestichting Bas Baltus, 2007), 602. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575-1675*, 87 and 93.

³⁸ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575-1675*, 340. Pier Winsemius, *Chronique ofte historische geschiedenisse van Vrieslant, Vol. 20. (Franeker, 1622)*, 910.

Letters written within the Republic during the relatively moderate winter of 1636/37 described ice in regional harbours, correspondence delayed due to sea ice and contrary winds, and heavy sea ice in the Baltic, where the winter was cooler than average. Written by the well-connected scholars Hugo de Groot in Paris and Nicolaes van Reigersberch in The Hague, the letters were based on reports from the Baltic. They suggest that conditions common during the minima of the Little Ice Age could also accompany winters during the generally warmer decades of the seventeenth and eighteenth centuries. Nevertheless, in the Republic and even the Baltic freezing and corresponding disruptions in transportation were not as severe as they were during the coldest years of the Grindelwald Fluctuation or Maunder Minimum. Overall, letters compiled during the Republic's Golden Age reveal that the complex environmental manifestations of contemporary climatic fluctuations could influence, and generally undermine, many expressions of the Dutch relationship with the Baltic.³⁹

Wind Velocity, Wind Direction, and Baltic Commerce in a Shifting Climate

While storms were rarely mentioned in the Heinsius correspondence, other documents suggest that a rise in the frequency of regional gales shipwrecked more vessels supporting Baltic commerce during the minima of the Little Ice Age than were sunk in warmer, more tranquil decades. When quantified, references to shipwrecks in letters and diary entries reveal that, for flutes sailing to or from the Baltic, disasters on the coasts of Texel were substantially more common during the nadir of the Maunder Minimum than they were before or after (Figure 3.6). Unlike East Indiamen, however, there was usually no particular reason for flutes to linger near Texel, for they were light enough to enter the Republic's silted harbours even when filled to

³⁹ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575-1675*, 349.

capacity. Consequently, although reconstructions of shipwrecks off Texel can suggest broader trends, they do not reflect the scale of the calamities that could befall flutes and their crews in the severe storms of Little Ice Age minima, because most would not have foundered near Texel.⁴⁰

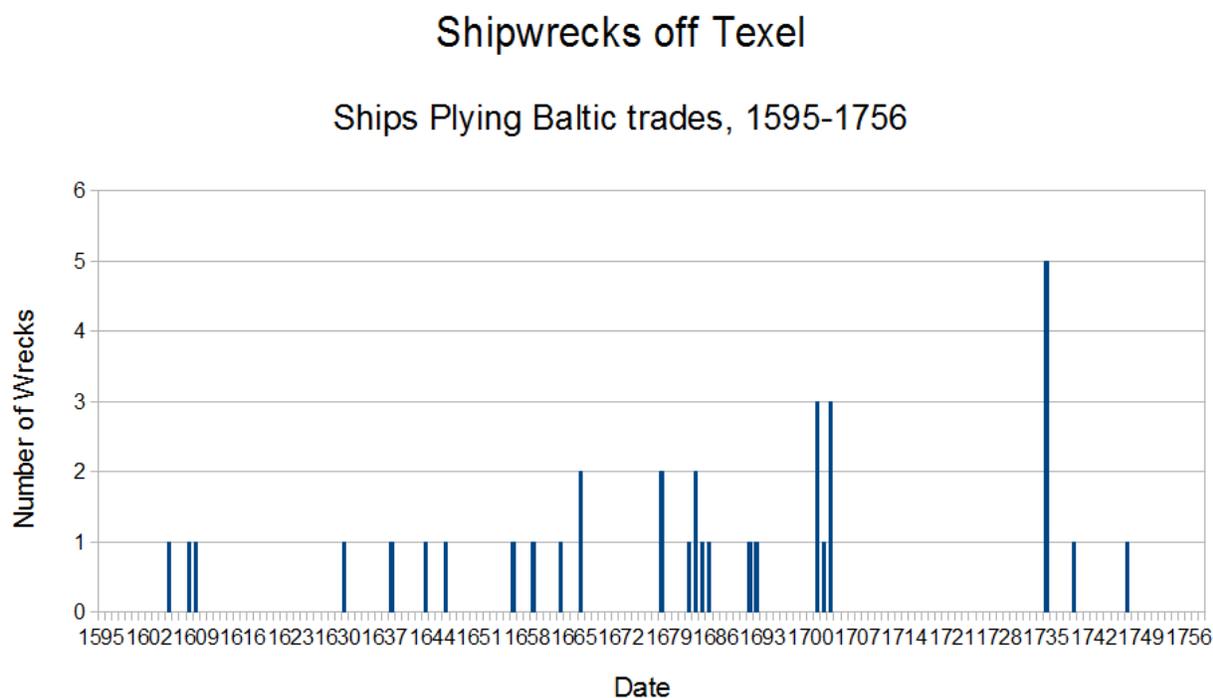


Fig. 3.6. Shipwrecks off Texel for vessels plying the Baltic trades, recorded in contemporary documents.

On 12 December 1659, in a cold winter just over two years before the beginning of the Maunder Minimum in the Low Countries, Adriaen van der Goes reported that, in the vicinity of The Hague, storms were unceasing and many merchant ships had stranded along the coast. On 18 August eleven years later, Van der Goes recounted that a merchant vessel had recently departed Rotterdam before being struck by lightning. The blast ruined much of the vessel's lucrative cargo and may have killed some of its crew, although Van der Goes omitted mention of the sailors on board. More severe storms affected the English Channel and the North Sea at the

⁴⁰ "Wrecks in Documents." Maritiem programma Nederland, Rijksdienst voor her Cultureel Erfgoed. Accessed 24 June 2013, http://www.maritiemprogramma.nl/WID_00.htm

nadir of the Maunder Minimum between 1695 and 1697, and the consequences were not limited to Dutch flutes. On 9 September 1695, as many as 1,000 mariners perished in shipwrecks across the North Sea as a series of storms imperiled regional commerce. On the evening of 21 September, a fierce gale tore ships from their anchors in English harbours and drove them into the Channel. Vessels were stranded along the coasts of France and the Low Countries, yet the night's greatest disaster was the loss of 70 English coal freighters along the shore of Norfolk.⁴¹

Intermittent frost in October of the following year succumbed repeatedly to thaws and accompanying gales that wrecked countless Dutch and English merchant vessels along the shores of the North Sea. In December, John Evelyn marvelled in his diary that “so wonderfull & perpetual Rainy season without frost, but exceeding greate storms wrecking many at sea, has not ben knowne in any mans [sic] memory.”⁴² Nevertheless, the mild but tempestuous autumn yielded to a bitterly cold winter that was accompanied by the rapid expansion of sea ice in the Baltic. In January and February, the icy conditions were joined by frequent storms that threatened shipping in the vicinity of the North Sea. In January, a Dutch warship under the command of Captain Jacob Schoon rescued the beleaguered survivors of a merchant vessel that had shipwrecked on the Norwegian coast nine days earlier. Most of the passengers and crew had already perished, but those who lived may have succumbed to cannibalism to sustain themselves. Recurrent and severe storminess likely persisted into the summer. In a diary entry written on 30 August 1697, Claas Ariszoon Caescoper reported that four days of unremitting storminess had contributed to numerous shipwrecks near Texel. For sailors near the Republic, the most threatening storms blew from the west, and such storms may have been less common during

⁴¹ Van der Goes, “Hage, den xij December 1659.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 51. Van der Goes, “Hage, den 18 Augusti 1659.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II.*, 146. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675-1750*, 224. Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 55.

⁴² Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675-1750*, 242.

Little Ice Age minima. On the other hand, that favourable change may have been offset by the greater frequency and severity of storms in colder decades, and indeed easterly winds created lee shores in other parts of a Baltic journey.⁴³



Fig. 3.7. A merchant vessel in a storm. During the Maunder Minimum, Dutch artists Willem van de Velde the Elder and his son, Willem van de Velde the Younger, painted many scenes of ships struggling through storms. Men of war often featured in these depictions, but this painting is an exception. Willem van de Velde the Younger, “A Dutch Ship Scudding Before a Storm,” painting, c. 1690, National Maritime Museum, <http://collections.rmg.co.uk/collections/objects/12397.html>.

Beyond destroying vessels already at sea, storms could also delay voyages by prohibiting or discouraging departure from port. For example, on 20 November 1670 Van der Goes informed

⁴³ Claas Arisz. Caescoper, “30 Augustus 1697.” *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad.

his brother that fourteen days of unrelenting gales had flooded nearby polders and prevented many ships from leaving port. Still, during lengthy gales the consequences of delays in the voyages of vessels travelling to or from the Baltic paled in comparison to the significance of shipwrecks, especially when extreme storms afflicted large convoys in times of war. Attempts to reunite scattered fleets could take weeks, compounding delays caused by vessels that remained in port to avoid stormy conditions, and exposing dispersed ships to enemy action. Worse, the loss of crews, commodities, and vessels was often complete, whether ships were dashed along the coast or sunk at sea during storms in the North Sea region (Figure 3.7).⁴⁴

To minimize financial risk, many merchants active in the Baltic trades distributed their goods in different ships. In the Republic, this “parcelling” appears to have accompanied the onset of the Grindelwald Fluctuation, and the corresponding rise in the frequency of storms in the North Sea region. After the first decades of the seventeenth century, parcelling separated those responsible for shipping from those who handled commercial activity. Most merchants now chartered vessels from shipmasters, and hired “factors” in Baltic ports to manage their business. As storms again grew more common and more severe in the late seventeenth century, merchants and shipmasters increasingly acquired marine insurance. Indeed the volume of insurance cases handled by the Republic’s Chamber of Insurance and Average appears to have risen in the wake of particularly severe winters.⁴⁵ Surviving documents do not mention if merchants and shipmasters were aware of long-term changes in prevailing weather. Regardless, those involved

⁴⁴ Van der Goes, “Hage, den 20 November 1670.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II.*, 160.

⁴⁵ Notably in 1709, 1726, 1729, 1740, 1763, 1784, and 1795. Sabine Go, *Marine Insurance in the Netherlands, 1600-1870: a comparative institutional approach*. (Amsterdam: Askant, 2009), 117.

in the Baltic trades responded creatively to environmental risks that grew more common during the minima of the Little Ice Age.⁴⁶

Of course, not only in the coldest years of the Little Ice Age did severe gales affect merchant shipping. For instance, over 20 merchant vessels, most returning from the Baltic, foundered on 6 January 1654 when a catastrophic storm struck an anchored Dutch convoy near Texel. Unusually frequent storminess may have affected shipping in the North Sea during the early 1650s (Chapter 4), yet such violent weather was even more common during the minima of the Little Ice Age. Indeed, the Sound toll accounts suggest that traffic through the Sound likely diminished during particularly stormy years in the Maunder Minimum. For example, the winter of 1694/95 was among the coldest of the Little Ice Age, but shipping through the Sound reached peak volume only long after the last ice had melted in the Baltic. Severe and persistent storms in the spring of 1695 may have encouraged some sailors to remain in port while contributing to the ruin of those who might otherwise have paid dues at the tollhouse of Elsinore (Figure 3.2). Four years later, temperatures matched their twentieth-century average, yet the winter of 1698/99 was distinguished by repeated storms that kindled fires in cities, beached whales, and ruined ships along the Republic's coast. In the Sound, winter shipping persisted but was abnormally low for such a moderate winter, possibly because gales interfered with voyages from the Republic (Figure 3.3).⁴⁷

In the absence of a systematic series of ship logbooks kept aboard vessels plying Baltic trades, no records survive to allow the reconstruction of relationships between shifts in prevailing wind and the duration of northern commercial journeys. Doubtless wind direction was important,

⁴⁶ Christensen, *Dutch Trade to the Baltic about 1600*, 177, 145.

⁴⁷ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675-1750*, 352, 255 and 267. "The Sound Toll Database," Sound Toll Registers Online, accessed 12 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>.

and indeed in 1673 a contract written by a captain off Stockholm promised the delivery of his cargo in Amsterdam “when God provides a favourable wind.”⁴⁸ Two years earlier Adriaen van der Goes wrote that persistent easterly winds prohibited travel northeast from the Republic, hampering Dutch trade with Archangel. More frequent easterly winds during the minima of the Little Ice Age may have facilitated departure from Dutch ports, arrival in Amsterdam’s harbour from the Zuider Zee, and travel through the Baltic by returning ships.⁴⁹

Surviving correspondence supports that notion. On 2 April 1709 a letter written to grand pensionary Heinsius from “Vrijbergen” in Copenhagen complained that no letters had been received from Holland, although the wind had persisted from the east. Winds from that direction likely delayed ships as they approached Copenhagen, but they also facilitated departure from most Dutch harbours, and perhaps this was more important. On 29 June another letter written in the same city by Goes described how a small French merchant fleet laden with grain was hindered by contrary winds as it struggled to depart the Baltic five days earlier. France, Britain and the Republic were among the European powers embroiled in the War of the Spanish Succession, but a pursuing British convoy was likewise thwarted by the wind, which probably blew from the west. Three French ships returned to port but set sail on 26 June, again evading the British squadron with favourable winds that now likely blew from the east. The letters from

⁴⁸ Written in 1673, the contract begins with: “Ick, Jan Fise van Stockholm, Schipper naeft Godr van mijnen Schepe genaemt het Riddarhuys als nu ter tijdt gereet liggende voor Stockholm om met ten goeden wint die Godt verleenen sal te zeylen na Amsterdam . . .” Unfortunately, the *Riddarhuys* was shipwrecked and never arrived in Amsterdam. “Documents regarding the recovery by Joseph Deutz of 48% insurance on 100 lasts of tar and 20 lasts of pitch on the ship *Ridderhuys*, of which only part was saved after foundering of the ship, 1673.” Deutz Family 1613-1878. Reference code: 234. Gemeente Amsterdam Stadsarchief (Amsterdam, Netherlands).

⁴⁹ Van der Goes, “Hage, den 7 May 1671.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 221. *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II*, 205.

Denmark reveal not only the importance of wind direction for ships plying the Baltic trades, but also that winds could affect different ships differently.⁵⁰

One month later, Goes relayed Danish displeasure over the presence of a large Anglo-Dutch fleet amassed in the city's harbour. Goes explained that, to depart, the British warships did not require a wind as favourable as that needed by the 160 merchant vessels belonging to the Dutch convoy. Consequently, the British ships set sail on 25 July, while the Dutch fleet was forced to wait for weeks, much to the consternation of Danish officials eager to maintain their state's neutrality. Despite such tantalizing references in correspondence, it is impossible to explore comprehensively how shifts in prevailing wind affected Baltic commerce without ship logbooks that provide detailed daily meteorological observations. Moreover, other surviving documentary evidence suggests that shifts in the abundance of storms and, in particular, winter ice cover were even more significant for Baltic journeys. Changes in prevailing wind direction during Little Ice Age minima may have affected voyage times for vessels sailing to and from the Baltic. However, more frequent storms and more extensive sea ice regularly contributed to shipwrecks or, in the case of ice, the complete cessation of trade for more than three months. While the influence of sea ice was difficult to mitigate, Dutch merchants responded creatively to the challenges imposed by more common storms during the minima of the Little Ice Age.⁵¹

Climatic Fluctuation and Baltic Commerce: Conclusions and Consequences

⁵⁰ Van Vrijbergen, "Van van Vrijbergen, 2 April 1709 *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VIII: 1 oktober 1708 – 30 juni 1709*. A.J. Venendaal Jr. (ed). ('s-Gravenhage: Martinus Mijhoff, 1986), 409. Goes, "Van Goes, 29 juni 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 oktober 1708 – 30 juni 1709*, 664. Goes, "Van Goes, 9 juli 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 juli 1709 – 31 december 1709*. A.J. Venendaal Jr. (ed). ('s-Gravenhage: Martinus Mijhoff, 1988), 29.

⁵¹ Goes, "Van Goes, 27 Juli 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 juli 1709 – 31 december 1709*, 99. Goes, "Van Goes, 6 augustus 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 juli 1709 – 31 december 1709*, 129. Goes, "Van Goes, 10 augustus 1709," *De Briefwisseling van Anthonie Heinsius, 1702-1720, Deel VIII: 1 juli 1709 – 31 december 1709*, 147.

Disruptions in Baltic commerce, influenced by weather that grew more common during Little Ice Age minima, may have had broader economic consequences. In a letter sent during the first years of the Maunder Minimum, Adriaen van der Goes on 26 December 1662 described the bitter cold of a particularly severe winter. Van der Goes reported that grain ships inbound from the Baltic had been trapped for two weeks in thick sea ice near Vlieland. Their goods had not been unloaded across the sea ice, perhaps because the ice was too unstable or uneven for transportation. Van der Goes hoped that the vessels had not been damaged and that thawing would soon bring open water, because he, like many others in The Hague, trusted that high grain prices would sink once the vessels were unloaded in port. Unfortunately, on 9 February 1663 Van der Goes wrote that the grain ships had now been stuck in the ice for two months, as persistent freezing prevented the thawing of the ice. However, on 12 December during the warmer year of 1669 Van der Goes described relatively warm weather and low grain prices.⁵²

The prices of wheat and even rye rose sharply in the Dutch Republic during the coldest, rainiest, and stormiest decades of the Little Ice Age.⁵³ Still, chronological correlation is not the same as causation. Relationships between the weather rendered more frequent in Little Ice Age minima, Baltic shipping, and grain prices within the Republic were mediated by powerful socioeconomic and demographic influences. In particular, the demographic expansion of Europe contributed to a lengthy inflation in grain prices and decline in the value of labour until the middle of the seventeenth century, when grain prices declined as labour's real wage increased until the 1740s. These Malthusian trends were occasionally punctuated by the influence of war,

⁵² Van der Goes, "Hage, den 26 December 1662." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 166. Van der Goes, "Hage, den 9 February 1663." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 171.

⁵³ De Vries and Van der Woude, *The First Modern Economy*, 200. Van Tielhof, *The Mother of All Trades*, 298.

which affected commodity prices, labour wages, and the flow of shipping through the waters off Northern Europe. In this context, the force of climatic trends and accompanying weather events is difficult to quantify. Contemporary serial sources recorded shifts in prices and harvest yields, but even documents that abound with meteorological references cannot reveal how weather influenced the daily growth of plants. Extreme weather events were described at length, and historians of both the early modern climate and the European economy have traced how severe droughts or lengthy winters, for example, affected grain prices. However, the more profound influence of relatively subtle decade-scale changes in average weather was less commonly documented, yielding a low geographic and temporal density of surviving documents.⁵⁴

Analyzing the extensively recorded movement of vessels through the Sound consequently provides new insights into the relationship between commodity prices and the climatic fluctuations of the Little Ice Age, provided these quantitative accounts are contextualized and interpreted using qualitative documents. Using relatively continuous statistics of daily dues paid by captains passing through the Sound between 1634 and 1800, total annual passages can be compiled into a long-term reconstruction of fluctuations in Baltic shipping. Gaps in the reconstruction reflect years for which no data has survived, yet the final statistics nevertheless reveal that dues paid at the tollhouse of Elsinore generally declined during the Maunder Minimum and rarely reached decadal peaks during abnormally frigid winters (Figure 3.8). Overall, passages through the Sound rose steadily during the eighteenth century, mirroring the economic and demographic expansion of contemporary Western Europe. Stagnation in dues paid also sharply corresponded to wars that economically or directly involved the Baltic region,

⁵⁴ De Vries and Van der Woude, *The First Modern Economy*, 26 and 200.

including the Anglo-Dutch Wars (1652-54, 1664-67, 1672-74), the Second Northern War (1655-60), the War of the Spanish Succession (1701-14), and the Great Northern War (1700-21).⁵⁵

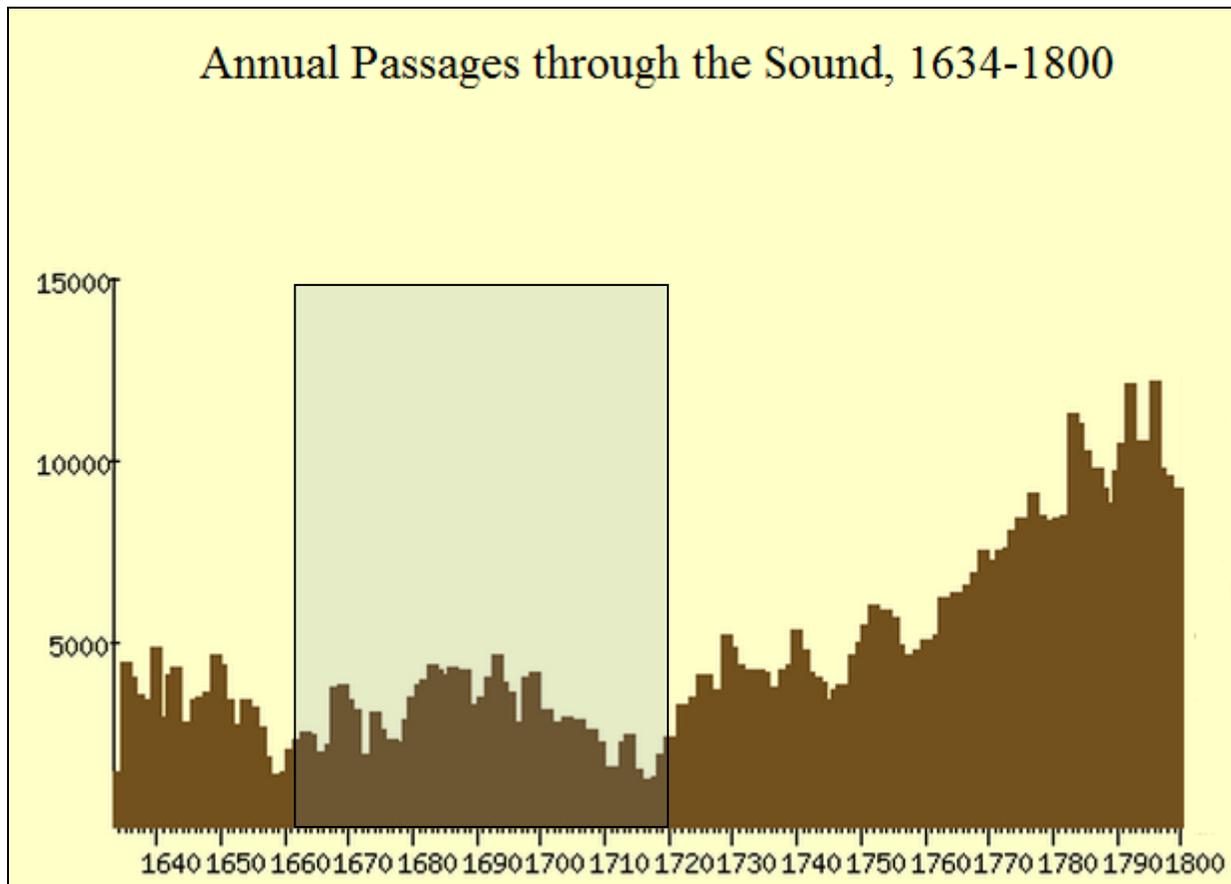


Fig. 3.8. Changes in the total volume of traffic through the Sound, 1686-1804. The Maunder Minimum is highlighted.

Still, correspondence and accounts recording daily dues paid at Elsinore both suggest that the stagnation in Baltic traffic recorded in the Sound toll reconstruction was also influenced by the frigid, stormy weather that accompanied the minima of the Little Ice Age. In years of particularly severe cold or precipitation, delays and disruptions in Baltic commerce, in turn, were

⁵⁵ "The Sound Toll Database," Sound Toll Registers Online, accessed 13 July 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>. Michael Flinn, *The European Demographic System, 1500-1820*. (Baltimore: Johns Hopkins University Press, 1981), 101.

likely related to fluctuations in the price of necessary commodities like wheat. These delays coincided with failed harvests that were also stimulated, in part, by the colder, stormier, wetter conditions during exceptional years of the Grindelwald Fluctuation and Maunder Minimum in northwestern Europe.⁵⁶ Jan de Vries has argued that climatic fluctuation was not a direct causal variable for Dutch grain prices, because shortages in the domestic supply could be supplemented by Baltic imports. In fact, precisely because grain prices in Amsterdam were attuned to international market prices, poor harvests and disruptions in Baltic commerce may have acted in concert to increase grain prices in the Republic and elsewhere.⁵⁷

Disruptions in the supply of cereals and corresponding price increases contributed to famine and unrest in much of Western Europe, yet in the Republic the picture could be far more complex. Meat, fish, cheese, and other sources of protein accounted for an unusually high share of the Dutch diet, and the storehouses of Amsterdam could compensate for disruptions in Baltic trade. The nutrition available to Dutch citizens was accordingly less affected by disruptions in the supply of grains than it was elsewhere in Europe. Moreover, because Dutch vessels carried the bulk of Europe's seaborne trade during the Republic's Golden Age, Dutch merchants profited by exploiting high grain prices in different regions. For the mariners engaged in Baltic commerce, the extensive sea ice and frequent storminess of Little Ice Age minima were frustrating and often deadly. Despite occasional interruptions in diplomatic negotiations and

⁵⁶ Historical climatologists have generally moved away from the notion that generally colder temperatures and excessive moisture inevitably hampered agricultural production. Still, years of extreme cold, unusually high or low rainfall and, in coastal regions, severe storms could contribute to bad harvests, often because farmers had little ability to adapt to extreme conditions. De Vries, "Measuring the Impact of Climate on History," 626.

⁵⁷ It should be noted that De Vries reached his conclusions using very imprecise indices of winter severity, which in fact does not influence grain yields as much as meteorological conditions during the growing season. In particular, cold temperatures during Little Ice Age minima could reduce by one month a growing season that, on average, was over six months between 1961 and 1998. Richards, *The Unending Frontier*, 75. De Vries, "Measuring the Impact of Climate on History," 613. Thomas Rötzer and Frank M. Chmielewski, "Phenological maps of Europe." *Climate Research* 18 (2001): 253.

military supply chains, however, delays in the Sound may actually have indirectly benefitted the economy of the Dutch Republic.⁵⁸

Climatic Fluctuation and Transportation within the Borders of the Republic

For the Republic's economy to retain its entrepôt function in global trade, commodities, information, and people from across an expanding commercial empire had to be transported from major harbours to specialized industrial, cultural, and political centres. They were inhaled through roads, creeks, canals, rivers, lakes, and coastal stretches of the sea, to towns like Leiden or nearby Haarlem. There goods were refined or transformed into finished products, information was interpreted and acted upon, and people assumed new socioeconomic roles or prepared for their return to the periphery. Before long, the internal transportation system of the Republic would gradually accommodate the steady exhalation of products, correspondence, and people returning to the sea. This breathing of the Republic's economy through intersecting transportation networks on land and water was an essential component of its dynamic capitalist economy. In a process that, in some respects, mirrored the first development of defences against the sea in the northern Netherlands, the growth of regional networks of transportation was slow, organic, and largely bereft of centralized planning.⁵⁹

By the sixteenth century, the gradual economic expansion of Dutch towns encouraged the further improvement of infrastructure that could reliably deliver buyers and goods to the burgeoning markets of the northern Netherlands. In 1529, Amsterdam and Hoorn established a service in which licensed skippers left at regular intervals to ferry passengers, goods, and

⁵⁸ De Vries and Van der Woude, *The First Modern Economy*, 153. Van Tielhof, *The Mother of All Trades*, 298.

⁵⁹ De Vries and Van der Woude, *The First Modern Economy*, 179.

correspondence between standardized destinations according to tariffs previously negotiated by the towns. The skippers aboard *beurt*, or “in turn,” ships were ordered to depart whether empty or full, and they possessed monopolies over the waterborne transport of goods and people between agreed-upon locations in the passage from Amsterdam to Hoorn. The *beurtveer* system expanded in step with the general rise of the Dutch economy in the final decades of the sixteenth century, as services to Rotterdam and, somewhat later, the Zaan villages were added to what was already an extensive network. Beurt ships typically harnessed the wind to move (Figure 3.9), and only when sailing was impossible did skippers employ animal or human labour. Even this was impractical on the rivers and lakes that frequently covered at least some of an established route.⁶⁰

⁶⁰ Klompmaker, *Handel in de Gouden Eeuw*, 70. Audrey M. Lambert, *The Making of the Dutch Landscape*, 203. De Vries and Van der Woude, *The First Modern Economy*, 181. R. Pots and J. Knoester, *Blauwe ader van de Bollenstreek: 350 jaar Haarlemmertrekvaart-Leidsevaart, 1657-2007. Geschiedenis, betekenis en toekomst*. (Leiden: Primavera Pers), 11. Horsten, *Doorgaande wegen in Nederland, 16e tot 19e eeuw*, 50.

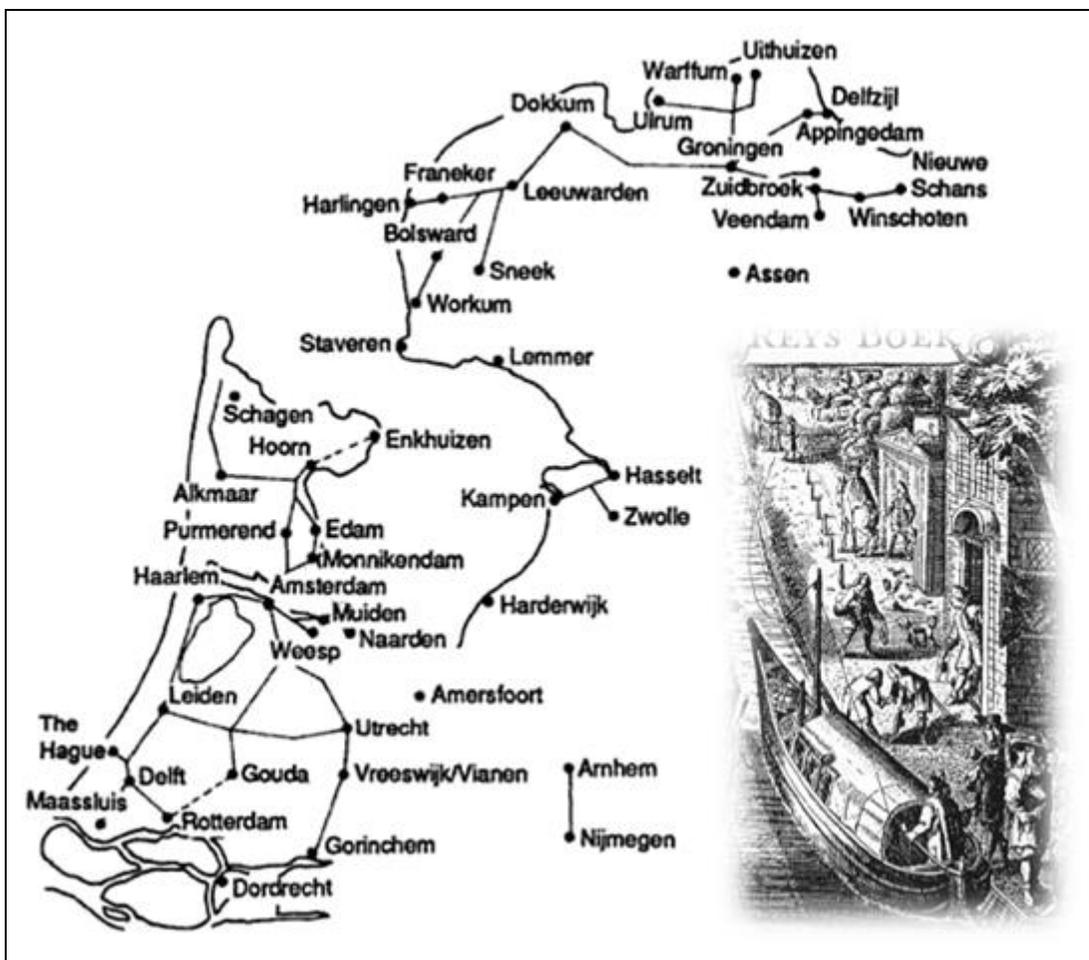


Fig. 3.9. A typical beurt ship of the seventeenth century sails with a light breeze. A thriving market existed in the Republic for art that depicted characteristically Dutch landscapes. Aelbert Cuyp, “River Scene with a Ferry Boat,” painting, c. 1652, Auckland Art Gallery Toiōtāmaki, <http://www.aucklandartgallery.com/the-collection/browse-artwork/121/river-scene-with-a-ferry-boat>. Mariët Westermann, *A Worldly Art: The Dutch Republic, 1585-1718*. (New Haven: Yale University Press, 1996), 67.

In the first decades of the seventeenth century, most of the population centres that were accessible by water were connected by the beurtveer network, and some were serviced many times in a day. Indeed, by the eighteenth century some 800 beurt ships departed each week from Amsterdam alone, bound for 121 destinations across the Republic. However, the capitalist economy of the Republic in its Golden Age required networks of transportation that were less subject to weather and tide. Accordingly cities and merchants financed the construction of

straight canals that, when bordered by tow paths, could accommodate horse-drawn barges that did not require sails. In 1632, the first of these *trek*, or “pull,” ferries opened between Amsterdam and Haarlem. The new *trekvaart* could offer hourly departures, a steady speed of approximately seven kilometres/hour, and standardized journeys of just over two hours. By the middle of the seventeenth century the service between Haarlem and Amsterdam accommodated over 300,000 annual travelers, and it had served as a template for the remarkable expansion of the network across the full breadth of the coastal provinces (Map 3.2). Barges travelling along the *trekvaart* network frequently carried goods or correspondence in small volumes, but the movement of people was the primary function of the horse-drawn system.⁶¹

⁶¹ H. Klomp maker, *Handel in de Gouden Eeuw*, 66. Lambert, *The Making of the Dutch Landscape*, 204. De Vries and Van der Woude, *The First Modern Economy*, 183. Pots and Knoester, *Blauwe ader van de Bollenstreek*, 11. Davids, *The Rise and Decline of Dutch Technological Leadership Vol. I*, 84.



Map 3.2. The trekvaart network in 1665, originally drawn by Jan de Vries. Inset: a *trekschuit* or “pull boat” strung to a horse. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 557. De Vries and Van der Woude, *The First Modern Economy*, 3.

By the middle of the seventeenth century, even minor centres in the Republic’s maritime provinces were woven into the overlapping networks of the trekvaart and beurtvaart. In the context of contemporary Europe, the networks yielded a uniquely flexible, reliable, inexpensive, and safe system for the transportation of commodities, correspondence, and people. However, intersecting and extending beyond the more celebrated infrastructure used by larger ferries were the relatively informal passages plied by boats individually or collectively owned by farmers and petty industrialists. Some of these routes worked their way through creeks and ditches, but others braved the same waterways navigated by much larger craft to transport goods between rural

communities or, more frequently, from rural to urban areas. Buttermilk, hay, fish, freshwater, and other commodities were transported in *schuiten*, watercraft up to 10 metres long that displaced two tons. Smaller boats in particular were often rowed, yet most *melkschuiten* or “milk boats” were sailed as they operated their essential trade.⁶²

Given the quality and diversity of the Republic’s waterborne transportation networks, it is no surprise that the vast majority of traffic in the early modern Netherlands travelled by water. Roads did exist, including larger *herenwegen* or “gentlemen’s roads” that connected major centres, but in the coastal provinces it was unusual to find wagons laden with goods. Nevertheless, even in wealthy, urbanized, waterlogged Holland, many travellers rode or simply walked to reach nearby destinations. The northern Netherlands was connected by more roads in 1600 than it was in 1848, but these roads were not paved streets but rather scarcely maintained and meandering paths of rutted dirt or sand. While the state of the Republic’s roads was hardly exceptional in the context of early modern Europe, it is not surprising that the *trekvaart* and *beurtvaart* dominated traffic through the coastal provinces. At least 95% of all travellers between Amsterdam and Haarlem took the *trekvaart* after it was constructed, and in the remaining decades of the seventeenth century its share of travellers between the cities never dipped far below 80%. However, in parts of the Republic’s relatively poor and sparsely populated eastern hinterland canals could not be constructed, and roads enabling travel by wagon, horse, or foot were consequently all that connected regional communities. Even there roads were not paved,

⁶² Schuiten were often, but not always, boats. Anton Wegman, *De Waterlandse Melkschuit: varende boeren tussen Waterland en Amsterdam 1600-1900*. (Amsterdam: Stichting de Waterlandse Melkschuit, 2011), 21. Marjolein 't Hart, “The Dutch Republic: the urban impact upon politics,” in *A Miracle Mirrored, A Miracle Mirrored: The Dutch Republic in European Perspective*, ed. Karel Davids and Jan Lucassen. (Cambridge: Cambridge University Press, 1996), 62.

most were unhardened, and all were quickly compromised in a diverse selection of common meteorological conditions.⁶³

The diversity of these intricately connected transportation networks on land and in water yielded second and third options for travel between many destinations within the northern Netherlands. In the context of early modern Europe, these additional options, while superficially redundant, nevertheless bestowed a unique resiliency to movement through the Dutch Republic in the coldest, wettest, stormiest years of Little Ice Age minima. Resilience was hardly absolute, as travel within the Dutch transportation system ground to a halt during major storms that coincided either with severe freezing or flooding. Although such events were typically short-lived, they were more frequent during the Grindelwald Fluctuation and Maunder Minimum than they were in warmer decades. Moreover, resiliency in the face of more common meteorological conditions during Little Ice Age minima and maxima was expressed not through stability but rather through shifts in the character of transportation in the northern Netherlands.

Meteorological conditions typical of the warm or cold decades of the Little Ice Age consistently enabled or facilitated some forms of transportation while hampering others, influencing the efficiency and culture of movement through the Dutch Republic. With the notable exception of trekvaart passages, individual journeys through the transportation system of the northern Netherlands generally escaped continuous, quantitative documentation of the kind that can serve both as a proxy for climatic reconstruction and a window into the social influence of climate change. Nevertheless, because inexpensive and reliable transportation was central to the prosperity of the Republic's relatively modern economy, numerous letters and diary entries

⁶³ For example, a recent archeological study has demonstrated that the Havenweg, a road near Hoorn, was covered with seashell and brick grit. Michiel H. Bartels, "Zeven keer door de Zuiderdijk." *Jaarboek 78* (2011): 72. Horsten, *Doorgaande wegen in Nederland, 16e tot 19e eeuw*, 47. De Vries and Van der Woude, *The First Modern Economy*, 187.

survive to describe relationships between travel disruptions and contemporary weather.

The various forms of transport available to travellers within the Republic were essential to the Dutch economy, and routinely depicted in contemporary art. That reality, as well as the enduring ubiquity of canals and toll stations in the modern Netherlands, has encouraged the growth of a vast but unbalanced historiography. Dutch inland shipping and travel by road has generated little systematic study, owing in part to a lack of historical sources.⁶⁴ Far more attention has been devoted to standardized travel by water, and multiple studies have, for example, reconstructed the history of individual trekvaart routes.⁶⁵ Owing in part to the pioneering work of Karel Davids, the history of Dutch transportation networks has increasingly been incorporated into the history of science. Building on earlier work by Jan de Vries, new studies argue that rapid technological innovations in the young Republic, expressed in part through the development of new transportation networks, were enabled by, and in turn accelerated, the economic expansion of the Dutch Golden Age.⁶⁶

Recently, this historiographical trend has readily incorporated the methodology of network theory. For example, in 2004 Erik van der Vleuten and Cornelis Disco explained how successive generations of Dutch engineers “networked” the “wet nature” of the northern Low Countries.⁶⁷ Because the manipulation of natural structures to achieve human ends is the focus of such work, it does not consider the concurrent influence of climatic trends on human

⁶⁴ Hence, one of the most important recent works on inland shipping uses archeological sources. André Frederik Lambertus van Holk, *Archeologie van de binnenvaart: wonen en werken aan boord van binnenvaartschepen (1600-1900)*. (PhD Diss., University of Groningen, 1997).

⁶⁵ For example, the trekvaart between Haarlem and Leiden. J. J. J. M. Beenakker, “De Trekvaart tussen Leiden en Haarlem.” *Dever Bulletin* (1994): 18 *Blauwe ader van de Bollenstreek*, 11. See also: S. J. Fockema Andreae, “De trekvaart Haarlem-Leiden driehonderd jaar,” In *Haerlem jaarboek*, 1959.

⁶⁶ Although Karel Davids is careful to acknowledge that “modern economic scholarship shows that it is extremely hard to pin down the role of technological change in economic growth.” Davids, “Technological Change and the Economic Expansion of the Dutch Republic, 1580-1680,” 80. C.A. Davids, “De technische ontwikkeling in Nederland in de vroeg-moderne tijd. Literatuur, problemen en hypothesen.” *Jaarboek voor de Geschiedenis van Bedrijf en Techniek* 8 (1991): 9. Davids, *The Rise and Decline of Dutch Technological Leadership Vol. 1*, 84.

⁶⁷ Van der Vleuten and Disco, “Water Wizards,” 292.

developments. In fact, the best analysis of these relationships was published in 1978, when Jan de Vries carefully reconstructed how winter weather affected the operation of the trekvaart network. Still, no study has explored the influence of weather rendered more likely in Little Ice Age maxima and minima across the full spectrum of transportation networks intersecting the Republic's coastal provinces.⁶⁸

The Beurtvaart and Trekvaart in Little Ice Age Minima and Maxima

During the climatic fluctuations of the Little Ice Age beurtveer skippers, like the mariners who plied the Baltic trades, were most affected by shifts in the extent and particularly the duration of ice cover along their prescribed routes. Just as the relationship between changes in sea ice cover and variations in Baltic traffic influenced more than those directly involved in commerce, the consequences of beurtvaart disruptions rippled through the socioeconomic fabric of the Republic. In a letter sent on 13 January 1637, Nicolaes van Reigersbech informed Hugo de Groot that the States-General could not assemble owing to sustained freezing and, in turn, the cessation of beurtveer traffic. Although temperatures during the winter of 1636/37 matched the twentieth-century norm, and were consequently typical of the interval between the Grindelwald Fluctuation and Maunder Minimum, the season was also marked by a long stretch of highly variable weather. Conditions in January were as cold as they were during many of the chilliest winters in the minima of the Little Ice Age, and the correspondence to De Groot reveals that large-scale arrangements to travel by land could be impractical during sustained freezing in the Republic. Moreover, as the beurtveer ground to a halt the payment of river tolls dropped

⁶⁸ De Vries, *Barges and Capitalism*, 287.

considerably in that frigid January, damaging the finances of the towns that typically administered their so-called local privileges.⁶⁹

If the waterways that supported the beurtvaart could freeze even during relatively moderate winters, sub-zero temperatures generally lingered far longer during the coldest years of the Little Ice Age. In the frigid winter of 1662/63, for example, the letters of Adriaen van der Goes described how sustained ice cover halted beurtveer traffic for nearly three months. During the equally severe winter of 1683/84, Claas Caescoper marvelled at six weeks of unrelenting freezing, and wrote that the beurtveer from Zaandam to Amsterdam could not sail for more than nine weeks. Even longer disruptions in beurtveer traffic afflicted the Republic during the similarly cold winters of 1694/95 and 1708/09. Moreover, when temperatures rose above freezing, thawing ice could accumulate in narrow or already obstructed parts of waterways, blocking them and often stimulating floods. Toll accounts written in the moderate winter of 1635/36 suggest that the inundations that frequently accompanied these “ice dams” could disrupt travel through the beurtveer network. Although floods increased the surface area of the watery networks that spanned the Republic’s coastal provinces, their occasionally rapid currents and invariably opaque water rendered them unsafe for beurt ships. Such floods were more common and more severe during the Grindelwald Fluctuation and Maunder Minimum. However, because ice dams typically accompanied rapid thawing, floods stimulated by accumulated ice do not appear to have halted beurtveer traffic for longer than a week at a time.⁷⁰

⁶⁹ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 439.

⁷⁰ Claas Arisz. Caescoper, “5 Maart 1684.” *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Van der Goes, “Soude syn van 6 Maert 1670.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II.*, 117. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 220. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. V*, 328. Egbert Alting, *Diarium van Egbert Alting, 1553-1594*, ed. W.J. Formsma and R. van Roijen. (The Hague: Nijhoff, 1964), 254. Gottschalk, *Stormvloed en rivieroverstromingen in Nederland, Vol II*, 818. Gottschalk, *Stormvloed en rivieroverstromingen in Nederland, Vol III*, 417.

Although the vessels that navigated the beurtveer employed sails, beurt skippers did not keep logbooks, hindering any attempt to trace how more common easterlies and high winds influenced traffic through the beurtvaart networks. Some routes might have been quicker during the Grindelwald Fluctuation and Maunder Minimum than they were in warmer decades, while others may have been slower. Many routes linking communities were likely faster for ships travelling in one direction than they were when the same vessels travelled back along the same course. Of course, departing and returning traffic did not necessarily have equal socioeconomic importance. Consequently, even along routes where accelerated voyages in a particular direction were balanced by slower journeys travelling back along the same course, shifts in average wind direction may have had significant consequences for local prosperity.

Moreover, in persistent contrary winds, outbound or inbound travel along some beurtvaart networks was probably impractical, especially when those winds blew at high velocity. On 17 December 1665, for example, Adriaen van der Goes described how a ship likely working the beurtvaart would reach Delft with the first easterly wind. Easterlies soon resumed in 1665, but in the first week of July 1686 Claas Caescoper in the Zaan near Amsterdam wrote that his beurt ship was delayed by high winds as it prepared to embark for Zeeland. Letters chronicling the passage of Oldenbarnevelt and accompanying officials through the Republic in 1589 reveal that lengthy delays in stormy weather also hampered the beurtveer during the Grindelwald Fluctuation. For travellers on the beurtvaart, gales were frustrating when they kept ships at their docks, but the same storms were far more serious when vessels were already on their way, particularly when routes crossed large bodies of water. In the frigid winter of 1586, a beurt ship sailing between Amsterdam and Leiden and carrying many passengers was wrecked during a severe storm. In autumn of 1671, a beurt ship travelling between Rotterdam and

Middelburg was stranded in what Adriaen van der Goes referred to as a “hurricane,” although it was eventually floated again with favourable winds. While such qualitative references cannot be supported by quantitative evidence, they hint that, for traffic through the beurtveer network, the influence of relatively frequent high winds and easterlies during the minima of the Little Ice Age may have equalled the more spectacular effect of winter freezing.⁷¹

Indeed it was the ability of wind to foil schedules of arrival or departure that encouraged the development of a kind of beurtveer that was less subject to meteorological conditions. Nevertheless, the trekvaart network, while remarkably reliable in the context of early modern Europe, was not immune to the social and environmental changes that affected the Republic. Although the service was hardly influenced by the First Anglo-Dutch War, traffic through the trekvaart declined during the second war and plummeted as large swaths of the Republic were occupied during the “year of disaster” in 1672. However, when the imminent threat to the Republic faded in 1673 passengers returned in large numbers. Because no further wars would be fought on Dutch soil until the Republic’s fall, the direct influence of war had only fleeting consequences for the subsequent popularity of trekvaart travel. On the other hand, economic trends reflecting both the rise of English commerce and the agricultural crisis of the late 1670s probably contributed to the first sharp fall in trekvaart passengers between 1674 and 1679. From 1686/87 to 1691, the second steep decline likely reflected the indirect economic influence of the outbreak of the Nine Years’ War. Although the recovery of the late 1690s was significant, these

⁷¹ Johan van Oldenbarnevelt, “Rapport van Oldenbarnevelt als Gecommitteerde der Staten van Holland, 12-22 Maart 1589.” In *Bescheiden betreffende zijn staatkundig beleid en zijn familia, Eerste Deel: 1570-1601*, ed. S.P. Haak. (The Hague: Martinus Nijhoff, 1934), 160. Claas Arisz. Caescoper, “1 Julij 1686.” *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Van der Goes, “Hage, den 17 December 1665.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 229. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 87 and 640.

severe reversals punctuated a general slump in trekvaart passages that deepened into the eighteenth century and mirrored the overall stagnation of the Dutch economy.⁷²

The history of traffic through the trekvaart network was shaped by warfare, economic trends, and personal agency, but these variables were inextricable from the influence of meteorological conditions and climatic trends. For example, floods in the relatively cool year of 1675 were, in fact, stimulated by storm surges that accompanied two severe gales in November and December and inundated huge swaths of land across the coastal Low Countries from Antwerp to Emden. Blowing from the north, the gales contributed to one of six catastrophic storm surge events in the history of the seventeenth-century Republic, all of which occurred during the minima of the Little Ice Age. The heartland of the Republic between Hoorn, Haarlem, Leiden, Utrecht, and Amsterdam was almost entirely flooded, causing spectacularly expensive damage to the Republic's defences against the sea. Because urgent repairs were needed, the States-General approved onerous land taxes that contributed to subsequent agricultural crisis and, in turn, the reduction in trekvaart passengers. The financial toll of the great floods of 1675, which followed costly artificial inundations during the desperate defense of Holland three years earlier, was compounded by calamitous river flooding only two years later. In the Republic, the great majority of river floods during the Maunder Minimum followed severe winters, when floating ice was prone to accumulate in ice dams.⁷³

Relationships between flood events, damage to infrastructure, economic performance, and lower trekvaart traffic were not confined to the 1670s. In 1652, a depression in annual trekvaart passengers followed concurrent storm and river flood events in the previous year, while

⁷² De Vries, *Barges and Capitalism*, 280.

⁷³ Caescoper, "November 1675." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V*, 24. Gottschalk, *Stormvloeden en rivieroverstromingen in Nederland, Vol III*, 417.

a subsequent trough in 1655 coincided with similarly widespread storm and river inundations. Following the onset of the Maunder Minimum, particularly severe storm flooding in 1664 preceded a lengthy decline in trekvaart passengers that overlapped with the Second Anglo-Dutch War. Inundations stimulated by gales in 1682 and 1683 similarly preceded a decline in trekvaart traffic in 1684. Troughs in trekvaart passengers routinely, if not invariably, followed major storm flooding by one year, perhaps because the costs of natural disasters took time to reach many of the trekvaart's regular travellers. On the other hand, the relationship between trekvaart popularity and river inundations was not as reliable. Indeed storm surges inundated land across the wealthy coastal provinces and typically damaged defences against the sea, while many river floods stimulated less costly destruction in the Republic's hinterland.⁷⁴

On the other hand, a year of higher than normal trekvaart popularity coincided with a significant river flood event in 1661, and in both 1671 and 1682 highs in trekvaart usage accompanied major storm surges. Clearly relationships between fluctuations in trekvaart passengers and storm and river flooding were mediated by political or socio-economic influences, and accordingly were hardly straightforward. Still, the damaging storm of 1671 also afflicted the coast only in November, when most of the year's passengers had already passed through the trekvaart. The consequences of most storm flood events also followed inundation by at least a year, and it is therefore unsurprising that the gale of 1682 did not reduce trekvaart traffic through the entire Republic in the same year. Neither correspondence, diary entries, nor newspaper articles mention a direct connection between flooding and disruptions in the trekvaart

⁷⁴ Jan De Vries, *Barges and Capitalism: Passenger Transportation in the Dutch Economy*, 279. Gottschalk, *Stormvloed en rivieroverstromingen in Nederland*, Vol. III, 414.

service, although the same sources contain regular reports of inundation interrupting other modes of travel through the Republic.⁷⁵

The combination of river flooding and high trekvaart traffic in 1661 is hardly surprising, because the trekvaart was simultaneously influenced by a meteorological condition that was even more significant than inundation for waterborne travel through the Republic. Financial accounts reveal that ice perpetuated by winter freezing closed the trekvaart canals for an average of 28 days in the seventeenth and eighteenth centuries. The winters of 1660/61 and 1661/62 just preceded the regional onset of the Maunder Minimum, and they were milder than the twentieth-century average. Consequently, ice cover never rendered unnavigable the canals of the trekvaart, and the service continued year-round, substantially increasing annual passenger volume. On the other hand, the winter of 1662/63 was among the most severe of the colder climatic regime, and travel through the trekvaart network was halted for more than 80 days. In letters to his brother, Van der Goes described the short-lived joy that followed the resumption of the service in the first week of February. However, freezing resumed after only three days of thawing, and the trekvaart was again suspended.⁷⁶

⁷⁵ This is surprising, because footpaths used by the horses that pulled trekvaart barges were presumably vulnerable to heavy rainfall. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 640.

⁷⁶ Van der Goes, "Hage, den xi January 1663." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 168. Van der Goes, "Hage, den 9 February 1663." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 171. Van der Goes, "Hage, den 23 February 1663." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 173. Jan De Vries, *Barges and Capitalism: Passenger Transportation in the Dutch Economy*, 287. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 575.

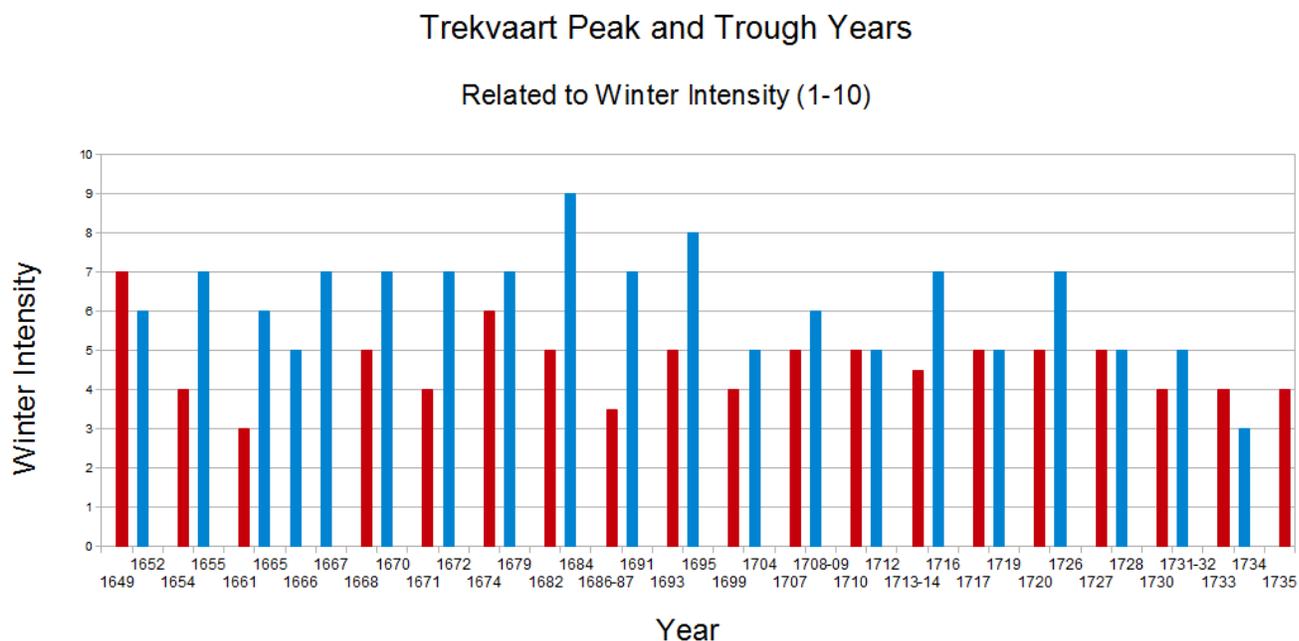


Fig. 3.10. Trekvaart peak years (red) and trough years (blue) compared to winter intensity. Winters in trough years were, on average, 10% more severe than the average twentieth-century value (5), while winters in peak years were, on average, 10% less severe. For winters, a nine equates to an average temperature in December, January, and December of -2.4 degrees Celsius, while a one denotes an average winter temperature of 6.2 degrees Celsius. For summers in the same graph, a nine reflects average temperatures in June, July, and August of 18.3 degrees Celsius, and a one records average temperatures of 14 degrees Celsius. Van Engelen, Buisman and Ijnsen, “A Millennium of Weather, Winds and Water in the Low Countries,” 112.

Jan de Vries has demonstrated that suspensions of 70 or more days during especially frigid, long-lasting winters reduced annual passenger volume by an average of nearly 7%, relative to typical winters during the Little Ice Age. After 1663, such freezing recurred five times before the end of the century. Lows in trekvaart traffic usually coincided with winters that were over 10% more severe than the twentieth-century average, while highs occurred in winters that were nearly 10% less severe (Figure 3.10). Still, changes in the volume of trekvaart and indeed beurtvaart traffic may actually have been less significant than even more drastic shifts in the availability of both the trekvaart and beurtvaart in cool winters. In this sense, the consequences of increased ice cover for travel through the Republic’s internal transportation networks were not dissimilar to those that followed from the simultaneous cessation of Baltic commerce.

Ultimately, the reduction in collected tolls and disruption in political assembly that accompanied the interruption of travel through the beurtvaart also resulted from the cessation of the trekvaart, as indeed both services were part of the same waterborne network.⁷⁷

Climatic Fluctuations and Travel through the Republic by Boat, Road, and Ice

Many within the Republic did not use the trekvaart or beurtvaart, and instead moved through the coastal provinces in their own small vessels. Owned by farmers, the boats that plied informal routes woven through the standardized connections of the beurtvaart were propelled by sail or, in less favourable winds, by oar. While their crews preferred to harness the wind, the possibility of rowing gave them greater resilience to meteorological changes than beurt ships. Boats carrying agricultural goods were also more flexible than the barges of the trekvaart, capable of navigating with equal proficiency both the rough seas off the Zuider Zee and the narrow spaces of Amsterdam's labyrinthine canals. The long, shallow rudder of a typical *schuit* allowed it to sail through very shallow water, while a leeboard⁷⁸ could be deployed amidships to mitigate the lateral force of a wind. Weighed down by agricultural goods, ballast, or in rare occasions even passengers, most farmer-owned boats were stable in rough seas.⁷⁹

However, records of voyages taken by *melkschuiten* or “milk boats” from agricultural Waterland to heavily urbanized Amsterdam reveal the peril posed by storms during the minima of the Little Ice Age. Waterland bordered the northern shore of the IJ, which in the seventeenth

⁷⁷ Jan De Vries, *Barges and Capitalism: Passenger Transportation in the Dutch Economy*, 287. Van Engelen, Buisman and Ijnsen, “A Millennium of Weather, Winds and Water in the Low Countries,” 112.

⁷⁸ In Dutch, *zijdzwaard*.

⁷⁹ Wegman, *De Waterlandse Melkschuit*, 27. See also: Maurice Kaak, *Vlaamse en Brabantse Binnenschepen uit de 18de en 19de eeuw: vergeten vaktaal en oude constructies*. Ghent: Provinciebestuur Oost-Vlaanderen, 2010. F. Post, *Groninger Scheepvaart en Scheepsbouw vanaf 1600*. Bedum: Profiel uitgeverij, 1997. P. J. V. M. Sopers and H. C. A. Kampen, *Schepen die verdwijnen*. Haarlem: Uitgeverij Hollandia, 2000. G. C. E. Crone, *Nederlandsche binnenschepen*. Amsterdam: Alert de Lange, 1944.

and eighteenth centuries was still a wide bay off the Zuider Zee, its salty water subject to tides as it snaked above Amsterdam and Haarlem. Consequently, to reach Amsterdam milk boats from Waterland were required to cross a waterway that had all the characteristics of an inland sea. Amsterdam's need for perishable dairy products was insatiable, and milk boats departed for the city even in less than ideal weather. Once in the IJ, however, there could be little recourse when a storm churned across waters already notorious for their roughness. In February 1661, for example, a boat carrying an unusually high number of passengers foundered in a severe storm, drowning twenty people. On 9 November 1697 a boat transporting milk to Amsterdam capsized in a storm as it struggled cross the IJ, and two years later another vessel succumbed in similar circumstances.⁸⁰

Additional milk boats sunk in 1763, 1764, and 1788, as colder, stormier weather grew more common in the Republic with the coming of the Dalton Minimum. In fact, wrecks were exclusively recorded during the minima of the Little Ice Age. Nevertheless, of the thousands of voyages conducted by farmers, very few appear to have ended in catastrophe. Of course, the low documentation of wrecked milk boats does not necessarily reflect a paucity of lost vessels and crews. Because individual milk boats and other *schuiten* were generally owned and operated by a small number of farmers, their loss only entered surviving elite correspondence and newspaper accounts in extreme circumstances: for example, when far too many passengers were on board. Nevertheless, more common than wrecks were likely delays in the departure of milk boats, such as those Caescoper observed during a particularly ferocious storm in January 1693. Because voyages from Waterland to Amsterdam lasted no more than three hours, they could be readily postponed if conditions were too severe. Still, lengthy delays during the long gales that grew

⁸⁰ Wegman, *De Waterlandse Melkschuit*, 43. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 569.

more common in Little Ice Age minima likely spoiled dairy products, although sufficiently detailed records kept by farmers have not survived.⁸¹

In frigid winters during the minima of the Little Ice Age, farmers who operated milk boats and other schuiten were affected by the same severe freezing that halted travel through the beurtvaart and trekvaart networks (Figure 3.11). For example, during the cold winter of 1586/87 Commander Van Vervou reported that extensive ice cover on the Eem River had prohibited boats from supplying pure water to brewers during a time of plague, when local water was contaminated. Correspondence and diary entries described how sustained freezing in the frigid winter of 1620/21 and 1621/22 prohibited travel by boat as the Republic's waterways solidified. The onset of the Maunder Minimum in 1660 was accompanied by the cool winter of 1659/60, during which letters sent by Adriaen van der Goes recorded the lengthy interruption of voyages by boat.⁸²

⁸¹ Claas Arisz. Caescoper, "Januarij 1693." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Wegman, *De Waterlandse Melkschuit*, 44.

⁸² Van der Goes, "Hage, den 22 January 1660." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 51. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V*, 220.



Fig. 3.11. A rural winter scene painted during the Grindelwald Fluctuation. Small boats are frozen amid the ice. A larger schuit is visible in the background. Hendrick Avercamp, “Winter Scene on a Canal,” painting, c. 1605, Toledo Museum of Art, <http://goo.gl/HndX5w>.

During the even cooler winter of 1662/63, Van der Goes observed that schuiten had only sailed for a few days in early February. Already on 19 November during the frigid winter of 1671, Van der Goes marvelled that “the boats lie still before Leiden, Utrecht and Amsterdam.” Caescoper suggested that travel by boat was impossible for more than three months during the landmark winters of 1683/84 and 1694/95. According to Caescoper, on 10 March 1695 major waterways could be traversed by boat, although ice remained in creeks, and in fact freezing continued to affect voyages by boat into August! Boats were forced from the water for several weeks even in relatively moderate winters, like those of 1661/62, 1670/71, 1685/86, and 1698/99, although the cessation of travel by boat was broken by sustained thawing and generally did not endure long past February.⁸³

⁸³ Caescoper, “November 1698.” *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Caescoper, “10 March 1695.” *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Van der Goes, “Hage, den 11 December 1662.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 160. Van der Goes, “Hage, den 16 January 1661.” *Briefwisseling tusschen de gebroeders van der Goes (1659-*

Nevertheless, the dairy supply of Amsterdam and other Dutch cities was too important to be entirely disrupted by ice, and indeed the small scale of individual boats and crews enabled alternatives to waterborne transportation. Although few records kept by farmers survive from the seventeenth century, later testaments suggest that most farmers in Waterland owned at least one sled. Farmers sailed as long as possible, and some illustrations suggest that milk boats were dragged across icy harbours if open water persisted in the IJ. When the ice had expanded too far, however, farmers loaded their goods into sleds and continued their trade. Because the kinetic friction of ice is higher than that of water, and early modern movement across a solid surface usually demanded human or animal muscle, travel by farmers in cold winters was less efficient and more arduous than it was in warmer winters. Nevertheless, with minimal capital and access to only the most rudimentary of early modern transportation technologies, farmers persisted in their commerce during periods of extensive ice cover, while the Republic's other waterborne networks ceased to function.⁸⁴

Amsterdam's inhabitants also depended on regular shipments of fresh water. By 1550, changes in the balance between land and the North Sea had rendered the water in Amsterdam's canals too salty for consumption. Entrepreneurs established a service that transported freshwater to Amsterdam by boat from nearby lakes and rivers. It expanded in the seventeenth and eighteenth centuries, and by 1781 more than 43 brewer ships and 114 private water-company ships delivered freshwater to Amsterdam's citizens. Like the supply of dairy products, this service was also disrupted by winter freezing, yet the city's brewers could collectively access greater capital than Holland's farmers. In 1651, the brewers founded a company to deploy an

1673) Vol II., 182. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 92.

⁸⁴ Wegman, *De Waterlandse Melkschuit*, 47. D.C.B. Evans et al., "The Kinetic Friction of Ice." *Proceedings of the Royal Society* 347:1651 (1976): 494.

icebreaker in Amsterdam's harbour. The icebreaker could not open the harbour for shipping, but it could preserve a watery corridor to the river Weesp. It was usually pulled by eight horses, but in cold winters it required 12, and in severe winters, such as those between 1687 and 1690, it could not be operated at all. In those winters the water route from Amsterdam to the Weesp was opened by hand. The price of fresh water in Amsterdam therefore fluctuated according to winter severity, yet its supply was maintained. In the cities of the Republic, brewers and farmers alike adapted to the severe winters of Little Ice Age minima, because some forms of mobility could not be abandoned.⁸⁵

The kind of weather that grew more frequent during the minima of the Little Ice Age not only altered how existing transportation networks were used, but also contributed to new modes of travel that facilitated new cultures and social spaces. Quintessentially Dutch winter scenes, most famously painted during the Grindelwald Fluctuation by Pieter Bruegel the Elder, reflect the popularity of skates and sleds when temperatures lingered below zero (Figure 3.12). However, they cannot do full justice to the scale of the icy thoroughfares that could emerge when freezing lingered for as many as three months. For example, in the frigid winter of 1620/21, chronicles and diaries described an ice fair near Harlingen that was visited by 1,300 sleds on just one day, some of which had been pulled across the full breadth of the Zuider Zee. Shortly thereafter, new patents for wind-driven wagons and even wind-driven sleds were submitted for the approval of the States-General (Chapter 7).⁸⁶

⁸⁵ Davids, *The Rise and Decline of Dutch Technological Leadership*, Vol. I, 137. Van Dam, "Water, Steam, Ice," 37.

⁸⁶ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 339.



Fig. 3.12. Ice skating and winter activities in the Republic during the first year of the Grindelwald Fluctuation. Pieter Bruegel the Elder, “Winter Landscape with a Bird Trap,” painting, 1565, Musées Royaux des Beaux-Arts, http://www.wga.hu/frames-e.html?html/b/bruegel/pieter_e/01/13winter.html.

Diary entries kept by Caescoper during the Maunder Minimum demonstrate that skating was common both out of necessity and for leisure as soon as freezing conditions endured for more than a few nights, and indeed when the ice thickened sufficiently skaters were joined by travellers on horseback or in carriages. Extensive exploitation of ice for transportation could occur in moderate winters, but it endured much longer in frigid winters that were more common during the minima of the Little Ice Age. Still, not all ice was alike. On 7 March during the cold winter of 1683/84, Caescoper described how ice on regional waterways remained very strong, before reflecting that “we have had no ice that can be crossed by skates.” Curiously, a week earlier Caescoper had reported people skating beside the Zaan, yet skating was evidently more

difficult and, perhaps, less widespread than it might have been given the duration of sub-zero conditions.⁸⁷

Indeed, although freezing stimulates smooth ice in calm water, higher winds and, in turn, waves during sufficiently cold temperatures distort the resulting ice into uneven surfaces. Caescoper also described several storms in diary entries kept during the winter of 1683/84, and it is possible that the stormier conditions of the Maunder Minimum contributed to rougher ice cover in the Republic. Consequently skating may have been hampered by the nature of freezing during Little Ice Age minima even as lengthier ice cover encouraged the greater exploitation of ice for transportation. On the other hand, ice can also become uneven when snow that has melted on the ice is refrozen. These conditions require warmer temperatures, and so might have grown less common in the minima of the Little Ice Age, which therefore could have actually facilitated skating. In any case, carriages, horses, and sleds were scarcely affected by changes in the kinetic friction presented by different forms of ice, except presumably in the Zuider Zee. There, thick shards of sea ice could converge in thawing and then refreeze in new formations as temperatures returned below zero. However, such impediments for movement across ice during the Grindelwald Fluctuation or Maunder Minimum were not recorded in surviving correspondence, diary entries, and newspaper accounts.⁸⁸

Obstructions to travel by ice were, of course, not the only concern for those who attempted to use the Republic's icy thoroughfares. It could be difficult to judge the thickness of ice, particularly at the beginning and end of winters, or when conditions had alternated between

⁸⁷ Caescoper, "7 Maert 1684." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Caescoper, "21 February 1695." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Caescoper, "25 December 1695." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad.

⁸⁸ D.A. Rothrock, "The energetics of the plastic deformation of pack ice by ridging." *Journal of Geophysical Research* 80:33 (1975): 4514. Caescoper, "29 February 1684." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Caescoper, "28 Maert 1684." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad.

freezing and thawing. For example, in March 1670 Adriaen van der Goes wrote that a horse, a coach driver and four women perished when they plunged through the ice at the Schie near Rotterdam. The chronicle kept by the Franciscan St. Elizabeth's covenant near the eastern border of the Republic at Huissen described how many monks fell through the ice on 10 March 1709, "so that it was a wonder that they did not break their legs." For travellers in the Republic, sustained temperatures, whether cool or warm, were likely easier to adapt to and consequently less dangerous than variability, so long as prolonged temperatures did not reach the meteorological extremes of the coldest winters of the Little Ice Age.⁸⁹

It is telling that so many journeying through the coastal provinces of the Dutch Republic by foot, horse, and carriage opted to use frozen water rather than roads during the winters of the Little Ice Age. Many of the Republic's roads were as vulnerable to shifts in temperature as the waterways that intersected them, as freezing rendered many rutted paths impassable, either through slipperiness or because mud and sand froze in uneven formations (Figure 3.13). Across Europe ice cover on city streets imperiled those who ventured outside, and many of those severely injured could expect chronic pain, or even lifelong hampered mobility. For example, on 19 January during the cold winter of 1664/65, Samuel Pepys in London recollected that he "saw a woman that broke her thigh, in her heels slipping up upon the frosty streete." Indeed diaries written on both shores of the North Sea in the winter of 1694/95 reveal that extreme cold could simply discourage travel altogether. In fact, on 23 January John Evelyn in London wrote that "so very fierce was the frost, as kept us still from church." Lyrics of popular songs performed during the frigid winter of 1708/09, although perhaps apocryphal, nevertheless described a postman frozen on his horse, and a family frozen on the street. Corpses belonging to unfortunate families

⁸⁹ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. V, 252. Van der Goes, "Soude syn van 6 Maert 1670." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II.*, 118.

were, in fact, discovered on roads and even in houses when the weather shifted from unseasonable warmth to nearly unprecedented cold on 5 January. Song lyrics consequently reflected exaggerated popular responses to the very real consequences of one of the last great winters during the Maunder Minimum.⁹⁰



Fig. 3.13. Two winter scenes, painted by father (inset) and son at the beginning and just after the end of the Grindelwald Fluctuation, depict travel by land through a wintry Republic. The wagons in the painting by Pieter Brueghel the Elder (inset) are still covered by snow, suggesting that they have not been used following a snowfall. While possibly an example of artistic license, perhaps Brueghel the Elder suggested that the wagons could not traverse their snow-covered roads. Pieter Brueghel the Younger, “Winter Scene with Ice Skaters and Birds,” painting, 1638, <http://goo.gl/8rbqLX>. Inset: Pieter Brueghel the Elder, “The Census at Bethlehem,” painting, 1566, Musées royaux des Beaux-Arts de Belgique, <http://www.wikipaintings.org/en/pieter-bruegel-the-elder/census-at-bethlehem-1566>.

⁹⁰ Samuel Pepys, “Wednesday 9 January 1664/65,” *Diary of Sir Samuel Pepys*. Accessed 25 July 2013 at: <http://www.pepysdiary.com/archive/1665/01>. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 213.

Moreover, in the minima of the Little Ice Age the development of new infrastructure was evidently as vulnerable to prolonged wintry weather as the use of existing roads and city streets. A letter sent by Adriaen van der Goes on 23 February 1663 reported that icy conditions had inhibited the construction of new paths for post wagons, which functioned as a sort of miniature land-based *trekvaart* connecting major towns. The maintenance of roads that had already been built was also hindered by freezing, particularly during the severe winters of Little Ice Age minima. For instance, in the frigid winter of 1666/67, an ordinance drafted by Amsterdam city officials reveals that maintenance of the Overtoomseweg (“Overtoom road”) was forcibly postponed by wintry weather. Because the labour of road maintenance may have taken longer during the minima of the Little Ice Age, its cost likely increased as well.⁹¹

Roads and the travellers who used them were also vulnerable to precipitation, particularly when rainfall or snowfall was expressed in the storms that grew more common during the Grindelwald Fluctuation and Maunder Minimum. On 29 February 1684, Caescoper reported that a torrential downpour during an otherwise frigid winter had left the road he was walking on wet and very dangerous. If the temporarily mild temperatures were hardly typical of a severe winter during the Maunder Minimum, the ferocious gale and its accompanying precipitation certainly were. On 5 August 1695, Christiaan Huygens described how a bout of rain had left one road so slippery that he had fallen on his way to lunch, albeit without serious injury. Flooding stimulated by storms, ice dams, and precipitation was a substantially more serious danger for those travelling on the Republic’s roads. On 8 December 1665, Van der Goes wrote that flooding

⁹¹ “Akte van overeenkomst tussen de dijkgraaf en heemraden van Nieuwer-Amstel met de stad Amsterdam en de eigenaren van landerijen en huizen langs de Overtoomseweg inzake het onderhoud van deze weg 1666 – 1800.” Reference number: 5501. Archief van het Ambacht Nierwer-Amstel, met het Archief van de Ambachten Rietwijk, Rietwijkeroord en Rietwijkeroorderpolder. “Keur van het Hoogheemraadschap van Rijnland tegen het zeilen in de Zuidbuurtse Watering.” Reference number: 1099. Regionaal Archief Leiden. Van der Goes, “Hage, den 23 February 1663.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol IV.*, 173.

stimulated by a catastrophic storm prohibited all travel through roads between Haarlem and The Hague.⁹²

Snowfall during severe winters could be an equally severe impediment to travel along the Republic's roads. In a blizzard during the winter of 1662/63, many post wagons were repeatedly delayed between Rotterdam and The Hague, and others vanished altogether. Although surviving correspondence does not record casualties, many letters never reached their destinations, hampering the flow of information through the Republic. For months during the bitterly cold winter of 1708/09, heavy snowfall accompanied bitterly cold conditions, impeding travel both on roads and in waterways. In the northern Netherlands, travel on land was likely hindered by conditions that were, on average, wetter during Little Ice Age minima, which slowed the trickle of people and correspondence along the roads of the Republic, and compounded the influence of delays in waterborne transportation.⁹³

Nevertheless, despite the limitations of roads in the context of early modern climatic fluctuation, shifts in both average annual precipitation and average winter freezing altered the usually lopsided balance between waterborne and land-based travel through the coastal Republic. Indeed, once water froze during the winter some travellers did take to the roads, as long as freezing was moderate and not accompanied by heavy snow. When Delfzijl's harbour was frozen shut in March 1587, for example, it proved possible to load fifty wagons with goods that would otherwise have travelled by ship. More significant, however, were shifts in annual precipitation and, in turn, water levels. Prolonged drought in December 1669 encouraged many to walk or ride

⁹² Van der Goes, "Hage, den 8 December 1665." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol IV.*, 221.

⁹³ Van der Goes, "Hage, den 22 January 1660." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 51. Caescoper, "29 February 1684." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V*, 219 and 352. Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 581.

across riverbeds, while similarly dry conditions in the spring of 1672 allowed invading French and German armies to easily ford the rivers that normally screened the Republic's southeastern borders. In the summer of 1707 Caescoper described lower water levels than anyone could remember, which evidently prompted many to ride their mules through former creeks and ditches. These years of lower than average water levels coincided with relatively mild winters, and because the minima of the Little Ice Age were accompanied by higher than average precipitation it may be that travel on land was more common during early modern climatic maxima than it was during colder decades. Of course, in parts of the Republic's eastern periphery during both warm and cold climatic regimes, there was little option for travellers but to either use the region's meandering latticework of roads or, in unfavourable weather, postpone their journeys.⁹⁴

Ultimately, in the Dutch trading empire the greatest resilience to the weather that accompanied the climatic fluctuations of the Little Ice Age might have been expressed in small-scale travel by water, ice, and road. The farmers who operated milk boats were rarely threatened by storms, and employed sleds to supply the Republic's cities when water froze in cold winters. Brewers invested in ice breakers and even manual labour to maintain the waterways essential to Amsterdam's supply of fresh water. Many travellers took to the ice using skates, especially during very cold or lengthy winters. Skating and sledding could be perilous, but still provided a means for speedy movement between population centres. Weather that accompanied Little Ice Age minima could hamper both the maintenance and use of the Republic's unhardened roads, yet travel by land continued and even increased during very cold or very dry conditions. The flow of people, goods, and information through the Republic never ceased entirely.

⁹⁴ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 93. Caescoper, "June, July, August 1707." *Nootijsye Boeck, anno 1669-1678, ofte Joernael*. Gemeente Archief Zaanstad.

Conclusions: Travel through the Dutch Republic during the Little Ice Age

Beyond the vicinity of major urban centres, travel across most of early modern Europe was possible only by using sparse, dangerous, often dilapidated roads. However, movement was central to the mercantile economies of the Dutch maritime provinces. The Republic's watery environment, already a product of centuries-long co-evolution with human activity, was accordingly manipulated to yield a complex network woven from diverse, flexible, and often overlapping lines of transportation. The result was a system that, while skewed heavily toward waterborne traffic, nevertheless accommodated many modes of movement that responded differently to weather rendered more or less common during the climatic fluctuations of the Little Ice Age.

The diversity and flexibility of the Republic's transportation network was particularly apparent in the way it responded to shifts in prevailing wind direction and velocity. During the minima of the Little Ice Age, most beurtvaart connections could not operate in more common high winds, and parts of the beurtvaart benefitted while others suffered from more frequent easterlies. On the other hand, travel through the trekvaart continued unabated irrespective of shifts in wind direction and, within limits, wind velocity. Indeed the correlation between the development and first implementation of the trekvaart and the final years of the Grindelwald Fluctuation might not have been coincidental. Changes in wind velocity and direction forced farmers in boats to employ oars, a tedious task that slowed the movement of agricultural goods to urban centres and between rural communities. Travel along roads, on the other hand, was scarcely affected.

Still, generalizations about relationships between climate, weather, and movement are particularly problematic when they concern unhardened roads in distinct environments, fashioned from different materials and subject to maintenance of varying consistency. Indeed, the diversity of different roads contributed to the seemingly bizarre practice in the Republic of constructing and preserving multiple roads that meandered to the same destination. Most roads were, however, compromised by excessive rain or snow, not only for travellers but also for labourers assigned to maintenance. Naturally, waterborne travel typically continued unabated during rain, and ceased with snowfall only if substantial ice had accumulated in waterways. It may be that precipitation undermined the paths bordering canals and travelled by the horses of the trekvaart, but relevant correspondence, diary entries, and newspaper accounts do not mention a correlation.

Diversity in the face of weather and climate also had its limits. Most forms of travel across water were halted during prolonged freezing, although even the consequences of freezing were subject to variation. Sub-zero temperatures generally endured longer in the northern Republic, and unlike travel through the beurtvaart and trekvaart, the transport of commodities in boats apparently continued when ice had already formed in harbours, so long as it did not extend too far from the coast. Ice cover could slow or even discourage travel across roads, but freezing did not affect travel by land as severely as it influenced movement by water. Overall, large-scale transportation in the northern Netherlands was generally impeded by freezing, because the volume of goods or people that regularly passed through the watery arteries of the Dutch Republic could not be fully displaced onto wagons, or even skates. Meanwhile, extreme cold discouraged all kinds of travel, and such conditions were far more common during the minima of the Little Ice Age. Moreover, storms rendered more likely in the same minima impeded the use

of conduits both on land and across water. Indeed, gales accompanied by heavy precipitation or flooding could prevent all movement through a particular region, overwhelming even the Republic's uniquely resilient transportation network.

Nevertheless, the history of relationships between transportation within the Republic's borders and meteorological conditions typical of Little Ice Age minima is not a declensionist narrative. Even in severe winters, Dutch labourers worked to maintain watery corridors through the ice near Amsterdam. Moreover, moderate freezing actually stimulated new forms of small-scale transportation across the ice that preserved some movement of goods, people, and information through the Dutch provinces. In fact, winters that were only slightly cooler than the twentieth-century average, and were accordingly accompanied by prolonged but tolerable freezing, were significantly more common than the landmark winters of, for example, 1627/28, 1683/84, or 1708/09. Unfortunately, records of severe weather abound in surviving sources, while relatively moderate shifts in meteorological conditions often went unreported in sources other than ship logbooks or weather diaries. In spite of that reality, paintings, diaries, and correspondence reflect the remarkable popularity of skating and ice fairs in the Republic during the Grindelwald Fluctuation and Maunder Minimum.

The popularity of skating in cold winters was but one expression of the impressive physical and intellectual energy with which Dutch citizens of different social strata confronted weather more frequent during the minima of the Little Ice Age. The infrastructure of the *trekvaart* was constructed to free waterborne transportation from its dependence on shifts in wind direction and, to some extent, velocity. Less structured networks established by farmers functioned organically and efficiently irrespective of wind or even ice cover. As cold winters grew more common and more severe, Dutch inventors developed patents that, while impractical,

nevertheless reflected a confident attitude affirming that environmental problems could be circumvented by human ingenuity. While the environmental crises that contributed to the Republic's decline would later expose the limitations of that notion (Introduction), it nevertheless typified the resilience of a dynamic society and a relatively modern economy during the minima of the Little Ice Age.

Ultimately, relationships between climatic oscillations, short-term weather, and changes in travel through the Republic were as complex as the socioeconomic consequences of those changes. Changes in, for example, travel through the trekvaart network or along roads in the eastern provinces were influenced not only by weather that directly affected infrastructure, but also by meteorological events and trends that contributed to or detracted from regional economies. For instance, rye prices increased in the year following a particularly cold winter during the Little Ice Age. Curiously, travel through the trekvaart network rose in tandem, even though a significant portion of household income was spent on bread in the early modern Republic, and demand for cereals like rye was consequently inelastic in a way that demand for travel was not for most families.⁹⁵

Of course, the number of passengers through the trekvaart declined in years accompanied by lengthy winter freezing, and it is not surprising that trekvaart popularity should rise alongside rye prices in the Republic. Still, the case highlights the difficulty of establishing connections between broad socio-economic trends and climatic fluctuation in early modern Europe. Consequently it is prudent to conclude simply that transportation through the Republic was more resilient to some expressions of Little Ice Age minima than it likely was in the less tightly connected agricultural economies that dominated early modern Europe. Because transportation

⁹⁵ Jan de Vries, *Barges and Capitalism*, 291.

was central to a Republic competing with these relatively agrarian entities for commerce and territory, that was not an insignificant advantage.⁹⁶

Ultimately, travel within the borders of the Republic, and in the European waters around it, was similarly hampered by lengthy and widespread freezing during the frigid winters of Little Ice Age minima. Moreover, storms could imperil voyages both for sailors plying the Baltic trades, and for travellers journeying between Dutch towns. Other weather patterns that accompanied Little Ice Age minima influenced travel near, and within, the northern Low Countries in different ways. For example, shifts in wind direction were more influential for mariners in the Baltic and the North Sea than they were for those moving through the Republic. On the other hand, major precipitation events were more significant for travellers on land than they were for those at sea. Overall, the meteorological expressions of Little Ice Age minima ambiguously influenced travel through the Republic's economic heartland in the Low Countries and the Baltic. Many Dutch citizens responded to the weather that accompanied the Little Ice Age in ways that often mitigated the disadvantages, and exploited the advantages, of an environment in flux.

⁹⁶ In a brief summary of the relationship between the Republic's economic cycles and cold winters during the Little Ice Age, Jan de Vries suggested that "this was not an economy that was shunted by the whims of Ceres and Mars between years of plenty and years of famine." The same likely applies for the Republic's networks of transportation, both in metropole and periphery. Jan de Vries, *Barges and Capitalism*, 295.

PART II: CONFLICT AND CLIMATE CHANGE

Defending Wealth in the Little Ice Age: Case Studies of the Anglo-Dutch Wars, 1652-1674

In Europe, 190 years between 1500 and 1700 were engulfed by war. In that context, military power was inextricably linked to the survival and expansion of the Dutch commercial empire. While the Republic's economic interests were global, the North Sea region and, to a lesser extent, the Baltic Sea remained the military focus of the Dutch Republic in the seventeenth century. The thousands of ships that serviced the Republic's many trade routes, fished for herring, and hunted whales all passed through these waters on their journeys to and from the Dutch coastal cities. Moreover, invasion from the sea and from land was a continual threat for a small but prosperous state ringed by larger rivals. Ultimately, the prosperity of the Dutch economy in its Golden Age would have been impossible without a powerful military capable of both aggression and defence.¹ In this sense the Republic was hardly unique within contemporary Europe, although the character of its defences on land, and its conduct of war at sea, were certainly unusual.²

Despite the importance of warfare in early modern Europe, until recently military history as a sub-discipline appeared on course to join political history in its irrelevance to the cutting edge of historical research.³ Nevertheless, enduring public interest in warfare, and the wealth of documentation generated by centuries of armed conflict, gradually encouraged social and eventually cultural historians to reinvigorate military history by exploring, for example, the memory of military campaigns, or their complex expressions of contemporary class distinctions.⁴

¹ Jan Glete explained that "efficiency in trade and shipping was intertwined with efficiency in fighting, and naval strategy was co-ordinated with mercantile strategy." Glete, *Warfare at Sea*, 165

² J.R. Hale, *War and Society in Renaissance Europe*. (London: Fontana, 1985), 22. Scammell, *The First Imperial Age*, 20. John A. Lynn, *Giant of the Grand Siècle: The French Army, 1610-1715*. (Cambridge: Cambridge University Press, 2006), 11. Ormrod, *The Rise of Commercial Empires*, 31. Glete, *Warfare at Sea*, 3, 40. 'T Hart, "The Dutch Republic: the urban impact upon politics," 68.

³ J.A. Lynn, "The Embattled Future of Academic Military History," *Journal of Military History* 61 (1997): 778.

⁴ Cultural histories of popular violence, as opposed to warfare, have a longer history. A classic example remains N.Z. Davis, "The Rites of Violence: Religious Riot in Sixteenth-Century France," *Past and Present* 59 (1973), 51-91. An equally important recent work in the same vein that begins to incorporate military operations is: Edward

Military historians, meanwhile, increasingly embrace gender, class, and other social or cultural concepts to write ground-breaking new studies of early modern military operations.⁵ In the last decade, environmental historians have begun to explore how military, scientific, industrial, and political interests in the modern era exploited and perceived foreign, domestic, or occupied ecologies in times of conflict. More recently still, environmental historians have started to unravel interactions between pre-industrial warfare and environment, as part of a growing understanding within environmental history that pre-industrial societies anticipated many of the ecological relationships previously thought peculiar to modernity.⁶ While studies considering pre-industrial warfare and environment remain rare, those that move beyond declensionist accounts of environmental destruction in times of war by devoting primary attention to the ways in which natural stimuli influenced armed conflict truly represent the vanguard of the new discipline.

Surviving documents chronicling pre-industrial wars frequently reveal that among natural influences weather events stimulated by past climatic fluctuation loomed large in the perceptions of combatants.⁷ Historians can unravel connections between past climates, weather conditions and military operations by deploying climate reconstructions and interdisciplinary methodologies

Muir, *Mad Blood Stirring: Vendetta and Factions in Friuli during the Renaissance*. (Baltimore and London: Johns Hopkins University Press, 1993), xx.

⁵ R.M. Citino, "Military Histories Old and New: A Reintroduction." *American Historical Review* 112 (2007): 1089. For two excellent examples of such studies, see: John A. Lynn, *Women, Armies, and Warfare in Early Modern Europe*. (Cambridge: Cambridge University Press, 2008), and James P. Kroker, "New Means to an Old End: Early Modern Maps in the Service of an Anti-Ottoman Crusade." *Imago Mundi* 60 (February 2008): 23-38.

⁶ If in 2001 the publication of the essays within *Natural Enemy, Natural Ally* heralded the development of a new sub-field in environmental history, in some respects J.R. McNeill's *Mosquito Empires*, published in 2011, represents its "coming of age." These books can be compared to Edmund Russell's *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring*, which considers how warfare influenced the industrial and scientific expressions of modernity. Richard P. Tucker and Edmund Russell (eds.), *Natural Enemy, Natural Ally: Toward an Environmental History of War*. Corvallis: Oregon State University Press, 2004. J.R. McNeill, *Mosquito Empires: Ecology and War in the Greater Caribbean, 1620-1914*. Cambridge: Cambridge University Press, 2011. Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring*. Cambridge: CUP, 2001.

⁷ Hubert Lamb, *Climate, History, and the Modern World*. 2nd Ed., 260. Bernstein et al., "Climate Change 2007: Synthesis Report," 30.

developed by historical climatologists. However, although historical climatologists have moved well beyond their long-standing agrarian focus to consider a diverse spectrum of relationships between humans, weather, and climate, no comprehensive study has yet considered how climatic fluctuation influenced armed conflict. Until very recently two of the most dynamic avenues in environmental history have essentially failed to interact.⁸

The following chapters bridge that gap by exploring relationships between climatic fluctuations, weather events, and the conduct of the three Anglo-Dutch Wars in the seventeenth century. Fought between 1652 and 1674, the wars coincided with a period of transition between climatic regimes. Slightly warmer conditions that generally prevailed after the conclusion of the Grindelwald Fluctuation in 1629 yielded in 1662 to the renewed cold of the Maunder Minimum. Newly considered Dutch and English ship logbooks, missives, weather journals, intelligence reports, and other sources demonstrate the halting but dramatic nature of this transition. They also suggest that oscillations in temperature were intimately connected to long-term shifts in wind direction over the North Sea and English Channel. Finally, they reveal that changes in prevalent weather conditions influenced the course of the Anglo-Dutch Wars in a way that was perceived and, to varying degrees, either consciously or unconsciously exploited by, the combatants.

In the First Anglo-Dutch War (1652-54), relationships between Anglo-Dutch culture, economy, technology, and environment, mediated through many layers of human agency, enabled the English to benefit from weather that accompanied a relative interruption in conditions typical of Little Ice Age minima. Persistent westerly winds probably born of a warmer

⁸ An exception are deterministic studies that argue for causation, but actually discover correlation, between war and climatic cooling or warming. See, for example: Richard S.J. Tol and Sebastian Wager, "Climate change and violent conflict in Europe over the last millennium." *Climatic Change* 99 (2010): 65-79. David D. Zhang et al., "Climate Change and War Frequency in Eastern China over the Last Millennium." *Human Ecology* 35 (2007): 403-414.

climate frequently helped crews aboard larger English warships set the terms of most naval engagements, increasing the tactical advantage provided by revolutionary “line of battle” tactics.⁹ By contrast, in the latter wars abundant storms and more frequent easterlies, likely stimulated by a cooling climate, granted critical advantages to Dutch fleets that had adopted elements of English tactics and technology. The second (1664-67) and third (1672-74) wars were also fought on land, where tactically relevant weather occasionally defied climatic trends and ultimately exerted an ambiguous influence on the defence of the Dutch Republic.

Climatic shifts alter regional patterns of prevailing weather on a decadal scale, yet military operations, like the voyages of Arctic explorers, Dutch East Indiamen, or *trekvaart* passengers, usually play out over a far shorter period. These chapters therefore demand the same methodology that has previously been deployed in case studies that examined movement through the Dutch trading empire. They investigate three relationships: between long-term regional climatic shifts and local, short-term environmental change, between human activity and local, short-term environmental change, and ultimately between climate and human history. Weather experienced during battles, raids, and other historical events will be considered a manifestation of a prevailing climate if it recurred during months in which it was rare during a preceding or subsequent climatic regime. Particularly persistent weather over the course of a month will also be tied to the prevailing climate if such weather grew more common during that climatic regime, even if such weather occurred regularly in the same month during preceding or subsequent climates.

Battles were staccato notes within the undulating melodies of the broader relationship between climate and early modern warfare. There were other notes, however, for in the

⁹ Tactics primarily relates to the conduct of battle: what is done while combatants are in physical contact. Strategy primarily refers to the process of maneuvering forces so they are best positioned to damage the enemy. There is, of course, some overlap between tactics and strategy. Glete, *Warfare at Sea*, 17.

seventeenth century major engagements at sea and on land were fought against a simmering context of small-scale violence, often pursued by private parties. Minor naval raids, privateering and piracy, marine intelligence networks manned by crews in small boats, victualing fleets, and the actions of civilian crews aboard merchant vessels all shaped the course of the Anglo-Dutch Wars. However, major battles between state armies and fleets receive far more attention than minor skirmishes in surviving documentary evidence. Moreover, despite the lingering importance of small-scale violence at sea, the Anglo-Dutch Wars were largely decided by large fleets assembled to decisively defeat their counterparts. These chapters therefore concentrate on the ways in which climate change and associated environmental conditions influenced preparations for, and the conduct of, major battles from 1652 to 1674.¹⁰

Dutch and English historians often disagree on even the most fundamental aspects of the largest battles fought during the Anglo-Dutch Wars. In particular, striking numerical discrepancies exist between Dutch and English historiographies. English historians rarely employ Dutch primary material that contradicts English accounts. Moreover, historians on both sides of the Channel have depended too much on statistics provided within propaganda that was written immediately after battles, which greatly exaggerated enemy losses. Reliable primary sources compiled by both Dutch and English sailors, and intended for internal use, provide the basis for most of the ship numbers introduced in these chapters. Where such documents are not available, a variety of English and Dutch primary and secondary sources can still provide relatively reliable statistics. However, they must be examined in concert, and screened for improbable fluctuations in ship numbers from battle to battle.

¹⁰ Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*. (Stroud: Sutton Publishing Limited, 1998), 25.

Climatic fluctuation plausibly influenced the Anglo-Dutch Wars not just by shaping tactical conditions, but also by changing the resources available to England and the Dutch Republic. The tremendously expensive navies that fought the wars were primarily funded by credit, but it was the ability of the Commonwealth parliaments to tax at unprecedented levels that enabled the earlier expansion of the English fleet and allowed it to successfully challenge Dutch naval supremacy. The most important taxes imposed by Cromwell's parliaments were the Customs, the Excise, and the Assessment, of which the Excise targeted items of common consumption – like food – while the Assessment taxed land. It is possible that warmer and more stable annual average temperatures during the relative pause in the nadir of the Little Ice Age increased English agricultural yields, ultimately strengthening the Commonwealth's finances.¹¹

Moreover, domestic woodlands and hemp crops provided the timber, iron, and sails necessary for ship construction. Dendrochronological data suggests that warm temperatures and moderate precipitation sharply accelerated the growth of pine and oak trees across Northwestern Europe from 1640 into the 1650s. Oak trees commonly served as timber, and it is possible that two decades of relatively strong growth reduced the cost and, perhaps, increased the accessibility of timber for some English shipyards. High grain yields and healthy woodlands therefore may have contributed to the English success in the First Anglo-Dutch War. However, examining such broad relationships is beyond the scope of these chapters, because the most convincing and best-documented connections between climate, weather, and the course of the Anglo-Dutch Wars

¹¹ N.A. M. Rodger, *The Command of the Ocean: A Naval History of Britain 1649-1815*. (London: Penguin Books, 2004), 38. Rodger writes that relative to the requirements of an army, "the demands of sea power were not only greater in themselves, but fell upon a much wider cross-section of society." N.A.M. Rodger, *The Safeguard of the Sea: A Naval History of Britain, 660-1649*. (New York: W.W. Norton & Company, 1997), 432. De Vries, "Measuring the Impact of Climate on History," 626. Paul Warde, *Energy Consumption in England & Wales*. (Rome: Consiglio Nazionale delle Ricerche, Istituto di studi sulle società del Mediterraneo, 2007), 124

were visible at the tactical level. There, those engaged in battle directly described the environmental conditions they encountered.¹²

The following three chapters begin with a comprehensive analysis of the environmental structures in which the Anglo-Dutch Wars were fought, which includes a detailed reconstruction of contemporary shifts in prevailing wind direction. The first chapter continues by introducing the cultural and socioeconomic frameworks that accounted for differences in Dutch and English military systems. The chapter then explores how major naval operations were affected by weather conditions that were, in turn, influenced by the climate of the slightly warmer and more tranquil interruption of the Little Ice Age in the middle of the seventeenth century. The next chapter begins by explaining how Dutch and English military systems changed from the end of the First Anglo-Dutch War to the commencement of the second. It then examines connections between the conduct of the war, which for the first time included fighting on land, and the cooler climate, and changed wind dynamics, that accompanied the Maunder Minimum. The third chapter describes the very different military context on the eve of the Third Anglo-Dutch War, which included a French and German invasion that almost overthrew the Republic. The chapter investigates how war on land and at sea was affected by weather that was largely, but not straightforwardly, shaped by the climate of the Maunder Minimum.

¹² Rodger, *The Safeguard of the Sea*, 430. J. R. Pilcher and B. Gray, "The Relationships Between Oak Tree Growth and Climate in Britain." *Journal of Ecology* 70 (1982): 297. Oliver Rackham, *Ancient Woodland: Its History, Vegetation and Uses in England*. (London: Castlepoint Press, 1980), 73. Briffa, K. R. et al. "European Tree Rings and Climate in the 16th Century," 156

Chapter 4

Warfare in a Warmer Climate: the First Anglo-Dutch War, 1652-54

When the Peace of Westphalia ended the Eighty Years' War in 1648, the prosperity of the Dutch Republic was widely resented in the courts of Europe, and many believed Amsterdam's commanding position in international commerce was possible only at the expense of competing economic interests.¹³ Both the French and Spanish economies complemented that of the Republic, and accordingly the Spanish had generally permitted trade with their rebellious provinces. However, after 1659 the government of Louis XIV actively sought to end its reliance on the entrepôt to the north by imposing a series of protectionist tariffs. These policies increasingly damaged Dutch economic interests, and the encroachment of French influence in the Spanish Netherlands alarmed many Dutch politicians. Nevertheless, in the seventeenth century the French government by itself could neither halt the flow of Dutch trade overall nor aspire to replace the Republic's unique place in the global economy.¹⁴

However, England loomed over vulnerable shipping lanes and fishing grounds in the English Channel and North Sea. Moreover, London was Europe's second-most developed urban

¹³ Not always resentment: after writing that "there is more to be earned by manufacture than by agriculture, and more by commerce than by industry," contemporary English economist and scientist William Petty praised the Republic for its commercial dominance. Many in early modern Europe believed that the key to the Republic's success was its favourable "balance of trade." Other historians have suggested that such a belief, and the policies that it encouraged, were a consequence of mercantilist economic ideology. However, since the first publication of Eli Heckscher's landmark *Mercantilism* in 1931, historians have so nuanced, challenged, and expanded or contracted the concept of "mercantilism" that it can scarcely be used without extensive qualification. Consequently, in this dissertation it is not employed to describe the economic circumstances that contributed to the outbreak of the seventeenth-century Anglo-Dutch Wars. Eli Heckscher, *Mercantilism*. (Oxford: Routledge, 2013; orig. 1931), xiii. Lars Magnusson, *Mercantilism: The Shaping of an Economic Language*. (Oxford: Routledge, 2002), 8. Dirk Jan Struik, *The Land of Stevin and Huygens: A Sketch of Science and Technology in the Dutch Republic During the Golden Century*. (Leiden: Springer, 1981), 93.

¹⁴ De Vries and Van der Woude, *The First Modern Economy*, 410. Jan Luiten van Zanden, "Early modern economic growth: A survey of the European economy, 1500-1800," in *Early Modern Capitalism: Economic and Social Change in Europe 1400-1800*, ed. Maarten Praak. (Oxford: Routledge 2005), 70. Van Zanden, "The Emergence of Modern Economic Growth in the North Sea Region," 260.

area, and ideally situated to usurp Amsterdam's entrepôt function in world trade. The circumstances that encouraged English governments to leverage these advantages were complex. Much responsibility for the wars that resulted can be attributed to political or religious similarities (under Oliver Cromwell's republic) or schisms (under the restored monarchy), domestic disputes between royalists and republicans and, of course, the personal agency of diplomats. Ultimately, the legislation most directly responsible for the First Anglo-Dutch War – the Navigation Act of October 1651 – was a protectionist measure born from mercantile pressure and aimed at eliminating Dutch entrepôt trade with English territories. Moreover, the act authorized English warships to take action against all vessels that did not acknowledge England's "sovereignty of the seas" by lowering their flags. Because commerce, fishing, and whaling at sea were integral to Dutch culture and prosperity, this stipulation was intolerable to the States-General.¹⁵

Most members of the States-General, indeed most observers in contemporary Europe, considered the Republic to be the world's preeminent naval power. However, the English admiralty had developed a revolutionary naval system that bestowed important advantages in the subsequent war. These advantages were exacerbated by weather patterns that were more common during the slightly warmer interval between the Grindelwald Fluctuation and the Maunder Minimum. Westerly winds allowed English fleets to easily leave port, and granted them the initiative they required to deploy their nascent line of battle tactics. They may also have helped English privateers claim far more prizes than their Dutch counterparts, which contributed

¹⁵ Jack S. Levy, "The Rise and Decline of Anglo-Dutch Rivalry, 1609-1689." In *Great Power Rivalries*, ed. William R. Thompson. (Columbia: University of South Carolina Press, 199), 173. Jack S. Levy and Salvatore Ali, "From Commercial Competition to Strategic Rivalry to War: The Evolution of the Anglo-Dutch Rivalry, 1609-52." In *The Dynamics of Enduring Rivalries*, ed. Paul Francis Diehl. (Champaign: University of Illinois Press, 1998), 31. De Vries and Van der Woude, *The First Modern Economy*, 376. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 111. Ormrod, *The Rise of Commercial Empires*, 35. Glete, *Warfare at Sea*, 15.

to the unequal outcome of the war. Other weather conditions also affected the course of the war, but they cannot yet be linked to the climate of the mid-seventeenth century.

Overview of Environmental Structures

The Anglo-Dutch Wars have stimulated English and especially Dutch historiographies that generally ignore environmental relationships while constructing detailed political, economic, and military narratives.¹⁶ Environmental histories of war have hardly ventured past the shore, and the Anglo-Dutch Wars, so closely identified with the North Sea, have entirely escaped the attention of environmental historians. Beyond the rising volume and sophistication of early modern documents related to fishing or whaling relatively few written sources survive to enable the reconstruction of human interactions with the myriad environments of the sea, as, for example, legal documents can aid scholarly analysis of woodland exploitation. The sea also appears unbounded; vast and, in the pre-industrial era, superficially bereft of the shifting patterns of environmental resilience and vulnerability described within some of the historiography connecting environment and warfare. Pre-industrial warfare did not destroy marine ecologies, for instance, whether directly, through the actions of military forces, nor indirectly, through the overexploitation of a resource base.

Nevertheless, the Anglo-Dutch Wars were influenced by the context of the geography and marine environment of the North Sea between the Strait of Dover and the Dogger Bank,

¹⁶ Among scholars who have contributed to a recent surge in the English historiography of the wars only J.R. Jones explores environmental contexts, although his *The Anglo-Dutch Wars of the Seventeenth Century* is certainly not an environmental history. The Dutch admirals that led the Dutch war effort – particularly Maarten Harpertzoon Tromp and Michiel Adriaanszoon de Ruyter – were folk heroes in their own time, known as *zeehelden* (sea heroes) and immortalized as symbols of the Dutch golden age. Not surprisingly, this has lent a hagiographical character to much of the extensive Dutch historiography.

where the bulk of its naval engagements were fought. Regional currents push north through the English Channel and past the Low Countries, but additional currents drive south from the subarctic into the North Sea, interacting with tides to influence ship journeys. During the Anglo-Dutch Wars, extensive shoals surrounding the English and particularly the Dutch coast constricted the movement of ships and affected tactical or strategic decision-making during the wars. The colour, texture, and composition of the seabed, regularly analysed, also provided clues for navigation when the shore was out of sight.¹⁷ Marine animals like mackerel or haddock could benefit military operations, supplementing much-needed victuals when successfully harvested. Barnacles, on the other hand, could dramatically slow warships that relied on speed; their inevitable accumulation on hulls necessitated regular and expensive cleaning.

More importantly, the extreme proximity of Dutch and English ports, fortifications and fleets in this region (Map 4.1) mitigated some of the organizational inefficiencies of the opposing admiralties. Because weather systems could span the entire theatre of war, these geographical constraints also enhanced the influence of meteorological conditions at sea.¹⁸ In the age of sail, wind direction and velocity not only provided a vessel's power supply but also constrained its ability to move according to the wishes of its crew. By the seventeenth century, ships had acquired the ability to tack against the wind, but this was difficult, time-consuming work and altogether impossible in intense winds. Storms were a constant menace, capable of throwing ships hundreds of miles off course, inflicting severe damage and either sinking ships at sea or

¹⁷ John Narbrough, "Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673. Pepysian MS. 2556" in *Journals and Narratives of the Third Dutch War*, ed. R. C. Anderson. (London: Publications of the Navy Records Society, 1945-1947), 213.

¹⁸ A week of contrary winds could thwart a naval raid in such narrow seas, for example, but would generally have a reduced influence on the journey time of a fleet bound for North America. Narbrough, "Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673," 213. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 17.

shattering them on the coast. Heavy rain could drown supplies of food or ammunition, while fog impeded navigation and increased the risk of collision.



Map 4.1. Locations of major engagements during the three Anglo-Dutch Wars. Locations of rival cities London and Amsterdam are also provided. Inset: seventeenth-century map of the North Sea and English Channel. Pierre D'Abbeville Du Val, *Carte des Isles Britanniques*, map, 1677. Accessed 10 April 2014, <http://goo.gl/I8zIX1>. Gerben Graddesz. Hellinga, *Zeehelden van de Gouden Eeuw*. (Zutphen: Walburg Pers, 2008), 20. True colour NASA satellite image, acquired 18 December, 2010.

Although the first two Anglo-Dutch Wars were largely determined at sea, the third war was fought in a shifting, amphibious landscape that responded to the different ways the Dutch,

and their enemies, waged war.¹⁹ The intricate defences against the sea that emerged from centuries of environmental and cultural co-evolution in the Low Countries were manipulated during the French and German invasion of the Third Anglo-Dutch War. Dutch defenders engaged the *Oude Hollandse Waterlinie* (“Old Hollandic Waterline”), a winding expanse of inundated farmland that effectively rendered the province of Holland an island.²⁰ The decisive months of the war were shaped by French, German, and English attempts to reach this new island. The Dutch struggled to balance the necessities of defending against naval invasion from the North Sea, and securing vulnerable fortresses along the waterline. Equally critical was the need to maintaining the required depth, and liquid state, of their protective waters.

On land and at sea, the prevailing weather of the North Sea region was therefore among the most important environmental structures in which the Anglo-Dutch Wars were fought, and it was in flux. Average winter temperatures, which had not been far removed from the twentieth-century norm in the first war, were sharply cooler in the second and third wars (Figure 4.1). Average summer temperatures declined less steadily, and were actually higher in the second war than they had been in the first. However, by the third war average summer temperatures were far colder than they had been in the earlier wars. Meanwhile, average temperatures in autumn and particularly spring declined between the first and third wars. Precipitation rose while the rate of

¹⁹ The concept of the “amphibious landscape,” and “amphibious culture” of the Republic has been developed by environmental historian Petra van Dam. While Van Dam’s meaning is specific, here the concept is used more generally. The landscape of the Netherlands was penetrated and encircled by water: for many in the Dutch Republic, water and land were equally surfaces on which to work, play, and fight. Never was this more apparent than in 1672 and 1673. Petra van Dam, “De amfibische cultuur.” For more on the amphibious landscape and culture of the Republic, see: G. P. van de Ven, *Man-made lowlands: History of water management and land reclamation in the Netherlands*. Utrecht: Uitgeverij Matrijs, 1993.

²⁰ This drastic and destructive last-ditch defence was employed following successful military inundations during the Eighty Years War, of which the relief of the siege of Leiden in 1574 was the most renowned. J.P.C.M. van Hoof, “Met een vijand als bondgenoot. De rol van het water bij de verdediging van het Nederlandse grondgebied tegen een aanval over land.” *BMGN* 103 (1985): 624. P.G. Vonk, *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*, 65. For more on the *Waterlinie*, see: Wim Klinkert, “Water in oorlog. De rol van het water in de militaire geschiedenis van Holland na 1550,” in *Hollanders en het water. Twintig eeuwen strijd en profijt*, Vol. II, ed. Eelco Beukers. (Hilversum: Uitgeverij Verloren, 2007), 451-504.

evaporation declined, and the southward movement of the circumpolar vortex encouraged greater storminess in many northern European regions, including the coasts of the North Sea.²¹

²¹ Gottschalk, *Stormvloed en rivieroverstromingen in Nederland, Vol III*, 159, 414. See also: Shabalova and Van Engelen, "Evaluation of a reconstruction of temperature in the Low Countries AD 764-1998." Christoph C. Raible, "Climate variability - observations, reconstructions, and model simulations."

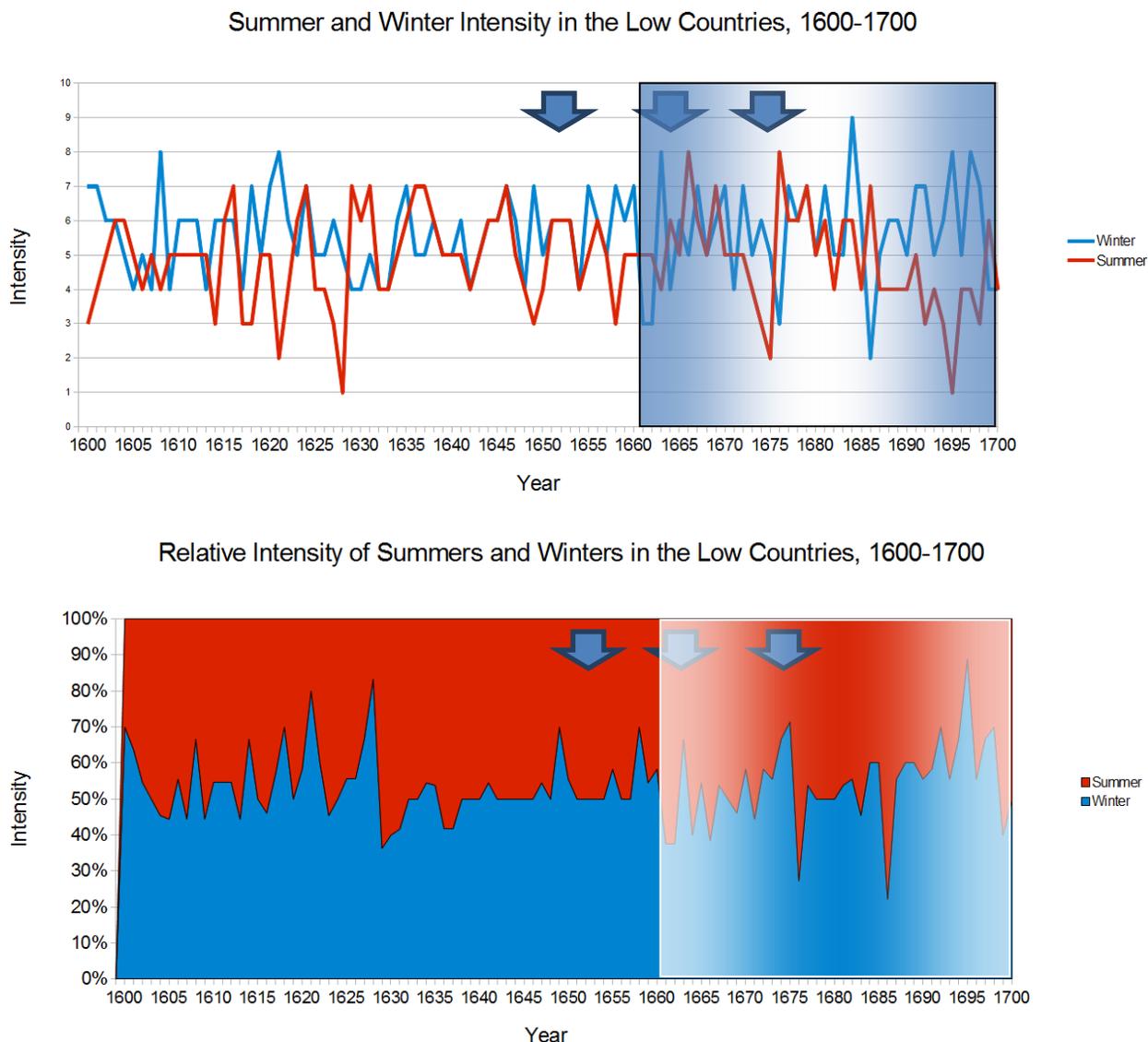


Fig. 4.1. Annual changes in Winter and Summer Intensity in the Low Countries, 1600-1700. This figure is compiled from climate reconstructions developed using diverse documentary evidence quantified by A.F.V. van Engelen, J. Buisman and F. Ijnsen. In both graphs, the Maunder Minimum (1662-1718, boxed area) and the Anglo-Dutch Wars (arrows) are highlighted. The top graph reveals winter and summer temperatures outside their relation to one another. Greater space between the winter and summer lines correspond to cooler yearly temperatures. The bottom graph records changes in the relationship between winter and summer intensity. For example, years in which both summer and winter intensity was a 4 receive the same “score” (5) as years in which summer and winter intensity was at 6. For further explanation of the relationship between these numbers and average seasonal temperatures, see Chapter 3, Figure 3.10. Van Engelen, Buisman and Ijnsen, “A Millennium of Weather, Winds and Water in the Low Countries,” 112. M.V. Shabalova and A.F.V. van Engelen, “Evaluation of a reconstruction of temperature in the Low Countries AD 764-1998.” *Climatic Change* (March 2000), 225.

However, gales during the latter wars may not have become more abundant in all seasons. In the spring, summer, and autumn of the later Maunder Minimum, steeper temperature

gradients between the sub-tropical and high latitudes probably channelled the polar jet south, imbuing the system with greater potential for storminess. In the winter well-developed continental anticyclones could have created “blocking” situations that led storm fronts away from the British Isles and, in turn, away from the region in which the Anglo-Dutch Wars were predominantly fought.²² Then again, according to Hubert Lamb several severe winter storms afflicted the North Sea region during the winters of the 1660s, and missives written by, for example, the brothers Van der Goes contain repeated references to calamitous winter gales. Consequently, although it is possible that storminess during winter months was reduced relative to twentieth-century averages for the whole of the Maunder Minimum, the majority of relevant research and primary sources currently suggest winter storms were symptomatic of the prevailing climate of the second and third Anglo-Dutch Wars.²³

Climatic cooling also influenced prevailing wind direction in the Second and Third Anglo-Dutch Wars. The North Sea lies in a zone between the Icelandic Low and Azores High, where depressions normally move east and winds consequently blow overwhelmingly from the west, particularly during moderate or warm climatic regimes. For example, between 1961 and 1970, a relatively cool decade by twentieth-century standards, westerly winds prevailed off the Dutch coast for every month except February, and even then easterlies were only marginally more common. Nevertheless, while westerlies were more common than easterlies during most months in the climate of the late twentieth century, and particularly in June and July, easterlies were at their most abundant in the spring.²⁴ Lamb was among the first historical climatologists to

²² Wheeler, “British Naval Logbooks from the Late Seventeenth Century,” 141.

²³ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 48. “Hage, den 8 December 1665.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 221.

²⁴ This is a generalization of weather patterns that are never stable; west-southwesterlies, for example, appear to have grown more frequent between 1988 and 1997, as mean wind velocity increased. Siegismund and Schrum, “Decadal changes in the wind forcing over the North Sea,” 44. Korevaar, *North Sea Climate, based on observations from ships and lightvessels*, 65. “Northeast England: Climate,” Met Office, accessed February 2, 2013,

use documentary evidence listing wind direction to suggest that the frequency of westerlies in the North Sea region rose during the warmer decades of the Little Ice Age, and fell during its coldest periods (Introduction).²⁵

Recently, Dennis Wheeler has employed British naval ship logbooks compiled in the English Channel between 1685 and 1750 to reveal that the overall frequency of westerly winds declined during much of the Maunder Minimum.²⁶ Ship logbooks written before the final decades of the seventeenth century are relatively rare; those that survive contain little detail and typically describe important but unrepresentative journeys.²⁷ Still, some ship logbooks do survive to shed light on the prevailing winds experienced during the First Anglo-Dutch War. For example, while limited to 1653, the meteorological readings in the ship logbook of Dutch Admiral Witte de With appear to confirm that westerlies were more common during the “maxima” of the Little Ice Age. Most of De With’s weather reports were taken during spring and fall, when winds from the east were more common in the twentieth-century climate. Nevertheless 51 per cent of De With’s 131 morning measurements recorded westerly winds and 35 per cent listed easterlies, while in the evening 55 per cent of his entries listed westerlies and just 34 per cent mentioned easterlies. In May, when easterlies can be more common than westerlies in even the warmer twentieth-century climate, De With still recorded more westerlies.²⁸

<http://www.metoffice.gov.uk/climate/uk/ne>. “Eastern England: Climate,” Met Office, accessed February 2, 2013, <http://www.metoffice.gov.uk/climate/uk/ee>.

²⁵ Lamb, *Climate, History and the Modern World*, 198.

²⁶ Wheeler, “British Naval Logbooks from the Late Seventeenth Century,” 136. Wheeler et al., “Atmospheric circulation and storminess derived from Royal Navy logbooks,” 13. Wheeler, “Understanding Seventeenth-Century Ships’ Logbooks,” 16. See also: Glaser and Koslowski, “Variations in reconstructed ice winter severity in the western Baltic from 1501 to 1995,” 188.

²⁷ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 611, 735.

²⁸ De With, Witte, “Journael off dagh register gehouden bij den Hr Vice Admiral Witte Cornelisz. de With, sedert 24 Aug. 1652 tot 5 Nov. 1658,” Aanwinsten Eerste Afdeling, Reference code: 1.11.01.01, Nationaal Archief (Den Haag, Netherlands). Korevaar, *North Sea Climate*, 65.

The longer and more continuous ship logbooks written by English naval officer Thomas Allin between July 1664 and November 1666 reflect a dramatically changed pattern of prevailing wind (Figure 4.2). According to Allin's log, easterlies outnumbered westerlies in 7 out of 25 months, and overall easterlies accounted for 39 per cent of recorded wind directions. The final statistic, while representing a 10 per cent increase in the frequency of easterly winds over the twentieth-century norm, may actually misrepresent the shift. Allin's first logbook of 1664, recorded in July, was written several months before the unofficial opening of the second Anglo-Dutch War, and just after the months when easterlies were particularly abundant in the climates of both the late Maunder Minimum and the late twentieth century.

Still, additional quantitative research is required to measure whether a spring abundance of easterlies was also typical of the climate of the early Maunder Minimum. More significantly, in June Allin sailed from England to take his new post as commander of the Mediterranean fleet, departing the Channel on 2 September, 1664 and returning by 24 March, 1665. Between 7 October and 5 December Allin was well into the Mediterranean Sea, before retiring to the area around the Straits of Gibraltar pending his return to the Channel. It is still uncertain to what extent shifts in wind patterns in the North Sea and English Channel were symptomatic of larger changes in the Northeastern Atlantic and, potentially, the Mediterranean, but between the beginning of October and the end of February only 29 per cent of Allin's entries described easterly winds. If Allin's logbooks are read from the start of 1665, and his time spent in or near the Mediterranean Sea is excluded, fully 45 per cent of Allin's meteorological observations record easterly winds!²⁹

²⁹ Thomas Allin, *The Journal of Sir Thomas Allin, Vol. I, 1660-1666*, ed. R.C. Anderson. London: Navy Records Society, 1939.

Prevailing Winds in the Second Anglo-Dutch War

Percentage of morning measurements that record easterly and westerly winds in the ship logbook of Sir Thomas Allin, 1664-1666

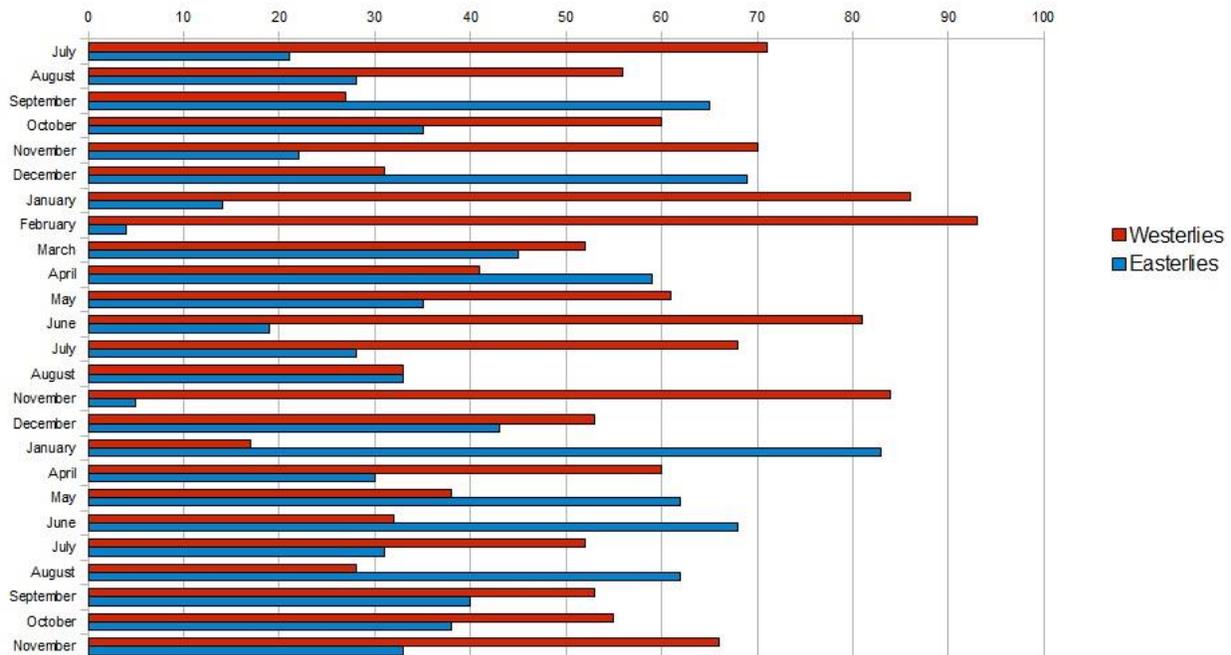


Fig. 4.2. Easterlies and westerlies recorded by Thomas Allin in the North Sea, English Channel, Northeastern Atlantic and Mediterranean Sea. Only months with at least six measurements are incorporated, although Allin took far more measurements in most months. Months with six measurements are: August 1665, January 1666 and November 1666. Morning measurements were used because they were more frequently kept than evening measurements; in rare cases when time of day was not specified the first (and, sometimes, the only) wind description was used. In rare entries where several wind directions were recorded for one morning the direction that endured the longest was employed. Allin's records end in 1666 because the English main fleet neither assembled nor sortied in 1667. Thomas Allin, *The Journal of Sir Thomas Allin, Vol. I, 1660-1666*, ed. R.C. Anderson. London: Navy Records Society, 1939.

Westerly winds were more common during the First Anglo-Dutch War, and easterly winds were remarkably abundant in the second war. The ship logbooks kept by captain John Narbrough from January 1672 to August 1673 reveal that in the third war easterlies were less frequent than they had been five years earlier, although they were still more common than they were in the warmer climate of the mid-seventeenth century (Figure 4.3). Narbrough's logbooks, rarely missing a day and hence significantly more continuous than the journals kept by Allin,

described winds in just 32 per cent of their entries, although easterlies outnumbered westerlies in 7 of 20 months. Once again, the final statistics may misrepresent the wartime frequency of easterlies in the North Sea region because Narbrough, on convoy duty, sailed out of the English Channel towards the Mediterranean Sea. Although Narbrough received his orders from the Duke of York on 6 December 1672, his vessel only passed Lisbon on 6 February. Even struggling against contrary winds in a convoy limited by the speed of its slowest ship, the journey would usually not have taken longer than a month, so it is possible that Narbrough remained in the Channel until the beginning of January. If wind directions recorded from the first of January through the end of April are omitted, 34 per cent of Narbrough's entries describe easterly winds. Because Narbrough's logbook ended just before a possible autumn rise in easterlies, his journal ultimately suggests that easterly winds, while not as common in the third war as in the second, were nevertheless significantly more frequent in both latter wars than they had been in the first.

Prevailing Winds in the Third Anglo-Dutch War

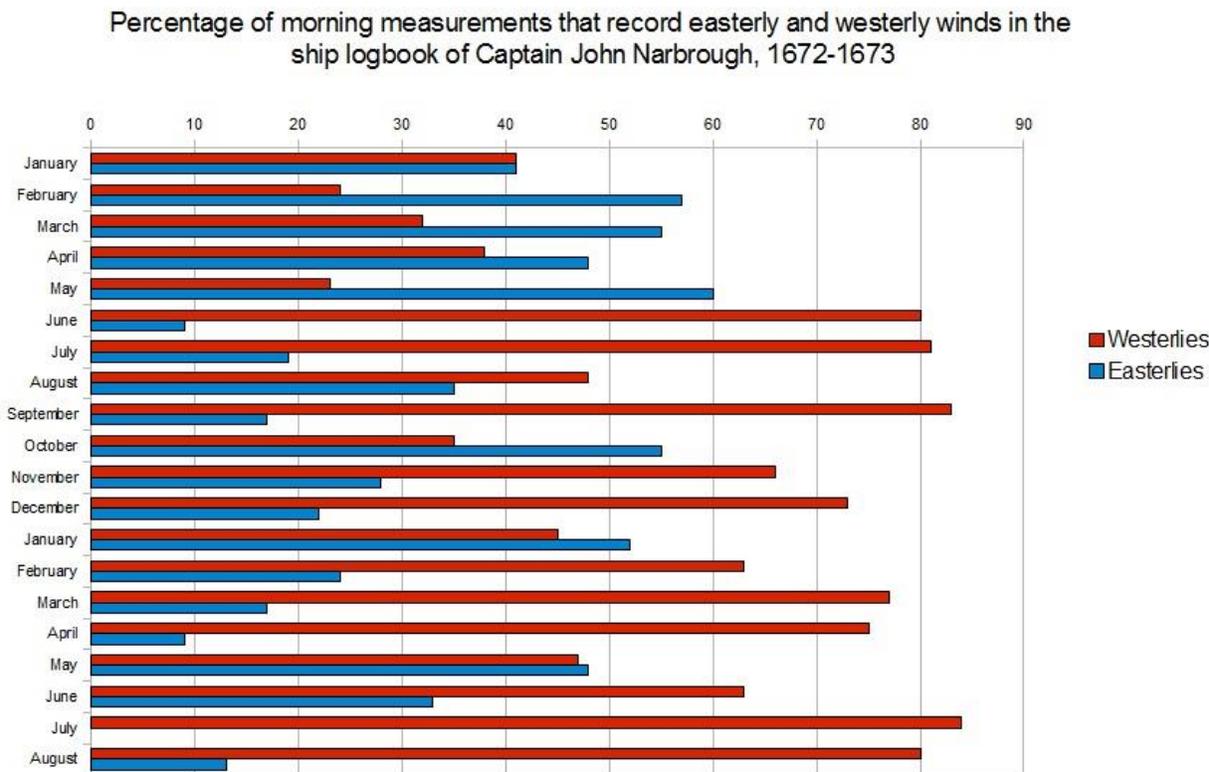


Fig. 4.3. Easterlies and westerlies recorded by John Narbrough in the North Sea, English Channel and Northeastern Atlantic. The same methodology was employed to compile this graph as was used to reconstruct wind directions in fig 5. In both cases the rare measurements of variable winds were not included. John Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672. Pepysian MS. 2555,” in *Journals and Narratives of the Third Dutch War*, ed. 108. John Narbrough, “Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673. Pepysian MS. 2556,” in *Journals and Narratives of the Third Dutch War*, ed. 200. John Narbrough, “Journal of John Narbrough, Captain of the *St. Michael*. July 1, 1673 to September 21, 1673. Pepysian MS. 2556,” in *Journals and Narratives of the Third Dutch War*, ed. 339.

Ship logbooks kept by De Ruyter, De With, Allin, Narbrough, and others can help reconstruct shifts in prevailing wind during the decades of the Anglo-Dutch Wars at a daily resolution, but the resulting statistics should still be approached with caution. Occasionally wind directions listed in ship logbooks measured not the general prevalence of easterlies or westerlies during the wars, but rather the ability of Dutch or English commanders to take advantage of winds that benefitted them on a given day. Fortunately, that problem is diminished by the reality that, once at sea, a wind that aided the English generally disadvantaged the Dutch, so that at least

one commander would commence hostilities. In fact, often the pressure to defeat the enemy at sea was such that commanders would engage their counterparts even in unfavourable weather. Still, other methodological issues are not so easily resolved. Minor discrepancies could exist between the meteorological measurements recorded in ship logbooks taken by different officers in different ships belonging to the same fleet.³⁰ Wind information taken at different times could yield contradictory morning measurements, and fleets could grow so large that two ships belonging to the same armada might be 10 kilometres apart. Consequently, in these reconstructions the complexity of the 32-point compass used by most officers has been simplified. Easterlies refer not only to wind directions that observers listed as simply “easterly,” but to all recorded wind directions that described easterly winds.³¹

Ultimately, many diaries, missives, newspaper articles, intelligence reports, and other documents survive to describe weather during major engagements during the Anglo-Dutch Wars, and can be used to verify meteorological information gleaned from ship logbooks. A quantitative analysis of weather descriptions in a diverse selection of textual evidence suggests that in the English Channel and North Sea westerly winds generally dominated during the warmer climate of the mid-seventeenth century before declining in frequency with the coming of the Maunder Minimum (Figure 4.4). In the middle latitudes air usually flows from west to east, but this system can break down, enabling the movement of air from other directions. During the Maunder Minimum such a breakdown probably occurred over the north-eastern Atlantic as a result of

³⁰ For example, De With listed Easterly winds on the morning of 8 June 1652, while De Ruyter recorded wind from the East-southeast. De Ruyter, Michiel Adriaanszoon. “Journaal gehouden op het schip De gekroonde Liefde door denzelfde, in gelijke hoedanigheid, als voren, eigenhandig 29 April - 13 Juni 1653.” Collectie de Ruyter, Reference code: 1.10.72.01, Nationaal Archief (Den Haag, Netherlands). De With, Witte, “Journal kept by vice-admiral Witte de With on board various ships during the first Anglo-Dutch War, the voyage to Norway to escort the merchant fleet to the Republic, and the voyage to the Sound to secure the Baltic Sea and to assist Denmark, 1652-1658,” Aanwinsten Eerste Afdeling, Reference code: 1.11.01.01, Nationaal Archief (Den Haag, Netherlands).

³¹ Including, for example, North easterlies, North-north easterlies, etc. Wind data was also streamlined because in a wind that blew from the east – even the North-northeast – a vessel sailing from the east typically had the weather gage over one that sailed from the west, and any exceptions are described in this chapter.

changes in the pattern of atmospheric pressure that constitutes the North Atlantic Oscillation, which permitted the subsequent intrusion of frigid Arctic air from the Norwegian Sea.³²

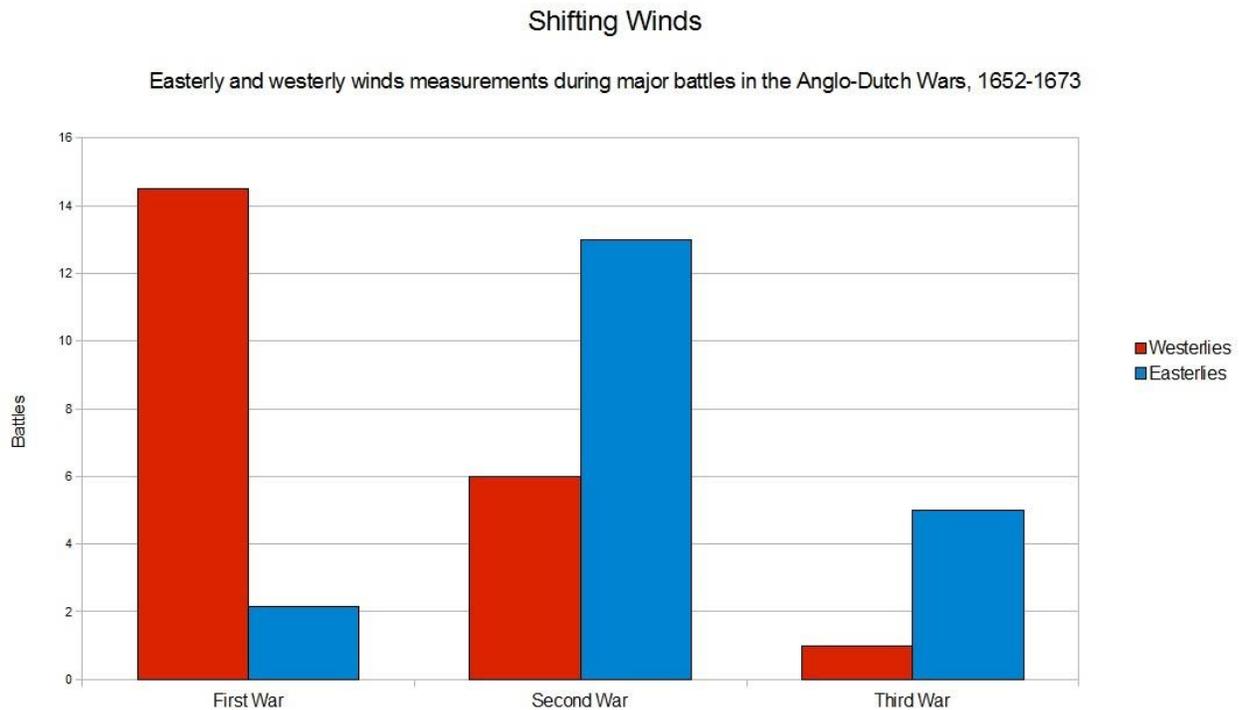


Fig. 4.4. Easterlies and westerlies recorded in Anglo-Dutch ship logs, missives, intelligence reports, newspaper stories, and diaries during the battles of the Anglo-Dutch Wars. This graph may slightly understate the number of easterlies measured in major battles during the second war because it accepts the English account of the wind measurements on the first day of the Four Days' Battle – which describes a Southwesterly wind – rather than the official Dutch narrative, which records Southeasterly winds.

Indeed, Dutch and English sources written during the Anglo-Dutch Wars abound with references to easterlies accompanying cold temperatures, and westerlies coinciding with warmer conditions. For example, cold days recorded by Narbrough during the Third Anglo-Dutch War were always accompanied by easterly or north-easterly winds. On 18 February 1672, Narbrough described how south-westerly winds accompanied balmy weather, but on the next day the wind

³² Wheeler, "Understanding Seventeenth-Century Ships' Logbooks," 16. See also: Glaser and Koslowski, "Variations in reconstructed ice winter severity in the western Baltic," 188.

had swung to the east and the temperature plummeted.³³ Civilian contemporaries not only described but were keenly aware that easterlies usually accompanied cold weather. In a missive written to his brother on 11 January 1664, Adriaen van der Goes reported the unusual warmth of winter weather that felt more like March, and wondered whether colder temperatures, then in the East, would blow over before the thaw began in earnest.³⁴ Van der Goes was surprised when easterlies did not accompany frigid weather, writing in the previous December that “for several days the wind has blown consistently from the East yet it has been misty, with no freezing, and this morning it began to rain with the wind still from the East.”³⁵

During the legendary wave of winter weather in March three years later, weaver Jan Hubrecht from Leiden described the persistent north-easterly winds that accompanied constant cloudiness and freezing of shocking intensity.³⁶ References to westerly warmth and easterly coldness were especially common during winter months, but this may be because winter freezing directly affected travel at sea and inland, rather than an indication that the relationship did not exist in other seasons. Regardless, the abundance of westerlies in the warmer mid-seventeenth century climate explains why English captain Nicholas Foster was astonished that the Republic risked war, “when (like an eagle’s wings extended over her body) our coast surrounded theirs for 120 leagues . . . and the wind blowing above three-quarters of the year westerly on the coast of England, made all our cape-lands and bays very good roads for ships to anchor at.” Changes in

³³ Narbrough, “Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673,” 95.

³⁴ “Het weer is hier soo laeuw off het halff Maert waer, sonder regen off vorst; t’staet te wachten, off de coude, die in oosten is, tegens dat het daer begint doeyen, niet en sal overwaeyen.” Adriaen van der Goes, *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 198.

³⁵ “Het heeft hier eenige daegen doorgaende oosten-windt gewaeyt doch mistich, sonder vorst, dese morgen begondt het te regenen en blyft de wint oost.” Adriaen van der Goes, *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 189.

³⁶ Buisman and Van Engelen, (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 611.

these weather patterns, and associated shifts in average seasonal storminess, temperature, and precipitation, would have important consequences for the conduct of the Anglo-Dutch Wars.³⁷

Commercial Rivalry and Competing Military Structures

The First Anglo-Dutch War was predominantly contested at sea between neighbouring maritime powers, but in their crews, institutions, and technologies the duelling fleets were expressions of relationships between different cultural, economic, and ecological systems that yielded distinct environmental vulnerabilities.³⁸ It was a sign of the commercial ethic of the Republic that most of the Dutch fleet was sold to foreign competitors after the Peace of Westphalia.³⁹ Without easy access to iron, in 1652 the Dutch admiralties populated their large but makeshift fleet with small frigates and converted merchant vessels, most armed with light guns that were typically arranged in two tiers and situated high above the water. Compared to their foreign counterparts, Dutch hulls were wider with far shallower draughts and fewer sharp lines, a necessity given the shallow approaches to Dutch harbours. This limited the maximum size of Dutch vessels but increased their stability in rough weather, allowed them to sail better in conditions of near calm, and enabled them to safely navigate over shoals that grounded other warships. The shape of the Republic's armada played to the strengths of its commanders, master mariners from port cities who had often risen from obscurity in the commercial fleets and had witnessed the success of superior seamanship against the Spanish. The Republic's admirals,

³⁷ Rodger, *The Command of the Ocean*, 11.

³⁸ A recent study by Greg Bankoff has, however, described the similarities between Dutch and English coastal regions, rather than their differences. See: Greg Bankoff, "The 'English Lowlands' and the North Sea Basin: A History of Shared Risk," *Environment and History* 19:1 (2013): 3-37.

³⁹ Some 40 ships had been retained, to which a further 36 were added in 1651. Most of these vessels were light, converted merchant ships. Samuel Rawson Gardiner, ed. *Letters and Papers Relating to the First Dutch War, 1652-1654, Vol I*. (London: Publications of the Navy Records Society, 1899), 57.

captains, pilots, and common sailors were Europe's preeminent seamen and collectively possessed unparalleled knowledge of the North Sea environment. Dutch tactics emphasized grappling, boarding, and firing at enemy rigging in an era when warships were powerfully built, easily repaired, and not easily sunk by artillery fire.⁴⁰

Meanwhile, with ready access to iron and deep harbours, the English under Cromwell's dictatorship constructed a standing navy around a core of "floating castles:" great ships of deep draught and tall hulls, many armed with 80 or more guns arranged in three tiers.⁴¹ The lower tier was located between four and five feet from the waterline, which meant it could not be opened in rough seas lest water flood in through the gun ports on the lee side. In 1653 the English navy categorized warships in six "rates" which corresponded to guns carried and, in turn, overall size. English first and second rates carried more artillery than an entire field army, and could sink opposing vessels at unprecedented range.⁴² Over the course of the First Anglo-Dutch War, English commanders, chosen from Cromwell's imposing army, improved the effectiveness of these vessels by developing line of battle tactics in which ships would sail by each other in single file while firing broadsides that targeted enemy hulls.⁴³

⁴⁰ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 22. Richard W. Unger, *Ships and Shipping in the North Sea and Atlantic, 1400-1800*. (Aldershot: Ashgate Publishing Limited, 1997), 28.

⁴¹ Between 1651 and 1655, Cromwell's regime built the same tonnage of warships as the monarchy had between 1588 and 1642. Rodger, *The Command of the Ocean*, 32. Before the First Anglo-Dutch War Adriaen Pauw, Grand Pensionary of Holland, declared that, "the English are about to attack a mountain of gold; by contrast we are about to attack one of iron" ("de Engelsche gaen tegens een gouden Berg aen; de onse ter contrarie tegen een Ysere"). Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 7. Rodger, *The Command of the Ocean*, 648.

⁴² As standardized in 1677 first rates carried between 90-100 guns, second rates 64-90 guns, third rates 56-70 guns, fourth rates 38-62 guns, fifth rates 28-38 guns and sixth rates 4-18 guns. Rodger, *The Command of the Ocean*, xxvii.

⁴³ Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 59. There were, of course, far more differences between Dutch and English naval systems than those described here, although they were generally not directly relevant (or easily relatable) to the climatic relationships described in this paper. Institutionally the English system was far more centralized, as the Republic was really a loose federation of provinces that required five admiralties, based in Rotterdam, Amsterdam, the North Quarter in Holland, Harlingen in Friesland and Middelburg in Zeeland. Not surprisingly, the inefficiencies that resulted played their part in Dutch reversals (and victories) during the wars. During the First Anglo-Dutch War the English high command was also far more unified than that of the Dutch, with fewer personal and political rivalries plaguing fleet unity, although this would change following the restoration of the English monarchy. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 22.

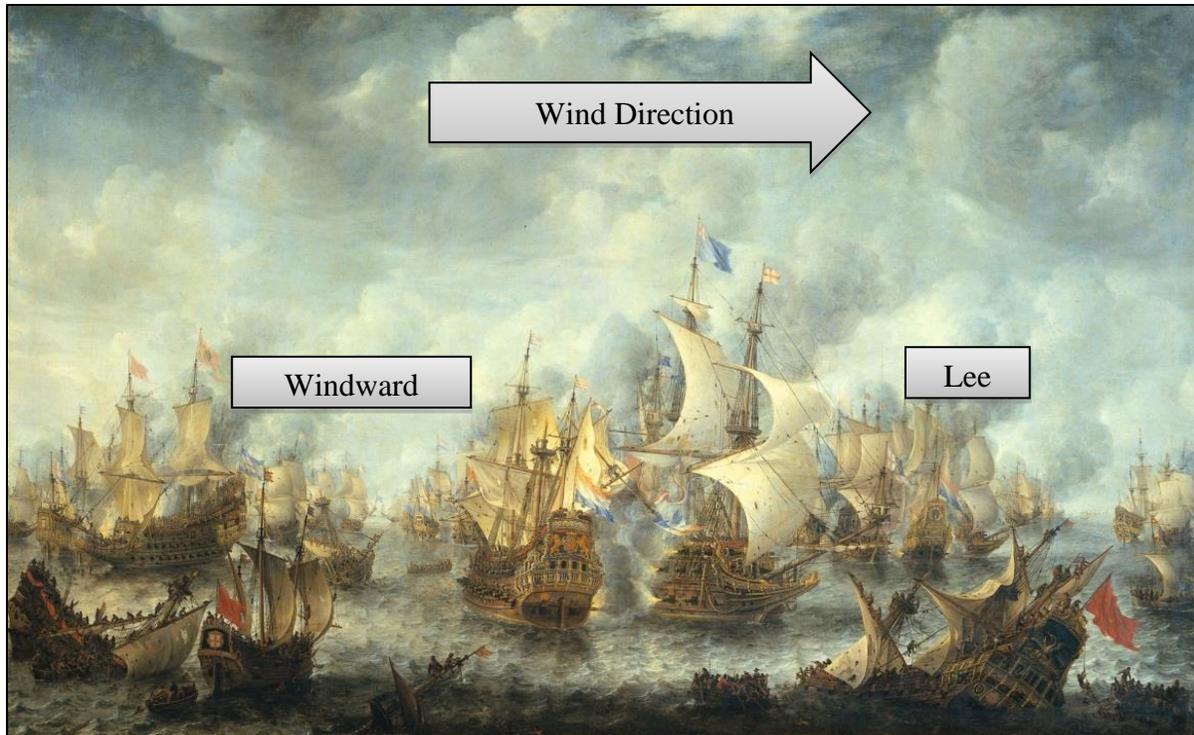


Fig. 4.5. Windward and lee positions in the battle of Scheveningen. In this depiction of the last major engagement of the First Anglo-Dutch War, the Dutch flagship at the centre of the painting is to windward and has the weather gage, while its English counterpart is leeward. See also: Figure I.6, Introduction. Jan Abrahamszoon Beerstraten, “Slag bij Ter Heijde,” painting, 1653-1666, Rijksmuseum Amsterdam, <https://www.rijksmuseum.nl/en/collection/SK-A-22>.

These English and Dutch “naval systems,” spun from a web of co-evolving cultural, economic, and environmental interactions, reacted differently to the prevailing weather experienced in each Anglo-Dutch War. Both systems depended on fleets attaining the “weather gage,” the windward position from the enemy that granted initiative in attack and, occasionally, retreat (Figure 4.5). The tactical strengths and vulnerabilities of the competing naval systems, overlaid with their shared reliance on the weather gage, ensured that wind direction and velocity – not temperature or precipitation – were the critical meteorological influences during the naval battles of the Anglo-Dutch Wars.

However, the picture was different on land. Because an English invasion was impossible without control of the North Sea and English Channel, war on land scarcely featured in the First

and Second Anglo-Dutch Wars. On the other hand, in the third war the powerful French army confronted Dutch defences that had been badly neglected in the wake of the Treaty of Westphalia. The expansionist ambitions of the highly centralized army of the Sun King in Europe contrasted sharply with the emphasis on decentralized naval power in the Dutch Republic, which strung together its loose trading empire. These geopolitical considerations were buttressed by the demands of domestic politics. After a brief civil war incited by William II in 1650, and his death later that year, the legislative power of the States-General was unchallenged by the executive power of the House of Orange. During this period of so-called “true freedom,” the Dutch army continued to supply a reservoir of Orangist sympathy. Accordingly, grand pensionary Jan de Witt feared that a strong army, which supported the regime of Louis XIV in France, would threaten the Dutch republican government with a revolution that would restore the power of the House of Orange. Moreover, as European states increasingly eschewed the hiring of unpredictable and undisciplined mercenaries, Dutch financial resources could no longer procure an army that could match those of its more populous neighbours. Ultimately, on the eve of the Third Anglo-Dutch War the States-General relied less on the strength of its army than the waters that encircled and interlaced their Republic. In this war, temperature and precipitation were therefore as important in victory or defeat as prevailing wind direction and velocity.⁴⁴

Beginning of the First Anglo-Dutch War

After Cromwell’s Commonwealth imposed the first Navigation Act in October 1651, the Republic’s States-General passed a resolution calling for its fleet of 76 vessels to be

⁴⁴ Lynn, *Giant of the Grand Siècle*, 12. Lynn, *Women, Armies, and Warfare in Early Modern Europe*, 20. Jones, *The Anglo-Dutch Wars*, 186. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 172.

supplemented by an additional 150 ships by 1 April 1652.⁴⁵ The planned flotilla was intended to resolve Anglo-Dutch tension through intimidation, but the Dutch admiralties, long starved of funds, were incapable of furnishing, let alone manning, the required vessels. Meanwhile, although the following summer was warm enough to render 1652 a year of average temperature by twentieth-century standards, the winter of 1651/52 had been cooler than normal. In coming years the slow pace of ship construction during the frequently frigid weather of the Maunder Minimum demonstrated that work in shipyards could be slowed in severe winters.⁴⁶

Consequently, in May 1652 Maarten Harpertzoon Tromp, Lieutenant Admiral of the Dutch Republic, left port with a ragtag fleet of just over 40 men-of-war, many converted merchant ships, most small and obsolete, with orders to protect Dutch merchant convoys from inspection or detention by English patrols.⁴⁷ Some English historians have claimed that Tromp's orders rendered conflict inevitable given the increasingly fragile state of the peace, but Tromp was ordered to avoid the English coast and use his own discretion in lowering the flag in the face of English provocation.⁴⁸

Indeed it was not Tromp's armada that instigated the first hostilities of the Anglo-Dutch Wars; fittingly these erupted off Start Point on 22 May 1652 when two warships and an armed merchantman attempted to enforce England's sovereignty of the seas against a small Dutch

⁴⁵ There is considerable historiographical confusion regarding the States-General's orders and the state of the Dutch fleet before the First Anglo-Dutch War. Hainsworth, Churches and Jones argue that the States-General called for a fleet of 150 ships to be assembled by 1 April, while N.A.M. Rodger describes how the States-General wished to supplement the existing fleet of 76 ships with an additional 150 ships. English and Dutch primary sources confirm Rodger's account. Samuel Rawson Gardiner, Ed. *Letters and Papers Relating to the First Dutch War, 1652-1654, Vol I, 57.*

⁴⁶ J. Buisman and Van Engelen (eds.), *Duizend jaar weer, wind en water in de Lage Landen*, 520.

⁴⁷ J.Jones, *The Anglo-Dutch Wars*, 113.

⁴⁸ In his massive and still-influential narrative of Dutch naval history, J.C. de Jonge in 1858 claimed that 50 Dutch warships sortied under Tromp in May 1652. On the other hand, Roger Hainsworth and Christine Churches argued in 1998 that only 41 ships departed that spring. J.C. De Jonge, *Het Nederlandsche Zeewezen, Vol I, 2nd Ed.* (Haarlem: A.C. Kruseman, 1858), 422. Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 4.

convoy defended by three warships.⁴⁹ The Dutch commander, Commodore Huyrlyt, lowered his flag and fired a salute, but Joris van der Zaanen, captain of the second escort, refused to follow his lead. Van der Zaanen approached the English on the westerly, windward side, an aggressive course that helped instigate a brief but inconclusive skirmish.⁵⁰ Two days later Tromp, oblivious, anchored his fleet off the Flemish town of Nieuwpoort when a powerful gale rose from the North-Northeast, threatening to destroy the Republic's ships on what was suddenly a lee shore. The storm worsened, damaging the Dutch vessels until Tromp decided to lead his fleet across the Channel for the sheltered corner of Dover. The Dutch fleet arrived there on 28 May 1652.

Nine English warships under Nehemiah Bourne were stationed behind the Goodwin Sands to the north of the port of Dover, while a larger Commonwealth fleet commanded by Admiral Robert Blake lay off Rye. Tromp sent emissaries to explain his presence, but Bourne prepared his fleet for action, and immediately dispatched a small, quick boat – or ketch – to warn his admiral. The ketch reached Blake's flagship that night, yet Blake was forced to tack against the strong, contrary winds still blowing from the East, and his journey up the Channel was laborious. Blake sent the ketch back to Bourne, but the boat struggled against the wind to such an extent that his order for Bourne to sail downwind and unite the fleet only arrived around 10:00 AM the next morning. Hence, Bourne was probably still negotiating the south end of the Goodwin Sands when the Dutch fleet weighed anchor and made for the French coast.

⁴⁹ All dates are given according to the Gregorian calendar used in the Dutch Republic, 10 days ahead of the Julian calendar long employed by the English.

⁵⁰ Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 4. J.R. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 114. J.C. De Jonge, *Het Nederlandsche Zeewezen, Vol I, 2nd Ed.*, 416. "Bloudy newes from Holland: being a true relation of the present proceedings of the Dutch-men against the English." London: Printed for E. Cotton, 1652.

Halfway across the Channel someone in Tromp's armada sighted an approaching Dutch ship, obviously scarred by battle. Van der Zaanen had been seeking Tromp to report the skirmish off Start Point and acquire aid for the convoy, then sheltering from the storm off Fairlight. Tromp, wrongly believing that the tiny but lucrative convoy had been captured, ordered his fleet to turn and face the English. A heavy growth of barnacles slowed Bourne's ships, and the English squadrons were still divided. However, the wind had shifted to blow from the Northwest, and this granted them the weather gage. At around 4:00 PM the English fired first, and their disunity actually helped them flank the more numerous Dutch vessels. Battles in the age of sail could not be fought in darkness, so the battle of Dover was brought to a close in a matter of hours, its outcome technically inconclusive. Still, the English almost certainly fared better in the encounter, capturing two vessels while losing none. One of their prizes was deemed unseaworthy and thus abandoned, but owing to westerly winds, the current, or both, it drifted back to the Dutch fleet that night to be salvaged by the Republic's superior mariners.⁵¹

The events that instigated the First Anglo-Dutch War reveal some of the limitations and possibilities of relating wind direction and velocity to the outcome of early modern naval operations. Certainly weather influenced the beginning of hostilities. Damage inflicted to Dutch ships by unusually persistent and severe northeasterly winds encouraged Tromp to disregard his instructions and seek the shelter of an English port, where his fleet would be safe from the perils of a lee shore. That decision brought the two Republican fleets within striking distance of one another, and the resulting tension was exacerbated by Tromp's failure to acknowledge England's sovereignty of the seas by lowering his flag. With the Dutch fleet so close it is certainly plausible

⁵¹ Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 5. De Jonge, *Het Nederlandsche Zeewezen Vol. I, 2nd Ed.*, 416. Hellinga, *Zeehelden van de Gouden Eeuw*, 137. J. Buisman and A.F.V. van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 522. Thomas White, "An exact and perfect relation relation [sic] of the terrible, and bloody fight: between the English and Dutch fleets in the Downs, on Wednesday the 19 of May, 1652." (London: Printed for Robert Wood, 1652), 5.

that Blake, Bourne, or both intended to initiate hostilities. Similarly, it is possible that Tromp might have realized that the Dutch merchant convoy had not been detained or, at least, that a less provocative course of action would have been taken had Tromp encountered Van der Zaanen at a different time, in a different place.

Certainly the resulting battle was shaped by the easterly winds that hampered Blake's quest to unify his armada, and the westerly winds that granted him initiative in battle but allowed the Dutch to salvage a prize the English had abandoned. The influence of these winds was mediated by personal agency, the cultural scaffolding that constituted each naval system, and the shape of local environments. Still, there is little doubt that weather events were an important, measureable factor in the outcome of the Battle of Dover. Moreover, the westerly winds that helped Van der Zaanen claim the weather gage at Start Point and, more importantly, granted a disjointed English fleet the initiative in the Battle of Dover were typical of the warmer climate in which the first Anglo-Dutch War was fought. However, the easterly winds that forced the Dutch fleet to seek shelter at Dover exerted equal influence over the nature of the subsequent confrontation. The presence of both easterlies and westerlies in the first week of a conflict dominated by the latter demonstrates that a spell of winds from any direction – or a stretch of daily temperature of any severity - could powerfully affect military operations and occur under all climatic regimes. The winds experienced by Tromp, Van der Zaanen, Blake, Bourne, and their men in the final week of May 1652 did not blow continuously from one direction, for an extended time. Accordingly, relationships between weather and climate in the English Channel during the last week of May 1652 are impossible to confirm. While environmental conditions helped stimulate the First Anglo-Dutch War, the initiation of hostilities cannot be linked to the prevailing climatic regime.

The Battle of Dover caused great alarm among the members of the States-General. The war had begun in earnest, yet strategies for its execution developed on both shores of the Channel were confused and short-lived. The Dutch merchant marine was originally the primary target of the English fleet. On 10 June the Council of States ordered Blake to seize the VOC fleet, take convoys destined for the Baltic, and disrupt the Dutch herring fleet off the English and Scottish coasts. While ambitious and potentially lucrative, this scheme threatened to dilute the strength of the English fleet in a series of raids across the North Sea, leaving it vulnerable to a united Dutch fleet.⁵² On the other hand, while the States-General on 6 July ordered Tromp to inflict “all imaginable damage” upon the English armada, the primary purpose of the Dutch fleet was still to escort merchant shipping. Neither Dutch nor English commanders yet realized that victory in contemporary naval warfare was possible only by engaging and decisively defeating the opposing fleet.⁵³

In June the Commonwealth experienced some success in disrupting Dutch shipping, with a fleet under Blake taking 11 Dutch merchantmen laden with salt, and an additional cruiser of 22 guns. However, eight days after Tromp received his instructions from the States-General, Blake and Ayscue divided the English fleet. Ayscue remained in the Channel to harass Dutch convoys sailing from the South, while Blake fulfilled his orders in the North.⁵⁴ The division of the English armada quickly bore fruit when Ayscue’s squadron attacked a Dutch convoy inbound from Portugal, seizing 6 vessels while grounding another 26. It was Tromp’s intention to sail north and protect the herring fleet, but persistent contrary winds, likely from the Northwest, foiled that

⁵² Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 23.

⁵³ J.R. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 115.

⁵⁴ Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 25.

ambition. These winds, typical of both the season and the prevailing climatic regime, ruled out of a defence of the herring busses but facilitated a sortie against Ayscue's fleet in the South.⁵⁵

On 15 July Tromp received orders to "attack, destroy or capture" the English ships in the Downs, so long as the wind continued to thwart any attempt to sail north. Although hindered by light winds, the Dutch armada approached the North Foreland over the next two days. Tromp commanded as many as 104 men-of-war and 10 fireships or *branders*, light vessels designed to burn warships. Having annihilated the Spanish fleet in the Downs in 1639, Tromp was keenly aware of the region's geography, and dispatched two squadrons to seal the southern entrance while the main fleet entered from the North. With as few as 20 ships, Ayscue could do little but gather his vessels under the guns of the shore fortifications. However, on the 16th and 17th the Dutch advance was slowed by calm winds. The northerly winds resumed on the 18th, yet blew so hard over the next three days that three fireships separated from the fleet, and an equal number threatened to sink. On the 21st the Dutch ships finally approached the North Foreland with light winds from the North-northwest, yet an English journalist recounted how the Dutch were soon forced to anchor, with "the tide of ebb being done and but little wind." Once the wind rose later that day it was from the Southwest, and Tromp immediately ordered his captains to set sail for the North.⁵⁶

Blake had struggled up the Scottish coast against the same contrary winds that dissuaded the Dutch pursuit, and he now used the southerly breeze to arrive off the Shetland Islands on the

⁵⁵ Harald Appelboom, "Harald Appelboom aan Axel Oxenstjerna, 27 July 1652," in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen, Vol. 1: 1652-1667*, ed. H.T. Colenbrander. (The Hague: Martinus Nijhoff, 1919), 7.

⁵⁶ The English journalist described how, "it pleased God that, the wind pending, the Dutch could not come in." "July 13/23, 1652: A Journal of the Movements of the Fleets in the Downs," in *Letters and Papers Relating to the First Dutch War, Vol I*, ed. Gardiner, 371. "221. July 14/24, 1652: A Letter from the Downs," in *Letters and Papers Relating to the First Dutch War, Vol I*, ed. Gardiner, 374. De Jonge, *Het Nederlandsche Zeewezen, Vol I, 2nd Ed.*, 422. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 28. While Hainsworth and Churches claim there were only 90 Dutch warships in the Republic's main fleet Tromp's letters from 18 July and 6 August, described by Harald Appelboom in his own letters to Axel Oxensjerna, appear to roughly confirm de Jonge's higher estimate.

22nd. He dispatched a squadron under Admiral William Penn that defeated the lighter Dutch escorts, but not before most of the roughly 600 herring busses had escaped. Fearing an unmanageable influx of prisoners, Blake suffered the rest to depart before making for Fair Isle, where he believed incoming Dutch convoys would gather before continuing south. With the Shetland Islands to the Northeast and the Orkney Islands to the Southwest, Fair Isle forms a string of islands stretching from Scotland into the North Sea towards Norway. Tromp assumed that Blake would station his fleet near Fair Isle and approached roughly a week later, with a numerically impressive armada that actually included ships that were, by now, barely seaworthy. On 4 August the opposing fleets drew together off the Shetlands, but a sudden calm thwarted an engagement. By the afternoon of the 5th the winds rose again but blew variable, before steadying into a northwesterly during the night. Under cover of darkness the wind carried several inbound Dutch West Indiaman to the safety of Tromp's fleet, much to the elation of their crews. However, in the morning that joy turned to misery as the wind swelled into a furious northwesterly gale. The Dutch ships, positioned nearer the rocky coast, were exposed to a lee shore and subject to the full force of the storm, but the English fleet, though not immune from damage, nevertheless found some shelter in Bressay Sound on the east coast of the Shetlands.

A Dutch survivor described how, "the fleet being . . . buried by the sea in the most horrible abysses, rose out of them, only to be tossed up to the clouds; here the masts were beaten down into the sea, there the deck was overflowed . . . the tempest was so much the mistress . . . the ships could be governed no longer." When the storm passed on 7 August Tromp was left with just 34 ships. Many of the Republic's warships and merchant vessels were scattered across the North Sea, most of which would find their way back to safe harbour. Still, thousands of seamen

drowned, while 16 warships and several merchantmen were lost. The crews of the ships that limped home under Tromp's command were soon subject to scurvy and malnutrition.⁵⁷

In the first months of Anglo-Dutch hostilities the weather that prevailed during naval operations strongly benefitted the Commonwealth. Recurrent westerly winds probably helped English squadrons leave port, enabled them to surprise Dutch convoys sailing up the Channel, and granted them the weather gage in combat with escorts. Westerlies did allow West Indiamen that might otherwise have been seized by the English to join the Dutch fleet, but that triumph proved fleeting. Moreover, Dutch merchantmen returning from the Baltic might have been slowed by common westerlies, and thereby exposed to English harassment. Regardless, the high frequency of these westerlies during the warmer mid-seventeenth century climate suggests a strong climatic link.

It was persistent northerlies that most influenced the decision of the States-General to dispatch the Dutch main fleet South against Ayscue, rather than North against Blake. Contrary to the States-General's orders, Tromp's subsequent letters, and the judgement of historians like Roger Hainsworth and Christine Churches, continual northerlies did not render a pursuit of Blake impossible. Blake, after all, was tacking against the same northerlies to reach the Shetland Islands. Rather, to Tromp and his political overlords it probably seemed easier to employ the prevailing winds and sail South to annihilate Ayscue's fleet, before waiting for the southerlies that would quicken a journey North. Indeed, trapping and destroying the English warships in the Downs probably would have been successful but for the unusually consistent calms that hampered Tromp's approach to the Downs, and the light North-northwesterly that blew for most of the 21st. Unfortunately, it is uncertain whether fluctuations in the frequency of northerlies,

⁵⁷ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 30. Harald Appelboom, "Harald Appelboom aan Axel Oxenstjerna, 27 July 1652," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. 1, 7.

southerlies and calms were part of Little Ice Age climatic shifts. Certainly the Dutch command's decision to exploit the division of the English fleet by engaging Ayscue's squadron is evidence of the culturally mediated influence of weather. However, apart from the westerlies that characterized the final day of the operation, the attempt and its failure cannot be used to link a warmer climate to the course of the war.

Though a combination of northerlies, southerlies, westerlies, and calms in the first months of the conflict facilitated English raiding while preserving the English naval presence at both ends of the North Sea, it was the storm of 6 August that first jeopardized the Dutch Republic's chances of winning the war. The design of Dutch ships actually rendered them less vulnerable to rough seas than their English counterparts, yet many of Tromp's ships were barely seaworthy when the winds rose on the morning of the 6th. Worse, the northwesterly direction of the storm exposed the Dutch fleet to a lee shore, and the rocky cliffs of the Shetland Islands offered little chance of survival for crews of foundered vessels. The westerly winds that influenced the devastation of a portion of the Dutch fleet were rendered more likely within the warmer climate of the mid-seventeenth century. The disaster was therefore worsened by the westerlies that were especially frequent in that climate, but the destructive velocity of these winds was not necessarily symptomatic of the prevailing climatic regime.

The First Anglo-Dutch War appears to have been nearly as tempestuous as the second, although it was less stormy than the third. It was not fought during the Maunder Minimum, when storms in spring, summer, and fall grew more common, yet climate change does not affect all weather events at the same time. Nevertheless, explanations for the late-seventeenth century rise in storminess provided by Lamb and Wheeler link more violent North Sea weather to a cooler climate, and the same meridionality that allowed for more easterlies during the second and third

wars. Still, long-term climatic trends are not the only influence on yearly variation in prevailing weather. The First Anglo-Dutch War was fought during warm summers and relatively cool winters, a condition that can lead to more frequent storminess in the North Sea region. Recent tree ring data also suggest that it coincided with the strongest El Niño of the century, a warming of the equatorial Pacific Ocean that may amplify cyclonic activity in Europe.⁵⁸ El Niño and La Niña fluctuations, while varying in intensity, are quasi-regular cycles in the world's climate that, at least in their origin, should be distinguished from overall climatic cooling or warming. Ultimately, while it is possible that European storminess between 1651 and 1653 was anomalous, it is equally likely that more frequent storms were stimulated by rhythmic climatic patterns of unusual severity or, perhaps, the first hints of the Maunder Minimum. Storms undoubtedly influenced the outcome and aftermath of the First Anglo-Dutch War, but because they cannot yet be convincingly linked to the coming of the Maunder Minimum they will receive no further analysis in this interpretation of the war, unless the winds that accompanied them blew from the west.

Conclusion of the First Anglo-Dutch War

On 26 September Admiral de Ruyter ended nearly a month of successful escort duty by joining his ragtag fleet of ships, many damaged by battle or storm, with the partially restored Dutch main fleet under Witte de With. After 11 of De Ruyter's ships were judged unseaworthy and returned to port, the united fleet consisted of just 62 vessels. Dutch mariners loathed De With, and their poor morale was compounded by poor pay, bad beer, and insufficient food. From

⁵⁸ Jinbao Li, et al., "Interdecadal modulation of El Niño amplitude during the past millennium." *Nature Climate Change* 1 (2011): 114.

this position of weakness the States-General commanded De With to engage Blake's armada of 68 larger, better-provisioned ships. Accordingly, on 5 October De With ordered his fleet to depart Nieuwpoort on the Flemish coast. He hoped to lure the deep-draughted vessels of the Commonwealth fleet under Blake from the Downs into the shoals of nearby Goodwin Sands.⁵⁹

However, De With's gambit failed just as the Downs appeared over his horizon, as southwesterly winds strengthened into a ferocious gale that pushed the Dutch fleet back into the North Sea. The storm persisted until the 7th, forcing Blake to remain in port while either sinking or aiding in the desertion of three Dutch warships. On the morning of 8 October the southwesterly winds finally moderated enough for the English to leave port, but the fleet's headlong rush to sea scattered its ships over many kilometres and entangled its three divisions.⁶⁰ De With was also struggling to reform his fleet into three divisions, with many of his ships dragging anchors or scattered by the storm. De With attempted to board the *Brederode*, Tromp's former flagship, but its crew refused his command and he was forced to move his flag to a converted Dutch East Indiaman with relatively sluggish sailing abilities and an inexperienced crew. Nevertheless, the Dutch armada was able to regroup more quickly than the Commonwealth fleet. Tacking against the wind, the Dutch vessels bore down upon the English from the northeast.⁶¹

⁵⁹ Gerard Brandt, *Uit het Leven en Bedrijf van den here Michiel de Ruiter*. (Amsterdam: G. Schreuders, 1687), 34. "Good newes from General Blakes fleet." (London: Printed for Robert Ibbitson dwelling in Smithfield neer Hosier Lane, 1652), 2. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 39.

⁶⁰ De Jonge, *Het Nederlandsche Zeewezen*, 416. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 41. Jones, *The Anglo-Dutch Wars*, 118. Jones argues that strong winds scattered the English fleet as it left port, while Hainsworth and Churches blame a lack of discipline among English captains. Because low winds characterized the subsequent battle, and because the English fleet would not have been able to leave port during strong winds, the explanation provided by Hainsworth and Churches seems more probable.

⁶¹ An element of uncertainty should be injected into this account of the Dutch seizing an initial tactical advantage. In a letter written several days after the return of the Dutch fleet Harald Appelboom describes how the English attacked the regrouping Dutch fleet so quickly that De With did not have time to call a council of war with his captains. De Jonge repeats this in *Het Nederlandsche Zeewezen*, although Jones, Hainsworth and Churches disagree. It is possible that accounts of the rapid English attack were given by Dutch commanders to undermine the detested De With, or perhaps to emphasize the difficulty of regrouping the fleet after the damaging gale. For his part De With characteristically blamed the cowardice of his captains for the defeat.

Two English divisions under Blake and Admiral William Penn launched a counterattack at approximately 4:00 PM. Blake attempted to hold the weather gage by ordering his ships to sail along the eastern edge of the Kentish Knock shoal, but the massive *James* and the 100-gun *Sovereign* were soon grounded. Penn's division was forced to surround the immobilized great ships while Blake's division engaged the entire Dutch fleet. The English appeared vulnerable, but De With, perhaps hampered by his unwieldy flagship, had never taken the weather gage. Light winds allowed the English warships to use their lower tier of guns, and this advantage, coupled with the initiative granted by the persistent westerly, allowed Blake's division to use the nascent line of battle tactics to their full effect (Figure 4.6). After its first pass through the Dutch ranks Blake's division turned, and the wind helped Bourne's division enter the fray before the extricated English great ships joined Penn's division to flank the deteriorating Dutch column. Meanwhile, numerous Dutch captains, unwilling to risk their lives for an unpopular admiral, lingered well behind the other Dutch vessels, shooting ineffectually at friend and foe alike. As the light faded many of the Dutch ships remained afloat only through heavy pumping and the superior seamanship of Dutch mariners, while most English ships had suffered damage only to their rigging.

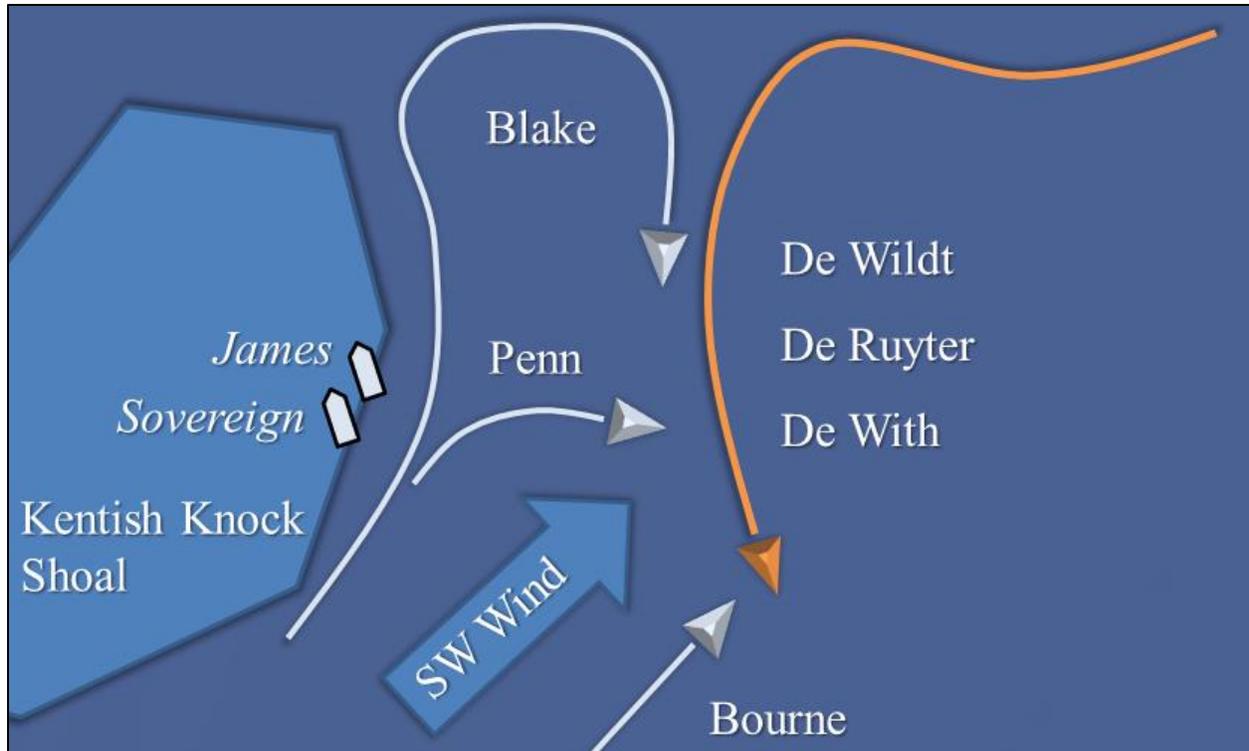


Fig. 4.6. The shape of the Battle of the Kentish Knock, with winds from the west proving decisive. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 44.

After a night of frantic repairs at sunrise both fleets were nearly 10 kilometres apart, drifting east in a westerly that blew too soft for battle. The light winds that had aided the English the day before now benefitted the Dutch fleet which, numbering less than 50 vessels, could not hope to defeat an English fleet that had probably been reinforced to 85 ships during the night. When the wind shifted to blow from the Northwest, De Ruyter convinced De With to order a retreat, and by the next day the Dutch ships reached the safety of their home shoals. Many of the Dutch Republic's vessels were heavily damaged, although ultimately only three were lost.⁶²

⁶² Harald Appelboom, "Harald Appelboom aan Christina van Zweden, 14 Oct 1652," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. 1: 1652-1667*, 27. Stoaks, "A great victory obtained by the English against the Dutch." (London: Geo: Horton), 1652. J.C. de Jonge, *Het Nederlandsche Zeewezen*, 430. Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 44. J.R. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 118. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 526.

The Battle of the Kentish Knock revealed that English great ships, deployed in line of battle tactics, could be highly effective against light Dutch ships arranged in loose formations. Westerly winds, although mediated by personal agency, the structure of each naval system and the shape of local environments, nevertheless enhanced these English advantages. When expressed in a storm, they thwarted De With's attempt to lure Blake into the Goodwin Sands, while in the subsequent battle they helped English commanders claim the weather gage and, in turn, the tactical initiative so crucial to line of battle tactics. Still, the pattern of advantages and disadvantages that linked each naval system with fluctuations in weather and climate was never straightforward. The storm's westerly winds scattered the Dutch fleet, but the resulting confusion, coupled with the chaos of the English departure from port, helped delay hostilities until the afternoon. The late hour ensured that only a limited number of ships could be lost on either side before the onset of night. The quest for the weather gage in the face of south-westerly winds also temporarily grounded the largest vessels in the English fleet, and a northwest wind aided the Dutch escape on 9 October. Consequently, although westerlies generally benefitted the English, they also played a role in diminishing the scale of the victory. Because these westerlies were likely more common during the prevailing climate in which the First Anglo-Dutch War was fought, that climatic regime rendered more likely, and may indeed have influenced, the outcome of the Battle of the Kentish Knock.

Changes in wind velocity compounded the complex but, to the English, ultimately advantageous influence of wind direction during the engagement. A gale may have foiled De With's trap, and during the battle it was light winds that allowed English commanders to maximize the effectiveness of their great ships by fielding all their guns. On the other hand, calm winds delayed hostilities on the morning of the 9th, giving De Ruyter the time necessary to

dissuade De With from resuming a hopeless battle. Unfortunately, reconstructions of average wind velocity have not been attempted for the seventeenth century. Moreover, wind intensity during the Anglo-Dutch Wars cannot be charted using the wealth of available sources documenting battles, because engagements were often avoided if winds were too high or low.⁶³ Hence, light winds, an important weather phenomenon that affected the Battle of the Kentish Knock and, ultimately, the course of the First Anglo-Dutch War, cannot at this point be tied to contemporary climatic fluctuations.

More damaging for the Dutch Republic than its defeat at Kentish Knock was the spectacular success of English privateering. Privateering was authorized by each state but pursued by private actors, generally for personal gain, and supported by investors, usually merchants whose commercial activities were thwarted by war. Privateering, and to a lesser extent piracy, were often the last resort for merchant crews unwilling or unable to serve in naval vessels, especially after the state's fleet lost an important engagement and merchant shipping was forbidden. Privateering crews as small as 50 men usually employed light, fast vessels that could carry as few as five guns, and their operations rarely involved more than a few ships. Large convoys were obviously protected from privateers, yet not every merchant vessel sailed in a fleet, with an escort. Profits from such captured prizes were divided between crews, investors, and the crown, and for the English these profits were continuing to support the war effort. The Dutch Republic would lose over 1,200 merchant vessels over the course of the war, most at the hands of English privateers. By contrast, Dutch privateers from Zeeland and Holland seized no more than 400 English prizes. The imbalance is not as extreme as it initially appears, given the

⁶³ Reconstructions of unusually high winds, which have been cited in this dissertation, do not reveal changes in average wind velocity.

far larger size of the Dutch merchant fleet, yet most of the Republic's prizes were taken in the final months of the war, when the outcome was largely decided.⁶⁴

Most within Cromwell's regime believed that the war was won after the Battle of the Kentish Knock. Certainly many Dutch ships had been severely damaged, but only three were actually taken or destroyed. Hence, few within the Dutch Republic's governing circles believed that the battle had revealed weaknesses in Dutch ship construction or naval tactics. Instead the States-General blamed De With for the reversal, and replaced him with Tromp on 27 October. Given these prevailing attitudes on both shores of the Channel in November, it is neither surprising that the English fleet was again divided when the Dutch fleet returned to sea, nor that Tromp's fleet consisted largely of light ships. A Dutch fleet under Admiral Van Galen had driven the English out of the Mediterranean in October, and English ships had been dispatched to both the Mediterranean and the Baltic, leaving a comparatively small force in the Channel under Admiral Blake. The admiral, however, took no action when warned that 400 fully freighted vessels were preparing to depart Dutch havens under Tromp's escort.⁶⁵

During the naval wars of the seventeenth century most warships were laid up by October, enabling sailors to serve on merchant vessels that would have otherwise taken to sea in the summer. A winter guard of greatly reduced strength was often maintained until the spring, when the main fleet would be reassembled for the campaigning season. Hence, Blake may have simply believed that Tromp would not sortie with nearly 500 ships in a season notorious for its dangerous weather. For the same reason the English would not attempt a blockade that might

⁶⁴ Gijs Rommelse, *The Second Anglo-Dutch War: international raison d'état, mercantilism and maritime strife*. (Hilversum: Uitgeverij Verloren, 2006), 115. Jones, *The Anglo-Dutch Wars*, 143. J. R. Bruijn, "Dutch Privateering during the Second and Third Anglo-Dutch Wars," in *The Low Countries History Yearbook 1978*, ed. I. Schöffer. (Dordrecht: Springer, 1979), 80. David J. Starkey, "Voluntaries and Sea Robbers: A review of the academic literature on privateering, corsairing, buccaneering and piracy." *The Mariners Mirror* 97:1 (2001): 130. Glete, *Warfare at Sea*, 41.

⁶⁵ Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 119.

have screened all avenues of departure. Similarly, before the Glorious Revolution of 1688 James II, an experienced seaman, did not seriously believe that William III would attempt an invasion in October or November because of the frequency of gales in the season. As it happened William's invading fleet was spirited to England by a favourable easterly, a "protestant wind."⁶⁶

Baltic freezing would have limited the Dutch convoy to a westerly course in most years during the seventeenth century. However, in 1652 Josselin in Essex wrote that October, November, and the first half of December, were remarkably mild and dry. New climatic reconstructions also suggest that the westerly winds more common during the First Anglo-Dutch War corresponded with reduced winter ice in the Baltic. Commonwealth commanders may have been uncertain about where to ambush the Dutch fleet because the lack of ice in the Baltic raised the prospect of the Dutch fleet taking a northerly or southerly course. Ultimately, warm, dry weather that was more likely during the First Anglo-Dutch War than it was in the latter wars may have encouraged the Dutch to field their main fleet in an unprecedented December convoy operation, while increasing uncertainty in English circles regarding the fleet's destination.⁶⁷

In the first week of December the Dutch convoy departed and took a southwesterly course down the English Channel, in spite of the Baltic's likely navigability. A northwesterly gale rose during the voyage and, at 4 AM on 9 December, spirited Tromp's war fleet into the Dover Strait well ahead of its civilian charges, leaving the Dutch captains unencumbered by escort duty. Departing the Downs on 10 December Blake commanded only 52 ships to Tromp's 88, of which 42 were of middling size while several were captained by unreliable privateers.

⁶⁶ Rodger, *The Command of the Ocean*, 138.

⁶⁷ Glaser and Koslowski. "Variations in reconstructed ice winter severity in the western Baltic," 118. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 526. J.R. Jones, likely supposing that all three Anglo-Dutch Wars were fought during a colder climate, described how "For some unknown reason neither the Council nor Blake took action when they received warning that the Dutch fleet under Tromp was being prepared for an early sortie . . . at this time of the year they must be bound for westward destinations, not the Baltic which was icing up." Jones, *The Anglo-Dutch Wars*, 157.

Consequently, Blake was ordered to sail southwest to unite with hastily converted merchantmen coming from Portland. A south-westerly breeze rose on 11 December, as the English and Dutch fleets sighted one another. Both fleets tacked against the wind to sail on parallel courses, temporarily separated by the perilous Varne sandbank. However, the shingle ridges of Dungeness loomed ahead, cutting off Blake's course. If the English divisions cleared the Varne sandbank before the Dutch, Blake would have the option of continuing on course to join with reinforcements from Portland. On the other hand, if the Dutch outraced the English they would gain the weather gage while blocking the route to the Portland squadron (Figure 4.7). In that event the most sensible option for the English would be to reverse course and retreat, leaving the inbound Portland crews to their own devices.⁶⁸

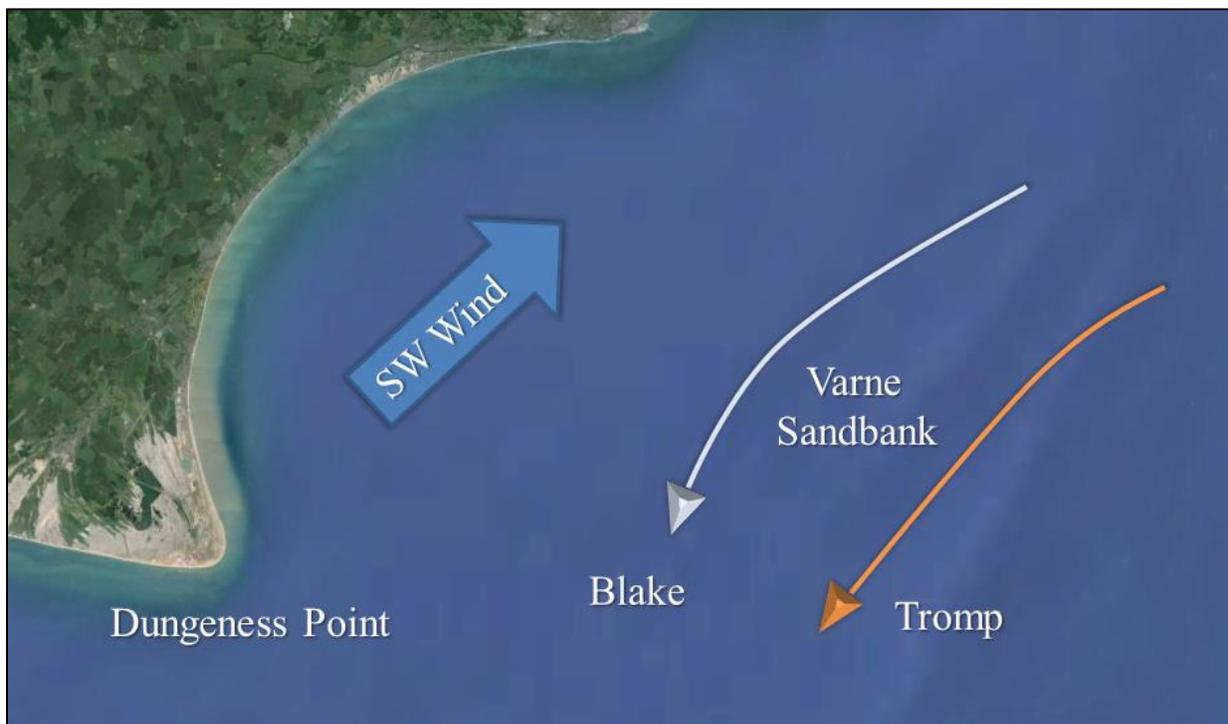


Fig. 4.7. The race along the Varne sandbank in the hours before the Battle of Dungeness. Dungeness Point, UK. (13 February 2014). Google Earth 6. Google.

⁶⁸ Jones, *The Anglo-Dutch Wars*, 120. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 526.

As Dungeness Point approached Tromp took the weather gage. However, Blake, making no attempt to concentrate his forces, turned to port and took the leading edge of the English fleet into the waiting Dutch lines. As many as 20 English captains refused to follow. Thwarted by the wind, Blake did not endeavour to use line of battle tactics, and hostilities soon degenerated into clusters of small-scale conflict. With superior numbers, Dutch mariners were able to use the wind to more easily come to one another's aid, and that proved decisive. While the English captured one Dutch ship, three English vessels were taken or destroyed. Of these one had been grounded, before it was freed by Dutch mariners who exploited the combined influence of the tide and persistent westerly winds.⁶⁹

The Battle of Dungeness was the last major conflict of the First Anglo-Dutch War that, in quantitative terms, could be described as a victory for the Dutch Republic. Although the battle was as indecisive a victory for the Dutch Republic as the Battle of the Kentish Knock had been for the English, the containment of the English fleet provided a vital reprieve for the Dutch trading economy and helped restore the Republic's prestige in Europe. Severe tactical and strategic miscalculations by the English nullified the advantages bestowed by their naval system. Equally important, however, was the influence of persistent westerly winds born of a warmer climate, which did not benefit but rather imperilled an English fleet caught badly out of position. The superior seamanship of the Dutch mariners earned them the weather gage, allowing Tromp

⁶⁹ This ship was the 36-gun *Hercules*, sailing from Portland to reinforce Blake's fleet. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 53. Jones, *The Anglo-Dutch Wars*, 118. A letter from Tromp reported by Harald Appelboom claimed that, in the Battle of Dungeness, four English ships were taken to two Dutch ships lost; Tromp was missing a total of ten ships from his fleet. Harald Appelboom, "Harald Appelboom aan Christina van Zweden, 23 December 1652," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. 1*, 37. It should be noted that Richard Harding presents a rather different account of the Battle of Dungeness in his rather glib summary of the Anglo-Dutch Wars, in which Tromp arrives at the Goodwin Sands on 4 December, hostilities are initially thwarted by "the weather," Blake opts to avoid battle when the Dutch fleet is sighted, and five English ships are lost to one Dutch vessel in the subsequent engagement. This narrative is not particularly convincing given its relative lack of detail, its contradiction with surviving primary sources and, in particular, Blake's aggressive action to turn into the Dutch fleet as the Point of Dungeness approached. Richard Harding, *Seapower and Naval Warfare, 1650-1830*. (London: UCL Press, 1999), 68.

to maximize the benefit of his greater numbers. Still, to acquire the weather gage the Dutch were forced to manoeuvre frantically; when the wind blew from the west it did not come easily for fleets sailing from eastern ports.

As with the Battle of the Kentish Knock, the Battle of Dungeness was preceded by a westerly gale that affected the Dutch fleet while the English armada sheltered in port. Mariners have always dreaded storms, but the very different consequences of the two gales reveal that each storm was distinct, expressed through weather that, while always defined by severe winds, could nevertheless yield very different results. Storms were mediated by a host of environmental and cultural frameworks, which were, in turn, channelled by human agency as battles were planned and fought. Intense westerly winds pushed De With's fleet away from its destination, but hurried Tromp's course towards the English fleet. Without the influence of the gale, Tromp, burdened with escort duty, would probably have been driven into a defensive battle, had the English decided to engage at all. Moreover, unlike it had been off the Shetlands, the Republic's fleet in December 1652 was far from a lee shore, or indeed any shore, when it encountered the storm that blew it into Dover Straits.

After the Battle of the Dungeness, the battered Commonwealth fleet retreated back to the Downs after a night of repairs, before retiring to the greater security of the Thames. Tromp was eager to pursue on 12 December, but the Dutch armada, scattered by battle and stormy weather, could only be reassembled on 13 December. Although Tromp was aware that the vulnerability of the English fleet stemmed from its temporary disunity, his pilots dissuaded him from raiding the Thames because westerly winds, when combined with an ebbing tide, could easily strand even the shallow hulls of the Dutch vessels.⁷⁰ In a 2005 article, Lisa Brady illustrated how

⁷⁰ The pilots warned of "adverse winds" which, given the approaches to the Thames, almost certainly meant westerlies. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 56.

relationships between warfare and environment, expressed most obviously in material terms, were even more importantly revealed in the coevolution between human psychology and (altered) local environments. Indeed, during the First Anglo-Dutch War persistent westerly winds typical of a warmer climate not only shaped the course of engagements in ways that were perceived and acted upon by their participants, but the frequency of these westerlies encouraged different “mental landscapes” – different conceptions of what was tactically possible – among many mariners. The resulting reticence to raid up the Thames rendered the Battle of Dungeness far less decisive than it might have been, and for the next two months the English fleet regrouped in safety.⁷¹

Tromp’s aborted raid was the last offensive operation planned by the Dutch in the First Anglo-Dutch War, although the dream of assaulting English naval infrastructure in the Thames endured. Changing tactical circumstances would soon prohibit such initiatives. In the last week of February 1653, the Dutch fleet under Tromp escorted a 150-vessel merchant fleet up the Channel, hugging the English coast while struggling against rough weather. Unbeknownst to the Dutch commanders, a restored English armada under Blake had left port days earlier. The Commonwealth fleet numbered 70 ships to the 80 that constituted the Dutch fleet, but Blake’s vessels were primarily second or third rates, with many even larger and better armed than Tromp’s flagship. Wrongly assuming that Tromp would avoid battle and stay to sea, Blake scattered his armada to better scour the breadth of the Channel. As a result Blake’s divisions were miles apart when the opposing fleets encountered one another near Portland on the morning of 28 February, while the united Dutch fleet was well positioned between the English and the

⁷¹ Lisa M. Brady, “The Wilderness of War: Nature and Strategy in the American Civil War.” *Environmental History*, 10:3 (2005): 423.

merchant convoy. With the wind out of the Northwest the Dutch fleet had the weather gage, and Tromp immediately ordered his captains to sail for the remnants of Blake's squadron.

Outnumbered four to one when hostilities erupted, Blake's division endured the Dutch onslaught for over an hour while Vice Admiral Penn and Rear Admiral Lawson ordered their squadrons to tack against the wind to gain the weather gage and join their beleaguered commander (Figure 4.8). Although the Dutch initially captured several English vessels by disabling their rigging, the battle turned decisively as the reinforcing English divisions joined the fray and targeted Dutch hulls with synchronized broadsides. Meanwhile, English commanders deployed quick fourth and fifth rates to raid the Dutch merchant fleet. Fortunately for the Republic's mariners the light faded quickly, and the long winter night was consumed with frantic repairs. With dwindling ammunition Tromp arranged his ships into a crescent to protect the merchant vessels, and for two days the Dutch desperately held the English at bay. On 2 March the battered remnants of the Dutch convoy approached the cliffs of Cap Gris Nez on the French coast, with winds steady from the Northwest. Blake decided the Dutch fleet was trapped, pinned against the dangerous shoals and rocks by wind and ebbing tide. However, that night Tromp guided the surviving Dutch ships between the cliffs, through a deep-water channel unknown to the English. On the next day the 70 combined merchantmen and men-of-war left to Tromp anchored off Dunkirk, as a rising westerly gale exposed the English to a lee shore. Fearful of winter weather, the English admirals retreated across the Channel with minimal losses. The Dutch, meanwhile, had lost approximately 15 warships, 45 merchantmen, and perhaps 3,000 seamen over three days in the first truly decisive engagement of the war.⁷²

⁷² Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 69. Jones, *The Anglo-Dutch Wars*, 118. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 527. Brandt, *Uit het Leven en Bedrijf van den here Michiel de Ruiter*, 56. "A Perfect relation of the great fight between the English and Dutch fleets on Fryday and Satturday [sic] last." (London: Printed for George Horton, 1653), 4. "Martenson aan Christian van

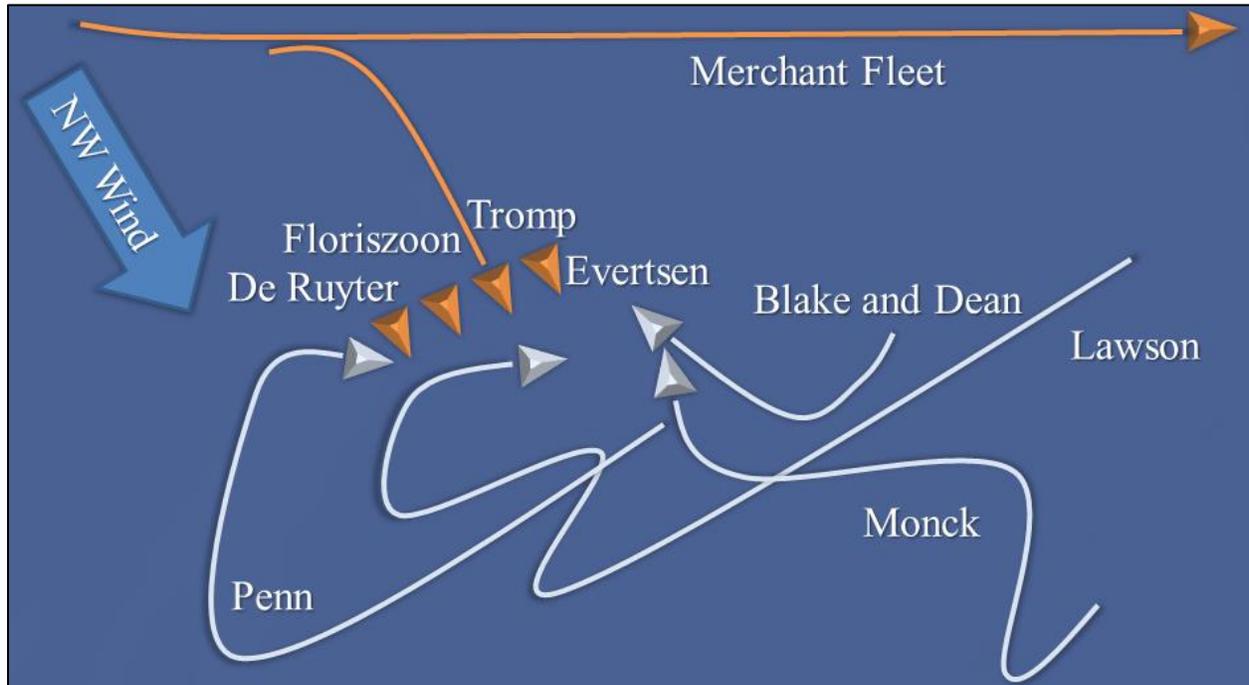


Fig. 4.8. The order of battle on the first day of the Battle of Portland/Driedaagse Zeeslag. Roger Hainsworth and Christine Churches, *The Anglo-Dutch Naval Wars*, 63.

The course of the Battle of Portland, known to the Dutch as the *Driedaagse Zeeslag* or “Three Days’ Naval Battle,” illustrates how wind patterns interacted differently with the distinct naval systems employed by the Dutch and English in the First Anglo-Dutch War. Initially, the tactical advantage bestowed by the windward position of Tromp’s united fleet in the face of Blake’s scattered divisions was nullified both by the increasingly obsolete Dutch tactic of targeting rigging, and, more importantly, by the far greater capacity of the larger Commonwealth

Zweden, 12 March 1653,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. 1, 47. Not surprisingly, estimates of Dutch losses vary greatly between these primary and secondary sources. The English author of “A Perfect relation” listed Dutch losses at 19 warships alone, while Brandt claimed only 9 Dutch warships and 24 merchant vessels were lost to 6 English ships. Brandt insisted that only 5-600 Dutch seamen were killed to 2000 Englishmen, and wondered whether both sides misrepresented the enemy’s losses in the aftermath of the battle. Indeed, Hainsworth and Churches write that 17 Dutch warships and 60 merchantmen were taken or sunk, but their figures are based exclusively on English primary sources. Relying on De Jonge’s patriotic account, meanwhile, Buisman describes how 11 Dutch warships were lost, along with just 30 merchantmen. With so many different accounts I have listed a middling figure. Either way the point revealed by nearly every source is that the Dutch suffered an important loss of warships and especially merchant ships, including VOC vessels, with casualties that far exceeded those of the English.

ships to withstand and inflict artillery bombardment. A master of defensive warfare on land, Blake ensured that the 20 vessels near his flagship were tightly arranged and prepared for the Dutch assault. Meanwhile, the quick action of the other English admirals helped them gain the weather gage against the confused and stationary swarm of Dutch vessels surrounding Blake's division. Although being windward granted one fleet an important advantage at the start of an engagement, the Battle of Portland, like the Battle of Dungeness, revealed that the weather gage could be lost even in steady winds if one armada managed to outmanoeuvre the other.

The threat of a lee shore in rising winds, however, could only be escaped before the wind strengthened into a gale, and then only through retreat. Tromp, a seasoned mariner, employed his remarkable seamanship and environmental knowledge to guide his convoy from the supposed trap of Cap Gris Nez. Nevertheless, it was building westerly winds that ultimately thwarted the English pursuit and saved the remnants of the Republic's fleet from annihilation. The unusual persistence of westerly winds during the convoy's journey home, the Battle of Portland, and the convoy's escape to Dunkirk, all in a month when winds typically emanated from many different directions even in the warm twentieth-century climate, reflects the general abundance of westerlies in the climate of the mid-seventeenth century.⁷³

Amsterdam's entrepôt economy essentially ground to a halt for over three months after the Battle of Portland, as Dutch warships could no longer escort convoys to and from the Republic. Negotiating a peace from such a weakened position was out of the question. By May the Republic's carpenters and shipwrights had prepared a fleet of nearly 100 men-of-war, although larger vessels designed to match the English great ships were not yet ready to sail. The restored fleet escorted several hundred merchantmen to the Shetland Islands, before sailing south to encounter a more numerous English fleet near the Gabbard shoal on 12 June, 1653. English

⁷³ Korevaar, *North Sea Climate*, 21.

vessels were still far larger than their Dutch counterparts, and most were equipped with castles to repel Dutch boarders. Moreover, their captains operated according to new *Fighting Instructions* that heralded the maturation of English line of battle tactics. Light, southwesterly winds allowed the English to claim the weather gage, which they used to bombard the Republic's fleet at range. On the second day of fighting the Dutch ranks broke, and Tromp's orderly withdrawal quickly became a chaotic rout. Several Dutch vessels collided with each other and, so entangled, were easily taken by the English. Only nightfall preserved the majority of the Republic's fleet, which found shelter in the Wielings, at the entrance to the Scheldt estuary.⁷⁴

Light, westerly winds during second day of the Battle off the Gabbard or *Zeeslag bij Nieuwpoort* ("Naval battle near Nieuwpoort") created ideal conditions for the English line of battle tactics. In fact, Dutch propaganda blamed the defeat on the westerly wind.⁷⁵ However, the ship logbooks kept by both Witte de With and Michiel de Ruyter reveal that these winds were not continuous. De With recorded westerly winds from the evening of the 9th to the 11th, and again from the 13th to the 14th. Still, of the 20 weather measurements he took in June, only nine listed winds from the West, while an equal number described winds from the East.⁷⁶ De Ruyter's logbook did not record anything from 13 June to 1 July, but his measurements for the first two weeks of June were nearly identical to those taken by de With.⁷⁷ Hence, although the Battle off the Gabbard was fought during a swell of westerly winds, those winds were neither continuous

⁷⁴ Jones, *The Anglo-Dutch Wars*, 130. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 77. Monck, "Two letters from the fleet: the one written by Generall Monck to the Commissioners of the Admiralty sitting at Whitehall. The other by Capt Bourn, captain of the Resolution to his wife . . ." London: Printed by Tho. Newcomb, dwelling in Thamestreet, over against Baynards-Castle, 1653. De With, "Journal kept by vice-admiral Witte de With."

⁷⁵ Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 130.

⁷⁶ De With, "Journal kept by vice-admiral Witte de With." De With came ashore on 15 June, and angrily asked the States-General: "why should I keep silence longer? . . . I can say that the English are at present masters both of us and of the seas." Unfortunately De With did not take meteorological records while on land, and it is possible that the westerlies he recorded before the 15th continued through the rest of the month. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 81.

⁷⁷ De Ruyter, "Journaal gehouden op het schip De gekroonde Liefde."

nor seasonally unusual, and can therefore not be convincingly tied to the influence of the prevailing climate.

With English mastery of the North Sea temporarily uncontested, an ailing Blake, soon to be replaced by Admiral George Monck, imposed the war's first systematic blockade. The English admiralty hoped to suffocate a Dutch economy that depended on maritime commerce, but harassment of Dutch ports was stymied by the extensive shoals that protected Dutch harbours and the entrance to the *Zuider Zee*. Even Dutch crews were required carefully to navigate through the narrow entrances to these shoals, most of which were either unknown to English pilots or impassable by the deep-draughted English vessels. In the sixteenth century, an elaborate warning system had also been established along the coast to allow the Dutch to remove buoys at the mouths of rivers and the entrances to harbours when hostile vessels approached.⁷⁸ Still, safety from English raids scarcely diminished the economic toll of the blockade. It could not endure for long in the seventeenth century, given the administrative weaknesses of contemporary naval systems, but it is likely that persistent westerlies stimulated by a warmer climate facilitated the delivery of supplies to English ships patrolling the Dutch coast.⁷⁹ Once again the Republic's leadership resolved that peace under these conditions was untenable; once again Dutch shipyards demonstrated their remarkable industriousness. By August, the Republic's naval strength amounted to perhaps 107 men-of-war and nine fireships, but it was divided between Tromp's southerly fleet in the *Wielings*, and De With's smaller squadron assembling near Den Helder to

⁷⁸ Sicking, *Neptune and the Netherlands*, 155. C. Postma, *Het hoogheemraadschap van Delfland in de middeleeuwen 1289-1589*. (Hilversum: Uitgeverij Verloren, 1989), 389.

⁷⁹ Even then, that was not the entire English fleet. According to Hainsworth and Churches, until the end of July most of the English fleet actually retired to Sole Bay to offload the sick and replenish supplies. Monck left behind fourth and fifth-rates to signal as though contacting the main fleet, ostensibly hovering over the horizon. The Dutch apparently never realized this ruse until the bulk of the English fleet returned. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 82.

the North. A westerly or southerly wind would allow help Tromp guide his divisions up the Dutch coast to Den Helder, but De With required an easterly or northerly wind to leave port.

Tromp took advantage of a westerly wind on 6 August and ordered his fleet to sail north, but Monck, aware of the Dutch predicament, had already stationed his fleet off Den Helder. When the English sighted Tromp's 82 vessels to the south on 8 August, Monck promptly abandoned his siege of Den Helder and ordered his captains to engage the Dutch fleet. Although Tromp initially sailed to sea in order to gain the weather gage, in the afternoon the wind shifted from west to north, and the English had the advantage. The Commonwealth fleet now chased Tromp's divisions, but northerly winds and Monck's preoccupation with Tromp had finally given De With an opportunity to leave Den Helder. Slowed by barnacles, Tromp's vessels were forced to give battle by 4:00 PM, and the Dutch fleet remained divided at nightfall. As the English drifted downwind in the night, Tromp ordered his fleet to execute a complicated tacking manoeuvre and sail north. It was a daring gambit in the darkness, but on 9 August the English awoke to find a united Dutch fleet sailing with the weather gage. Nevertheless, rising north-westerly winds strengthened into a gale and prohibited battle.

The wind moderated by the morning of the 10th, with the opposing armadas drifting off the Scheveningen, not far from Haarlem. The fleets had switched places in the storm, but with the breeze now from the south-southwest the Dutch had retained the weather gage. Unlike Blake, who at Portland had waited for the Dutch to bear down with the wind, Monck resolved to aggressively tack against the wind. He hoped that his fleet would sail through the Dutch lines and so claim the weather gage. As the English fleet passed the Dutch ranks Tromp ordered his vessels to follow, hoping to prevent Monck from turning before the wind. In the tacking battle that ensued the English crossed through Dutch lines on four occasions, with Tromp dying on the

first pass. The ship logbook of the *Vanguard* records how, by afternoon, “many of their ships’ masts were shot by the board, others sunk to the number of twenty. At last God gave us the wind.” Most Dutch ships were now retreating before the wind, bearing Northeast to the island of Texel, but some heavily damaged vessels under De Ruyter and Evertsen could not manoeuvre past the English fleet. Their crews were forced to sail west against the wind, with Monck’s fleet in pursuit. By nightfall perhaps 3,000 Dutch seamen had died with 15 ships lost, to at most 900 Englishmen and only two English vessels, one a fireship. Still, Monck was forced to lift the blockade and retire his fleet to Southwold for repairs, because virtually all English ships had sustained some damage to their masts.⁸⁰

While the westerlies that prevailed during the Battle of Scheveningen were seasonally typical, De With’s ship journal strongly suggests that the battle was fought in a period of unusually continuous westerly winds. Of the 31 weather observations written by De With in August and September, 19.5 – or 63% – recorded westerly winds.⁸¹ Accordingly the Battle of Scheveningen was likely influenced by the climate of the mid-seventeenth century. However, during the engagement the pattern of advantages and disadvantages bestowed by persistent westerly winds shifted from one fleet to the other, with both commanders employing innovative strategies to claim the weather gage. The manoeuvres ordered by Tromp, De With and Monck demonstrated that although the quest for the weather gage could dictate the strategies pursued in battle, the weather gage, when claimed, was neither a permanent nor necessarily decisive advantage. As ever, the influence of wind patterns was mediated not only by cultural frameworks

⁸⁰ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 83. Jones, *The Anglo-Dutch Wars*, 132. Buisman and A.F.V. van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 528.

⁸¹ De With, Witte, “Journal kept by vice-admiral Witte de With.”

and human initiative, but also by environmental circumstances as superficially innocuous as a cluster of barnacles.⁸²

The division of the Dutch armada into separate retreats against and before the wind also demonstrates how wind patterns could influence withdrawal from battle. Although both retreating and pursuing fleets sailed with or against the same wind, fleeing crews usually wished to minimize their time away from the shelter of friendly shoals and harbours. Even when retreating vessels were out of range of enemy fire, ships with damaged masts were vulnerable in storms, those with punctured hulls could not be continually pumped free of water, injured seamen required medical attention on shore, and larger or less seaworthy vessels were often vulnerable to the harrying of faster frigates. Hence, during the Battle of Scheveningen the worst Dutch losses were suffered by the damaged ships that fled west, against the wind and away from the Republic, with Monck's fleet in hot pursuit.

Still, the relationship between wind patterns and retreat was differently expressed in the unique geographic, environmental, cultural, and tactical frameworks that coloured each battle of the Anglo-Dutch Wars. By similarly thwarting the progress of both retreating and chasing fleets, contrary winds could also aid fleeing ships, especially when those vessels were out of range, and particularly when they were slower than their pursuers. Wind velocity was equally important. For example, storms could expose retreating ships to a lee shore, depending on their wind direction and the state of the chase. Storms that did not blow pursuing ships towards the coast could also benefit fleeing vessels, especially if those storms struck in the late stages of a retreat. The pursuers could then find themselves in a very vulnerable position, because fleeing vessels were typically closer to shelter. Similarly, light winds, so beneficial to English gunnery, could

⁸² Barnacles were, of course, also a product of human agency: they could be removed, and Tromp's ships had not been properly maintained.

also benefit retreating Dutch ships that had passed out of firing range, as Dutch vessels sailed better on calm seas.

The Battle of Scheveningen had ended in retreat and destruction for the Republic, but Monck's blockade had been lifted. The States-General hastily coordinated the assembly of a new fleet, and ordered De With to escort a fleet of merchantmen towards the North. Inadequately provisioned, the Republic's makeshift fleet returned to Texel in October with over 400 merchantmen. Fearful of desertion, the States-General dismissed De With's "ridiculous" pleas to return to port, resolving instead to supply the fleet at sea until more merchant vessels could be brought to safety. De With's fears were realized on 7 November, when a ferocious gale rose from the Northwest and endured for five days, exposing the Dutch fleet to a lee shore. By the third day De With wrote that his ships were losing their anchors and each other, and when the winds moderated on 12 November as many as 11 warships were lost. Of the rest at least 24 had lost their masts.⁸³

In the twentieth century, North Sea westerlies were slightly more common in November than winds from other directions, but for in the first two weeks of November 1653 De With recorded westerlies in fully 83% of his weather observations. One can imagine De With penning his request to the States-General in the days before the storm, as a westerly wind rocked his cabin. Ultimately, the direction of the winds that exposed De With's ships to the shore of Texel – if not their velocity – can be linked to the warmer climate in which the war was fought. That climate did not render the westerly storm inevitable, but it certainly made it highly probable as the Dutch fleet continued to linger at sea. Royalist preachers loyal to the disempowered House of

⁸³ The storm of 7-12 November was powerful enough to damage dikes as far south as Zeeland and Western Brabant, and flooded polders including Van Namen (Saaftinge), Ossendrecht, and the Alloijzenpolder at Dubbeldam. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 531. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 90. Jones, *The Anglo-Dutch Wars*, 135.

Orange regarded the gale as divine punishment for negotiations with Cromwell's regime. Still, the losses suffered by the Dutch convinced Grand Pensionary Jan de Witt and his fellow republicans that peace was necessary.⁸⁴

Having deposed the English monarchy, Cromwell feared that the Republic's defeat would incite a royalist revolt in favour of the House of Orange. Such a revolt might install an even more implacable adversary across the North Sea, and this concern, as well as the state of English finances, led English negotiators to conclude a peace so lenient that it scarcely amounted to an English victory. According to the Treaty of Westminster, Dutch captains were required to acknowledge England's sovereignty of the seas by saluting their English counterparts in the North Sea, and the Dutch would pay tribute when their herring fleets fished off the English coast. The Dutch also agreed to recognize the terms of the 1651 Navigation Act.⁸⁵ Dutch ships were now prohibited from importing goods to England or its colonies, but Dutch merchants quickly circumvented the new trade restrictions. The peace therefore had little potential to damage Amsterdam's primacy in world trade. Still, beyond the terms of peace the first Anglo-Dutch War had been costly for the Dutch Republic. Many of the ships captured by English privateers were flutes, and the efficiency of these vessels temporarily enabled English merchants to offer rates comparable to those of their Dutch colleagues. Also costly was the VOC's need to replace East Indiamen that had been drafted into the Republic's fleet and subsequently destroyed. Moreover, resources that would otherwise have been directed to combat colonial rebellion and Portuguese resistance in Brazil had been diverted to the struggle against the Commonwealth. In 1654, the

⁸⁴ De With, "Journal kept by vice-admiral Witte de With."

⁸⁵ Lacey Baldwin Smith, *This Realm of England, 1399-1688, Eighth Edition*. (Boston: Houghton Mifflin Company, 2001), 311.

WIC surrendered Recife, permanently altering the possibilities for a Dutch empire in the new world.⁸⁶

The First Anglo-Dutch War was fought between two increasingly global empires, but its outcome was decided in the space between Amsterdam and London, the narrow swath of the North Sea and English Channel through which flowed the commerce of both world systems. There, frequent westerly winds that accompanied a slightly warmer climate influenced naval operations on various scales, in a manner that, while complex, nevertheless favoured the English in most occasions. Persistent westerlies, mediated through a web of cultural and environmental relationships, granted tactical initiative to English privateers and sped supply ships destined for English blockades. More importantly, westerlies frequently aided English armadas in battle and, when expressed in storms, ravaged Dutch fleets. Prevailing westerlies also coloured Dutch “landscapes of the mind,” limiting Dutch attacks on English naval infrastructure. Ultimately, the conclusion of the First Anglo-Dutch War was more a truce than a lasting peace, but the next conflict would be fought in changed environmental circumstances, between very different naval adversaries.

⁸⁶ Israel, *The Dutch Republic*, 935. De Vries and Van der Woude, *The First Modern Economy*, 465. Jones, *The Anglo-Dutch Wars*, 143. A. Staarman, “De VOC en der Staten-Generaal in de Engelse Oorlogen: een ongemakkelijk bondgenootschap,” *Tijdschrift for Zeegeschiedenis* 15 (1996): 3.

Chapter 5

Warfare in a Colder Climate: the Second Anglo-Dutch War, 1664-67

Unrest following Oliver Cromwell's death in 1658 prompted George Monck to restore the monarchy by negotiating the return of Charles II in 1660. The Dutch state was now Europe's only major Republic. Its States-General sent lavish gifts to Charles II, but although he had spent his exile in Breda he remained implacably hostile. In 1660 the English parliament passed a new Navigation Act that introduced a register of ships permitted to trade with England, stipulated that every ship's crew would be 75% English, banned foreign merchants from English colonies, and ensured that all colonial goods would be sent to English ports before arriving at their ultimate destinations. Arguably the most effective protectionist policy proposed by a rival power since the origins of the Republic, the Act threatened to end Dutch participation in English commercial life.¹

The Navigation Act of 1660 antagonized the States-General, but it was the actions of a belligerent cabal of merchants, politicians, and naval officers under James, the Duke of York, that ultimately instigated the Second Anglo-Dutch War. The failure of the English East India Company to challenge the VOC's Asian monopoly convinced the group that only action in the North Sea and English Channel could force the WIC and VOC to yield to English demands. In the first years of the 1660s, Sir George Downing, the resolutely antagonistic envoy to the Republic, continually pressured the States-General to make commercial concessions. Ultimately, he succeeded only in convincing its grand pensionary, Jan de Witt, that appeasement would be futile. In that increasingly poisonous atmosphere the Royal Adventurers, a trading company

¹ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 101.

associated with the Duke of York's cabal, engaged the WIC in an escalating series of hostilities over the West African slave trade. In 1664, James instructed a small fleet under Sir Robert Holmes to eliminate the WIC's presence in West Africa. By September Holmes had captured several Dutch ships, seized all the primary WIC fortifications except Elmina, and negotiated new agreements with indigenous chiefs.²

English provocations after the restoration of Charles II were as much a response to the Dutch Republic's perceived economic strength as a reaction to its assumed military weakness. Since James and his allies believed that the Dutch could not defeat the English fleet, they guessed that the States-General would ultimately quail in the face of English pressure. In fact, since the First Anglo-Dutch War, De Witt had spearheaded the transformation of the Dutch naval system, which had adopted many of the most effective elements of its English counterpart. After the Treaty of Westminster was signed, a belated Dutch campaign to build ships equal to English second or third rates had yielded 64 men-of-war of revolutionary size, which now formed the core of the Republic's new standing navy. The largest of these ships, while not as massive as the English first-rates, nevertheless approached the maximum size contemporary Dutch harbours could accommodate. Meanwhile, Dutch assets would be protected from English raids by as many as 90 smaller, quicker warships. De Witt also simplified and centralized Dutch naval administration under his effective leadership, while increasing the income of the Republic's five Admiralties. However, the Republic's naval system had not improved in every respect. While Tromp's remarkable seamanship had counted among the Republic's few advantages in the First

² Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 150. Other Anglo-Dutch tensions in the early 1660s included a bill before English parliament that would have prohibited Dutch fishing near the English coast, and the nomination of Charles II as the guardian of Prince William upon the death of Princess Mary in 1661. The nomination undermined the attempts of Dutch republicans to limit the power of the House of Orange and raised the spectre of at least implicit English support for an Orangist revolt. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 101.

Anglo-Dutch War, in the second war Jacob van Wassenaer, an officer in the army, was selected as Lieutenant Admiral, after De Ruyter declined De Witt's offer. Nevertheless, on balance the changes appear to have improved the overall morale of Dutch sailors.³

In composition and tactics the English fleet was in most respects fundamentally unchanged since the Treaty of Westminster. Many of its warships were renamed after the restoration, yet few had been constructed in the following decade. Still, the *Fighting Instructions* had been further refined. They now specified that captains would fight in a single line during the entire battle, keeping the stations assigned to them before the commencement of hostilities. Overall, the authors of the *Fighting Instructions* sought to expand the tactical unit beyond the individual warship to encompass the entire line of battle. Consequently they prohibited the taking of prizes without a flag officer's permission, instructed disabled ships to fall to the rear rather than seek immediate help, and dispersed heavier ships among lighter vessels. English tactics emphasized unity and discipline as never before, but the state's naval leadership was divided between pardoned republicans and staunch monarchists. The English naval system was therefore characterized by tactical sophistication but also hubris, internal division, and a damaging lull in naval construction. It had assumed many of the worst institutional traits that had plagued the Dutch at the onset of the First Anglo-Dutch War. Moreover, it would now face similar meteorological disadvantages, stimulated by a shifting climatic regime.⁴

In the Second Anglo-Dutch War, meteorological conditions rendered more likely in a cooler climate granted important advantages to the Republic. More common easterly winds enabled the Dutch fleet to claim the weather gage, and in turn the tactical initiative, in most battles. Changed patterns of prevailing wind usually allowed the Republic's armadas to easily

³ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 92.

⁴ Ibid, 115. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*, 146.

leave port, and may have aided Dutch privateers. Moreover, persistent easterlies fanned the Fire of London in 1666 and a Dutch raid up the Medway River in 1667, disasters that financially crippled the English war effort. In naval engagements, high winds more common in a cooler climate repeatedly forced English crews to close their lower tier of guns, against a Dutch fleet with ships and artillery that increasingly matched their own. Cold winters likely slowed both English and Dutch ship construction, but also contributed to the failure of a Münsterite invasion of the Republic. Still, the military impact of the weather that accompanied a cooler climate was hardly straightforward. Meteorological conditions less likely during the Maunder Minimum occasionally provided advantages to English fleets, while the influence of weather rendered more common was directed by choices taken, or not taken, by commanders and their subordinates.

Beginning of the Second Anglo-Dutch War

After the near destruction of the WIC's presence in West Africa the Duke of York commanded a fleet to wait in the English Channel and challenge any Dutch fleet that departed the Republic for Africa. Anticipating this, De Witt sent word to De Ruyter's Mediterranean squadron, ordering them to sail south and avenge Dutch losses. In October De Ruyter swept down the coast of West Africa, seizing many ships and all English fortifications except Cape Coast castle. When the humiliating news returned to London in December, the English Privy Council permitted English vessels to seize Dutch shipping in the Channel and the North Sea. On 29 December a squadron under Thomas Allin ambushed a Dutch convoy sailing from Smyrna in rough weather. With eight men-of-war the English heavily outgunned the Dutch, but in the stormy weather most of the English vessels ran aground, and the rest were heavily damaged.

Allin wrote that, “had God pleased to have sent us fair weather, we had gone great service, but it was a fret of wind, that we did not handle our sails to fight.” Of 33 Dutch ships only three were lost, of which two had been captured.⁵

Destructive gales were as common in the North Sea region during Second Anglo-Dutch War as they were in the first, although they were less numerous than they would be in the third war.⁶ The stimulus for increased cyclonic activity during the First Anglo-Dutch War may have been tied to the regular rhythms of climatic cycles, but the rise in severe storms after 1660 has been linked to the onset of the Maunder Minimum. On the other hand, Allin engaged the Smyrna fleet south of the North Sea region, and the geographical extent of changes in storm frequency is not yet known. Still, severe storms rendered more common in a cooling climate probably affected the attempted capture of the Dutch Smyrna fleet, stressing the already problematic interplay between English ship design, nearby shoals, and tactical blunders made by English commanders.

Changing weather patterns associated with a shifting climate could influence not only military operations but also the efficiency of essential infrastructure. Shipyards and transportation networks in particular occupied the conceptual space between the relatively narrow, well-documented tactical execution of naval operations and broader strategic issues of resource supply in different economies. Such infrastructure was strongly affected by shifts in winter temperature. Statistics created from a synthesis of material and documentary proxy data indicate that the winter of 1664/1665 was generally only slightly colder than the twentieth-

⁵ Allin, *The Journal of Sir Thomas Allin, Vol. I*, 193. Samuel Pepys, “Monday 23 January 1664/65,” *Diary of Samuel Pepys*, <http://www.pepysdiary.com/archive/1665/01>. Rommelse, *The Second Anglo-Dutch War*, 115. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 110. Jones, *The Anglo-Dutch Wars*, 151.

⁶ Allin’s attack on the Smyrna fleet was actually fought well south of the English Channel – indeed, not far from Cadiz - but it is assumed here that similar weather patterns were felt beyond the North Sea and English Channel. Allin, *The Journal of Sir Thomas Allin, Vol. I*, 193.

century average, but an examination of qualitative sources demonstrates the unusual concentration and, consequently, the heightened effect of severe winter weather. After Allin's disappointing raid temperatures plummeted for the rest of December, and until February the winter of 1664/1665 was, according to Josselin in Essex, "wonderfull sharpe beyond what was known for so long."⁷ In his diary, Samuel Pepys, Chief Secretary to the English Admiralty, frequently described abundant snow and frigid temperatures, writing on 14 January that, "I walked home, it being a very hard frost, and I find myself as heretofore in cold weather to begin to burn within and pimples and pricks all over my body, my pores with cold being shut up."⁸ On 16 February Pepys wrote that "this was one of the coldest days, all say, they ever felt in England."⁹ In the Dutch Republic the Maas froze through much of January, then again for parts of February, while the *trekvaart* between Haarlem and Leiden was halted by ice for six weeks, before westerly winds ushered in thawing towards the end of February.¹⁰

On 6 February the most important of the Dutch admiralties, the Admiralty of the Maas, wrote to the States-General explaining delays in the construction of 24 new great ships. These included *De Zeven Provinciën*, which would later serve as De Ruyter's flagship in the Second and Third Anglo-Dutch Wars.¹¹ According to the letter, construction had been slowed by prolonged freezing and "other inconveniences," ensuring that the vessels would not be

⁷ Buisman and A.F.V. van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 592.

⁸ Samuel Pepys, "Wednesday 4 January 1664/65," in *Diary of Sir Samuel Pepys*. Pepys described extreme cold on most days in January, and on 19 January (NS) related how, "in my way saw a woman that broke her thigh, in her heels slipping up upon the frosty streete." Samuel Pepys, "Wednesday 9 January 1664/65," in *Diary of Sir Samuel Pepys*. The dates in the citations are in the Julian calendar.

⁹ Samuel Pepys, "Monday 6 February 1664/65," in *Diary of Sir Samuel Pepys*. On 27 February Pepys mentioned ". . . it being bitter cold, and frost and snow, which I had thought had quite left us . . ." Samuel Pepys, "Friday 17 February 1664/65," *Diary of Sir Samuel Pepys*.

¹⁰ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 593.

¹¹ The Admiralty of the Maas constructed all of the fleet's flagships. Vonk, *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*, 68.

completed on time.¹² Unfortunately, neither the Admiralty's letter, nor subsequent missives written by important members of the States-General, described how cold winter weather affected shipbuilding.¹³ It is possible that frozen canals prohibited or, at least, slowed the transportation of supplies necessary for the construction of the new great ships, although most of these materials would have already been on site. Most likely construction was slowed as labourers suffered from discomfort caused by cold and required more resources to sustain their work.¹⁴

This delay would have consequences. In April the English main fleet under the Duke of York sortied from the Gunfleet, Essex before the Dutch armada could assemble. While stationed off Texel the fleet captured eight Dutch merchantmen inbound from Bordeaux and Lisbon, but thereafter it was beset by gales. With no rich prizes expected for several months James II soon commanded his captains to abandon the blockade and return to the Gunfleet. The Dutch fleet finally assembled near Texel, and at 120 mostly large vessels it was the most powerful armada ever assembled by the Republic, likely equal to that fielded by the English. After uniting through May, in the first week of June the fleet departed in haste for the Dogger Sands. Surviving missives reveal that the fleet's commanders acted on the widespread belief that the English armada had been scattered and heavily damaged by a recent storm.¹⁵

¹² “Wij hebben wel met allen ijver getracht te voldoen [...] omme aen te bouwen ons aenpart inde geordonnerde wierentwintich capitale schepen van oorlog [...], maer siende dat door den langdurigen vorst ende andere inconvenienten den voortgang van de voorseide aenbouw merckelijcq wort verhindert; daerdoor alles soo spoedig niet sal connen werden geeffectueert als Uwe Hoogmoogenden van ons begeeren.” Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 592.

¹³ Indeed, at the time Jan de Witt was more concerned with preserving the low interest rates that allowed the Republic to borrow more easily than the English. Jan de Witt, *Brieven van Johan de Witt, Derde Deel: 1665-1669*, ed. Robert Fruin. (Amsterdam: Johannes Müller, 1912), 16.

¹⁴ In fact, in the winter of 1666/1667 English sailors cannibalized ships and ship supplies to warm themselves. It is possible that Dutch sailors did the same in 1664/1665. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 120

¹⁵ Appelboom, “Harald Appelboom aan Adolf Johan van Zweden, Lowestoft, 13 June 1665,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 178. “Nieuwsbericht uit Amsterdam, 25 Mei 1665,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 180.

Particularly illuminating are the letters of George Downing, whose well-founded intelligence reports are a critical source for the history of the Second Anglo-Dutch War. On 5 June, he reported that “[the Dutch] suppose and report that [the Duke of York’s fleet was] scattered by the late storme, and that they are putt over to the coast of England to rendez-vous againe.”¹⁶ According to Downing, the Dutch believed that the storm, apart from damaging the English fleet, also granted the Republic more time to train its new sailors, of which there were many. On 12 June Downing lamented that, “the weather and wind have bin these 3 or 4 dayes as fit for their goeing thither and for a fight as could be wished,” before describing how the Dutch were “exceeding confident . . . of getting the better.”¹⁷

Given these widespread attitudes, Van Wassenaer’s orders at sea are especially perplexing. On 11 June the Dutch armada encountered the English fleet 40 miles Southeast of Lowestoft. However, Van Wassenaer did not command an attack, despite being windward of the prevailing Northeasterly. On the 12th the English were just ten miles distant, but again Van Wassenaer did not exploit his advantage. The winds were relatively light, but during the late Maunder Minimum gales were almost twice as common in June as they were in the twentieth century. Accordingly, it is possible that Van Wassenaer was waiting for rougher weather. Higher winds would have forced the English to close their lowest gun ports, and would have strained repairs necessitated by the storm several days earlier. Still, Van Wassenaer’s hesitation puzzled

¹⁶ Downing continued by writing, “I need not tell you how high they are now here and how big they talke having such a fleet and joined together and out at sea.” George Downing, “Downing aan Arlington, 26 Mei 1665,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 181. The date recorded by Downing was almost certainly according to the Julian calendar. The extensive reach of Downing’s intelligence network, formed largely from Organist (royalist) sympathizers, was well known to Jan de Witt. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 125.

¹⁷ George Downing, “Downing aan Arlington, 2 Juni 1665,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 183. An English report written after the subsequent battle, likely written by an English captain, related how the Dutch had been, “brought thither [to the English shore] in all probabilities more with the opinion of finding ours in disorder upon the preceding foule weather, and reports they heard of our unreadinesse, then from their owne innate valour, though the sequel of the story shewes they had sufficiently to accompany them in this great undertaking.” “Verhaal van den slag bij Lowestoft, 13 Juni 1665,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 188.

both Dutch and English captains, with one Dutch captain writing that “God Almighty took away the skill of our Commander in Chief, or never gave him any.”¹⁸

By the evening of the 12th the wind shifted to blow from the South-southwest, and by the morning of 13 June the English had claimed the weather gage. The Duke of York promptly ordered his captains to attack with the wind. The English squadrons clustered together in their first pass, with some ships firing into friendly vessels, but English lack of discipline paled in comparison to the chaotic conduct of Dutch captains, who abandoned any semblance of order in their haste to claim prizes. The Dutch, to leeward, were unable to use their fireships, and both fleets bombarded each other as thick smoke blew away from the English vessels to envelop the Dutch. At 3:00 PM the powder magazine in Van Wassenaer’s flagship exploded under the onslaught of several English three-deckers, killing the admiral and his crew. The death of Van Wassenaer’s direct subordinate and subsequent miscommunication among the surviving admirals promptly scattered the Dutch fleet.

Over 112 kilometres from safety, the damaged remnants of the Dutch fleet might have been annihilated but for the actions of the Duke of York’s gentleman-in-waiting. Acting on prior orders from Anne Hyde, the Duchess of York, he commanded the captain of the English flagship to shorten sail while James was sleeping, causing the fleet to abandon its pursuit.¹⁹ This critical decision changed the character of the Dutch defeat. On the morning of the 14th the bulk of the Republic’s fleet reached the safety of the shoals that enveloped its ports. Only one English vessel

¹⁸ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 120. Admittedly Maarten’s son, Admiral Cornelis Tromp, later informed the States-General that although the wind was easterly it was too calm on the 12th to close with the English and open hostilities. Cornelis Tromp also reported that the English were trying to “entice” the Dutch “among the sands,” which seems improbable given the relatively shallow draughts of even the largest Dutch vessels. It is likely that Tromp was merely providing posthumous support to a fellow Orangist; regardless his apology for van Wassenaer found little purchase in the Republic. Cornelis Tromp, “Dutch account printed in contemporary broadsheet.” *The Second Dutch War: described in pictures & manuscripts of the time*, 12.

¹⁹ Henry Brouncker, the Duke’s gentleman-in-waiting, commanded the captain to shorten sail because the Duchess of York had ordered the Duke’s servants to hinder him from getting too embroiled in the fighting. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 125.

had been sunk and 800 seamen had been killed, but a disproportionate toll had fallen upon the English command. While the Dutch had lost 17 ships and at least 5,000 men, each fleet counted two admirals and many captains among the dead.²⁰ Moreover, in the aftermath of the battle English dominance in the North Sea was frustrated by several months of persistent storminess, during which the Dutch completed their delayed great ships.²¹ An English report to the Committee of Parliament presented on 1 November 1667 identified the difficulty of pressing the English advantage after the battle as the most important failure of the war.²²

The Battle of Lowestoft was contested in westerly winds. Nevertheless, weather conditions typical of the Maunder Minimum, filtered through the occasionally bizarre lens of personal agency, influenced where, when and how the engagement was fought. Prevailing westerly winds prompted caution among Dutch pilots in the First Anglo-Dutch War, thwarting Tromp's hopes for a raid down the Thames. By contrast, in 1665 reports that a gale had struck the English fleet, when coupled with persistent easterly winds that enabled entry to the North Sea from Texel, encouraged Dutch commanders to hazard a battle far from the safety of their home shoals. Both the storm and the summer easterly were rendered more likely in the climate of the deepening Maunder Minimum. Still, Van Wassenaer had been reluctant to depart Texel, much to Jan de Witt's frustration, and on 11 June he was again strangely hesitant to exploit steady

²⁰ William Penn, "Observations on the Battle," in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum. (London: Her Majesty's Stationery Office, 1667), 12. "Verhaal van den slag bij Lowestoft, 13 Juni 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 188. Allin, *The Journal of Sir Thomas Allin*, Vol. I, 234. Jones, *The Anglo-Dutch Wars*, 158.

²¹ George Downing, "Downing aan Arlington, 21 Juli 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 272. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 596.

²² "The heads of the miscarriages of the late warr as they lay before the Committee of Parliament, 1 Nov. 1667," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 595.

easterlies by attacking the English with the weather gage.²³ Van Wassenaer's tactical blunder and the machinations of the Duchess of York demonstrate that environmental structures can never be considered direct influences in human affairs.

Anthropologist E. Jones has conceptualized a climatic event, "as a funnel through which ongoing processes are channelled, and are in some sense transformed," and certainly weather typical of new climatic regime, interacting with other environmental structures, helped channel the course of the Battle of Lowestoft on a level beyond individual agency.²⁴ That these weather conditions were advantageous for the Dutch fleet was understood not only by politicians and mariners but also large swaths of a population that was intimately connected to maritime life. Nevertheless, if climatic stimuli were interacting with cultural and social structures to funnel the impending battle to a certain outcome on 11 June, then Van Wassenaer's decisions were sufficient to influence the effectiveness of his naval system, changing the pattern of advantages and disadvantages afforded by a shifting climate. Small wonder, then, that he was little mourned. In a letter to Sir Henry Bennet, Downing wrote that most Dutchmen, "hardly give [van Wassenaer] a good word. They attribute the loss of this Battle mainly to the English their having the wind of them, and they say that if ever they should come to fight againe and have the wind of the English, they doubt not but they should give a better account of it."²⁵

The Dutch Republic may have lost the first major battle of the Second Anglo-Dutch War, but its naval effort was succeeding in small ways that would ultimately have major consequences. Unfortunately, source limitations generally constrain an exploration of

²³ George Downing, "Downing aan Arlington, 2 Juni 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 184.

²⁴ E. Jones, "Climate, Archaeology, History, and the Arthurian Tradition: A Multiple-Source Study of Two Dark-Age Puzzles," in *The Years Without Summer: Tracing AD 536 and its Aftermath*, ed. J. D. Gunn. (Oxford: Archaeopress, 2000), 31.

²⁵ George Downing, "Downing aan Arlington, 19 Juni 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 209. Bennet would become the first Earl of Arlington, and was secretary of state during the Second Anglo-Dutch War.

relationships between climatic shifts, weather events, and naval operations to an examination of large-scale engagements. Nevertheless, Dutch awareness of the storm that damaged the English fleet on the eve of the Battle of Lowestoft reflects the effectiveness of the Republic's maritime intelligence network. Beacons and missives like Downing's intelligence reports helped inform opposing commanders, but far-flung networks of small boats called "galjoots" provided the bulk of naval intelligence gathering. These boats allowed opposing fleets to encounter one another in a region that, while geographically constrained, is frequently stormy, foggy, and perilous even for modern mariners in a warmer climate. Surviving letters reveal that the Republic's galiot system was likely superior to that of the English, at least in the Second Anglo-Dutch War. After the Battle of Lowestoft, Downing reported that Dutch galiots had been sent north of Scotland to instruct all returning vessels to seek shelter in northern ports while the Republic's fleet was restored, adding that, "some nimble *capers* [privateers] or other men-of-warre would make worke among those galliotts."²⁶

On 30 June, 1665 Downing acknowledged that the Dutch, "are here mightily to be comended for keeping such a number galliotts continually at sea for advice," and on 17 July he warned that "Galliotts lye still about Holland to advertise all ships that are comeing this way." Several months later the Earl of Sandwich, who succeeded the Duke of York as commander in chief after the Battle of Lowestoft, defended his decision to abandon a cruise along the east end of the Dogger Bank by writing that "the multitude of galliotts the Dutch keepe abroad to give advice" would thwart any attempt to capture prizes there.²⁷ Unfortunately, because individual galjoots were inexpensive, lightly crewed by relatively unskilled mariners, and engaged in

²⁶ "Downing aan Arlington, 16 Juni 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 198. "Caper" is the Dutch term for "privateer."

²⁷ "Lord Sandwich's Narrative, 11 Juli-12 Oct 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 253.

ostensibly inglorious activities, no surviving sources record how the Republic's extensive and apparently effective intelligence network was affected by weather events. Still, it is possible that more common storms proved deadly for many galiot crews, while easterly winds allowed elements of the network to quickly assume new positions.²⁸

Equally important for the outcome of the Second Anglo-Dutch War was the improved performance of Dutch privateers. In the First Anglo-Dutch War, English privateers had devastated the Republic's merchant shipping, and expectations of similar success encouraged English provocations in the months before the second war was officially declared. Instead, Dutch privateers seized as many prizes as their English rivals over the course of the war, and the much larger size of the Dutch merchant fleet meant English losses were far more damaging. The rising success of Dutch privateering was a sustained trend. During the Third Anglo-Dutch War the wealth acquired by English privateers was again expected to help finance English naval operations, but the Republic's privateers ultimately captured far more vessels than their English counterparts. Because the wars were fought largely to expand English trade, the success of Dutch privateers was an important catalyst behind English efforts to commence peace negotiations. The decision of the States-General to forbid merchant shipping that did not service the oceanic rich trades, English strategic errors, and the efficiency of the Dutch galiot network all contributed to the success of Dutch privateering after the First Anglo-Dutch War.²⁹

It is also plausible that the onset of the Maunder Minimum proved beneficial for Dutch privateers. Easterly winds likely enabled the Republic's privateers to surprise their prey while granting them the initiative in battle. Moreover, privateers often lurked near typically sheltered coasts, and it is possible that more frequent, more severe storms inflicted damage to merchant

²⁸ George Downing, "Downing aan Arlington, 17 Juli 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 268.

²⁹ Jones, *The Anglo-Dutch Wars*, 30. Rommelse, *The Second Anglo-Dutch War*, 115.

ships at sea that privateers avoided. These merchant vessels may have been more easily seized in the wake of such storms. However, the surviving sources that describe the exploits of privateers do not reliably record meteorological data in a manner that would enable firm conclusions about the broader relationship between a shifting climate, changing weather patterns, and the nature of Anglo-Dutch privateering.³⁰

Moreover, the Anglo-Dutch Wars revealed that only large fleets assembled to defeat their counterparts could win or lose a naval war, despite the enduring importance of maritime intelligence networks and privateering. Some tempting targets were also too important and consequently too well defended to be taken by privateers. After avenging Dutch losses in West Africa and raiding English possessions in the New World, by July De Ruyter and the men-of-war still under his command were expected to enter the North Sea. As Van Wassenaer's natural successor, De Ruyter was critical to the Dutch war effort. Indeed on 28 June Downing reported that, "every body at the court is lookeing how the wind blowes, and they expect with infinite impatience de Ruyter's returne, who . . . is to come round Scotland." De Ruyter's anticipated return corresponded with the expected arrival of the VOC fleet in Norway, which carried wealth that, if lost to the English, threatened to decide the war.³¹ On 10 July, a large English armada under Sandwich was already sailing north towards Bergen, Norway, after English agents reported that the VOC fleet had just entered the city's harbour. The Republic's main fleet was hastily readied to escort De Ruyter and the East India fleet back to Texel in the face of English opposition.³²

³⁰ Rommelse, *The Second Anglo-Dutch War*, 125.

³¹ The VOC fleet was taking the "back way." See Map 2.1, Chapter 2.

³² "Downing aan Arlington, 28 Juni 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 253.

De Ruyter's battered squadron reached Bergen with the English fast approaching. However, the Dutch employed a succession of southerly winds, fog, and persistent easterlies to slip by the English fleet and return safely to Delfzijl.³³ Gerard Brandt, a contemporary biographer of De Ruyter, wrote that after an English scout spotted the Dutch the "fog . . . cloaked the [Dutch] ships by night, the changing winds . . . constantly deceived the English, and the same winds . . . delivered [De Ruyter's fleet] from peril."³⁴ The fog encountered by De Ruyter was stimulated by warmer air from the south flowing over cold water, and the spring of 1665 had been cool. While the southerly breeze encountered by De Ruyter's fleet was not rendered more likely during the Maunder Minimum, regional water may have been chilled by the influence of a cooler climatic regime, perhaps thickening the fog that helped the Dutch escape the English fleet. Certainly the easterlies that aided De Ruyter's return to the Republic would have been particularly rare in June just ten years earlier.³⁵

The English fleet under Sandwich had actually struggled for weeks to reach Bergen in the face of calms and northerly winds, and now De Ruyter's squadron had slipped from its grasp. On the other hand, Gilbert Talbot, the English envoy in Copenhagen, had been in negotiations with King Frederick of Denmark, who ruled southern Norway and nominally supported the Republic. Talbot now reported that Frederick would break treaty with the Dutch by surrendering the fleet

³³ "Lord Sandwich's Narrative, 11 Juli-12 Oct 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 255. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 131.

³⁴ De Ruyter "slipte, getuigt een Engelsch schrijver, stil voorbij de Engelsche vloot henen, (die als in een mist lag beneveld) gelijk luiden die langs den weg gaan, met hunne mantels om de ooren geslingerd, om 't gezelschap dergenen, die ze niet gaarne willen ontmoeten, te mijden. Doch de mantel, die De Ruiter en de vloot bedekte, was de goddelijke voorzorge van boven, die hen behoedde: die de duisterheid bij nacht voor de Engelschen onzichtbaar maakte: die de veranderlijke winden uit zulke hoeken liet waaien, dat zij de Engelschen en de Engelschen hun telkens miszeilden: en die hen eindelijk, door dezelfde winden, beter dan door de beste loodsluiden, langs den streek, die hen ter behoudenis leide, voortdreef. Ook plag De Ruiter Gode altijd de eere van zijne behoudenis te geven, zeggende, 't is God alleen, die ons, buiten 't gezicht van onze vijanden, geleidde." Brandt, *Uit het Leven en Bedrijf van den here Michiel de Ruiter*, 153.

³⁵ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 594.

into English hands, in return for half the spoils. On 9 August, Sandwich dispatched a squadron of 15 warships and two fireships under Sir Thomas Teddiman to engage the VOC fleet in Bergen, while the rest of the English armada waited to ambush the Dutch main fleet when it arrived from the South.³⁶

However, when Teddiman reached Bergen the governor, Claus von Aslefeldt, denied all knowledge of the secret agreement and insisted that no more than five ships could enter the harbour. Meanwhile, severe southeasterly winds blew directly out of the harbour, and threatened to impede any attack. During the night, the Dutch repositioned their ships and fortified the garrison on the shore as negotiations dragged on between Teddiman's representative and Von Aslefeldt. Victuals were now running low aboard the English ships, and the Danes were continuing to stall for time. Accordingly, at first light the next day Teddiman ordered an attack, although his squadron faced a persistent and intense southeasterly. Eight English vessels attacked the VOC fleet while the others engaged the nearby Danish castle, but their rigging quickly disintegrated in the face of Danish and Dutch cannon fire. Increasingly out of control, Teddiman's vessels threatened to run afoul of one another. Sandwich wrote that "if God had given us but few howers of a faire wind, against the opposition both of the Dane and Dutch wee had destroyed both the shippes and towne."³⁷ Instead, Teddiman's fireships were ineffectual, and the English squadron was driven from Bergen with 400 seamen killed, to 29 for the Dutch.³⁸

³⁶ It was a tactical risk to divide the fleet, but Lord Sandwich wrote that the gamble was justified because losing the VOC fleet would have "given an unsupportable blow to the Hollanders . . . I am apt to believe scarce at any time in one place soe great a mass of wealth was ever heaped together." "Lord Sandwich's Narrative, 11 Juli-12 Oct 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 257.

³⁷ "Lord Sandwich's Narrative, 11 Juli-12 Oct 1665," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 258. Teddiman wrote that, "the dispute lasted 3 hours and a half, the wind right out of the port, and for my heart I could not get the fireships in, there being so many guns placed on me, that cut to pieces our cables, so that we had like to have drove foul of another." "Letter from Sir Thomas Teddiman to Sandwich, copied into the latter's journal, printed in Navy Records Society Vol. LXIV," in *The Second Dutch War*, National Maritime Museum, 15.

³⁸ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 131. Jones, *The Anglo-Dutch Wars*, 163.

Miscommunication among Danish officials, the shortage of victuals among English vessels, and the threat of the Dutch fleet's impending arrival influenced Teddiman's disastrous decision to attack in a high easterly winds that, while seasonally unusual, were symptomatic of the Maunder Minimum in the North Sea. The Southeasterly winds that so benefitted the VOC convoy also drove the main English fleet towards the Northwest, away from its planned rendezvous with Teddiman's squadron. Sandwich and his commanders resolved to make for the Shetland Islands owing to lack of supplies, particularly water, and their analysis of "the damage our heavy shippes must have received in hulls and masts in that climate and season."³⁹ By 20 September the English fleet was again in the North Sea when it was grazed by a severe storm that disabled one vessel, flooded the ammunition stores of a second, but did not separate any ships.⁴⁰ However, the Dutch fleet under De Ruyter, then escorting the VOC convoy back from Bergen, was directly struck by the same gale and was scattered. On 22 September, Sandwich exploited the tactical situation created by the storm's unequal toll by overseeing the capture of seven Dutch ships, including two hulking East Indiamen. During the battle, the English vessel *Hector*, fighting with its lower gun ports open, was sunk when it tilted in a sudden gust of wind. Still, a week later the English fleet seized two West Indiamen and four men-of-war, before pursuing a large squadron of 30 ships bearing for Texel under the command of Vice Admiral Van Nes. This time contrary, northeasterly winds hampered the English attempt to close, while a

³⁹ Of 10 morning and evening measurements taken by Thomas Allin between the departure of Teddiman's squadron and the Council of War that resolved to head for safe harbour, Allin recorded 6 days of South-southeasterly wind, and just three days of Southwesterlies. Interestingly, although Sandwich, Allin and their fellow commanders resolved to make for the Shetland Islands if the wind continued from the South, and Sole Bay if it persisted from the North, it appears that the fleet actually arrived at Sole Bay by 30 August. Allin, *The Journal of Sir Thomas Allin, Vol. I*, 249. "Lord Sandwich's Narrative, 11 Juli-12 Oct 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 262.

⁴⁰ "God bee prayesd," Sandwich wrote, "wee suffered little loss, only the *Diamond* lost her masts and was forced to bee sent home, and the *Sovereigne* by a leake wett 40 barrells of her powder, and the fleete escaped seperation." "Lord Sandwich's Narrative, 11 Juli-12 Oct 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 262.

rising storm threatened to expose the English to a lee shore should the wind change.⁴¹ Sandwich abandoned the hunt in the evening of 30 September, and during the night was driven back towards Sole Bay by high easterly winds.⁴²

Weather conditions typical of the Little Ice Age superficially benefitted the English in the weeks that followed the disastrous English attempt to capture the VOC fleet at Bergen. The dispersal of the Dutch fleet after the storm of 20 September allowed Sandwich and his subordinates to seize some of the spoils that had earlier escaped Teddiman's squadron. On the other hand, ten days after the storm English raiding was cut short by another gale. Although it blew from a direction that preserved English vessels in the face of a potential lee shore, it also stymied any attempt to seize the largest collection of Dutch ships spotted since Bergen. In fact, the number of prizes taken was quantitatively quite low considering the weakness of the Dutch tactical situation after 20 September. Moreover, the qualitative value of the two captured VOC ships may have encouraged Sandwich to embezzle some of their wealth. Those rumours were central to his subsequent dismissal, and may have been impossible without the storm that scattered the Dutch fleet and exposed the East Indiamen to the English. By at least partially facilitating English naval operations against Dutch merchant vessels, the meteorological conditions typical of the Little Ice Age likely weakened the English in coming engagements by enabling interactions between cultural frameworks and human agency that allowed ambitious officials to remove Sandwich from the theatre of war.

⁴¹ Sandwich explained that, "the chase in the morning before the wind cost us 4 howers home to master them. To chase shippis out of the winde is a longer worke." On the benefit of the same wind in enabling the English to avoid a lee shore: "if God had not beene pleased to cause the winde to shift to the N. and N.N.E. it might have beene fatall to the fleete," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 265.

⁴² Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 597. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 134.

In October, it was the reassembled Dutch fleet that appeared off the English coast, braving the season's tempestuous weather at De Witt's insistence. The fleet captured few prizes, and was eventually driven off by storms and an outbreak of plague that also ravaged London. Still, the inability of the English fleet to leave the Thames and confront De Ruyter's armada demonstrated the weakness of English finances.⁴³ Charles was, however, capable of promising subsidies to the Bishop of Münster, Bernhard von Galen, in return for an invasion of the Dutch Republic from its eastern borders. While the Dutch fleet appeared off the English coast in the autumn of 1665, 20,000 soldiers under Von Galen invaded the Republic's peripheral regions of Achterhoek, Twente, and Drenthe. The invasion represented a shift in the way the Anglo-Dutch Wars were fought. It was the first land campaign attempted during the wars, and the first large-scale offensive launched by a third party. The young Louis XIV, only recently crowned King of France, had resisted direct participation in the war. Still, the terms of a 1662 treaty technically obligated France to support the Republic in the face of English aggression. Now the invasion of troops under Von Galen, a Habsburg ally, raised the prospect of the Republic's imminent collapse and, in turn, Habsburg encirclement. Louis was compelled to act, and thereafter the threat or reality of French and German intervention would influence the rest of the wars. Fighting would expand beyond the narrow swath of the English Channel and North Sea where most naval battles were decided, although military campaigns within the borders of the Republic were still of relatively minor importance in the second war.

⁴³ "Nieuwsbericht uit Rotterdam, 30 Oct. 1665," in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 293. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 134. Ironically the dismal state of English finances also helped thwart De Witt's plans for a raid on the Thames, a version of a scheme that he had advocated since the First Anglo-Dutch War. De Witt intended for the Dutch fleet to draw the English armada from the Thames before sinking blockships in the river, but with English vessels unable to leave port his trap could not be sprung. Jones, *The Anglo-Dutch Wars*, 165.

Troops under the Bishop of Münster initially overran poorly prepared Dutch defences and even threatened the city of Groningen, but by October the invasion stalled in the face of torrential rains and severe storms. The unhardened roads that connected population centres in the peripheral territories of the Republic could not be used in the heavy rain. Multiple roads serviced every major transportation corridor, but the weather of late 1665 overwhelmed these redundancies. Dutch soldiers destroyed agricultural infrastructure in their retreat, and now starvation spread among the deluged invaders. Still, the Germans faced only ineffectual military opposition until the arrival of French troops in November. The French routed Münster's demoralized army, ultimately forcing Von Galen to sign a disadvantageous peace. In January, Louis XIV finally declared war on England.⁴⁴

High winds during storms affected seventeenth-century military campaigns on land and at sea, but the meteorological conditions that most influenced the possibilities open to an army were temperature and precipitation. The failure of Von Galen's offensive was a product of complex interactions between these meteorological conditions and the evolving military structures that have encouraged some historians to identify a contemporary "military revolution."⁴⁵ The increased importance of artillery during the Eighty Years' War in the late sixteenth century stimulated the extensive expansion of defensive fortifications and the widespread adoption of the star-shaped Italian bastion in the Low Countries.⁴⁶ New

⁴⁴ De Witt, "Aen de Heer Extr. Minister C. Van Beuningen, den 30 December 1665." In *Brieven, Geschreven ende gewisselt tusschen den Heer Johan de Witt, Raedt-Pensionaris, ende de Gevolmghigden van den Staedt der Vereenighde Nederlanden, so in Vranckryck, Engelandt, Sweden, Denemarcken, Poolen, enz: Beginnende met den jaere 1652 tot het jaer 1669 incluyt, Vol. II.* (The Hague: Hendrick Scheurleer, 1723), 136. Rommelse, *The Second Anglo-Dutch War*, 147. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 600. Adriaen van der Goes, "Hage, 17 December 1665," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 228.

⁴⁵ That military revolution likely extended to war at sea, but how, when, and to what extent, is still the subject of intense historiographical debate. For a good summary see: Glete, *Warfare at Sea*, 9-15.

⁴⁶ Hale, *War and Society in Renaissance Europe*, 47, 206. Parker, *The Army of Flanders*, 4. See also: Charles van den Heuvel, "De verspreiding van de Italiaanse vestingbouwkunde in de Nederlanden in de tweede helft van de

fortifications, designed to function in tandem with inundations in the Republic's easily flooded environments, encouraged costly sieges that frequently endured through the winter. Fluctuations in temperature during the year's coldest months could affect the number of soldiers who died through exposure, the resource consumption of defenders and attackers, the morale of armies frequently prone to mutiny, and the effectiveness of watery defences, with potentially decisive consequences for the fate of besieged citadels. Sustained rain could also stymie attempts to erect earthen fortifications, vital for both besiegers and besieged.⁴⁷

Meanwhile, the rising value of firearms helped spur a dramatic increase in contemporary army size, while the new emphasis on the drill and other forms of military discipline simultaneously increased the proportion of officers to common soldiers. In general, military campaigns grew more expensive, increasingly relying on new instruments of taxation and credit that partially drew from a resource base that was probably influenced by climatic fluctuations. Moreover, larger armies and their vast baggage trains, heavily burdened with weighty artillery, were sustained by raiding local resources and transported along frequently unhardened roads susceptible to torrential rainfall.⁴⁸ Ultimately, Von Galen's failure to claim the relatively prosperous city of Groningen before the arrival of French forces was likely influenced more by the impassable state of waterlogged roads than any action taken by the beleaguered Dutch defenders.

zestiende eeuw," in *Vesting: Vier eeuwen vestingbouw in Nederland*, ed. J. Snee, H. A. Treu and M. Tydeman. The Hague: Stichting Menno van Coehoorn, 1982.

⁴⁷ Parker, *The Army of Flanders*, 169. Parker, *The Dutch Revolt*, 164. J. Black, "Was There a Military Revolution in Early Modern Europe?" *History Today* 58:7 (July 2008): 34. Hale, *War and Society in Renaissance Europe*, 46. Pieter Christiaanszoon Bor, *Oorsprongk, begin, en vervolgh der Nederlandsche oorlogen, Vol. I* (Amsterdam: Joannes van Someren, Abraham Wolfgangh, Hendrick en Dirck Boom, 1679-1684), 423, 432. Duyck, Anthonis. *De slag bij Nieuwpoort: Journaal van de tocht naar Vlaanderen in 1600*. (Nijmegen: SUN, 2000), 80. While not as important as fluctuations in temperature and precipitation, changes in wind directions could also influence the effectiveness of military inundations. For example, the relief of the siege of Leiden in 1574 was long delayed by persistent Northeasterly winds, which slowed the advance of flooding waters and, in turn, the progress of a relieving rebel (Dutch) fleet. Bor, Pieter Christiaanszoon. *Oorsprongk, begin, en vervolgh der Nederlandsche oorlogen, Vol. I*, 557.

⁴⁸ John Landers, "The Destructiveness of Pre-Industrial Warfare," *Journal of Peace Research* (July 2005), 460.

Conclusion of the Second Anglo-Dutch War

In April 1666 the English and Dutch fleets began to assemble for another season of campaigning, but it was not until June that both were ready to leave port. As early as 15 February English agents reported that frigid weather was delaying the construction and repair of Dutch vessels, which they projected would hamper the union and sortie of the Republic's fleet in the spring. One source in Rotterdam conveyed that "this last frost has hindered them much in the building; their business begins to loocke as it did last year when they said that in April they wold be ready to goe to sea but found themselves much disappointed . . . by all appearance they wil be so late a coming to sea as they wer last yeare."⁴⁹ The winter of 1665-66 was no colder than the twentieth-century average, but the end of January and most of March was unusually cold and dry. Accordingly, it is possible that frigid weather conditions interfered with the Republic's extensive shipbuilding campaign, as they may have a year earlier.⁵⁰

The correspondence of the Van der Goes brothers suggests that severe storms may have also stalled the Dutch shipbuilding effort in a way that was recognized by contemporaries. In a letter to his brother on 8 December 1665, Adriaen van der Goes described a gale of unprecedented fury that blew for a day and was accompanied by a storm surge higher than had been seen before the town of Scheveningen for 80 years. The storm was the dramatic conclusion of several days of tempestuous weather throughout Northwestern Europe that devastated coastal towns, flooded polders, washed away dunes, destroyed dikes, stranded ships, and drowned animals and people across the Republic's maritime provinces. Lightning accompanied severe

⁴⁹ "Nieuwsbericht uit Rotterdam, 5 Febr. 1666," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 297.

⁵⁰ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 604.

snow and hail, igniting fires outside Haarlem that were fanned by high winds.⁵¹ Van der Goes described the damage in a missive written on 17 December, emphasizing that the loss of the polders in particular was a “major disaster” and a “severe financial reversal.” Van der Goes continued by writing that, “meanwhile much money will be required for the urgent equipping of 170 warships, including 60 new vessels.”⁵² Indeed on 4 June an English source reported how ships belonging to North Holland and Friesland – the provinces most affected by the December storm – had been delayed in joining the Republic’s fleet owing to a lack of money.⁵³ Financial distress exacerbated by the cost of repairs rendered necessary by the December gale had likely been compounded by major storms that continued to afflict the Republic between January and April, 1666.⁵⁴

Whether owing to severe storms, a series of unusually cold weeks, or both, the departure of the united Dutch fleet was probably hampered by weather typical of the Maunder Minimum. The storms that devastated the low-lying, coastal regions of the Republic blew from the Northwest, and were therefore less damaging to the English coast.⁵⁵ Nevertheless, stretches of cold weather were felt on both shores of the North Sea, and the state of English finances was even more precarious than that of the Dutch. If the weather of the Maunder Minimum was less

⁵¹ Adriaen van der Goes, “Hage, 17 December 1665,” in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. I*, 221. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 602.

⁵² “Dat verlies van polders en schade geeft hier een groote ellende, en verset de finantien seer, also men de luyden nu qualick soo can schatten, als men for desen wel gedaen heeft – Ondertusschen sal wel groot gelt van node syn tot d’equipage van 170 scheepen, daer onder t’sestich gans nieuwe, die alle met grooten erenst toegerust werden.” Adriaen van der Goes, “Hage, 17 December 1665,” in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. I*, 229.

⁵³ “Nieuwsbericht uit Haarlem, 4 Juni 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 313.

⁵⁴ For example, on 5 February van der Goes described the Northwesterly storm of the previous day, which stimulated a storm surge that would “undoubtedly inflict even more damage on the rivers” – although at least the ice had melted (“gister heeft het heel hardt gewaeyt en stormt het noch uyt den noordtwesten, soodat de zee heel hooch staet; sal ontwyffelijck op de rivieren al weer schade vallen, doch het ys is wech”). Adriaen van der Goes, “Hage, den 5 February 1666,” in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. I*, 245.

⁵⁵ Storms blowing from all directions can, of course, be included under the umbrella of weather rendered more frequent and more severe during the Maunder Minimum.

destructive in England during the winter of 1665/66 than it was in the Republic, it also coincided with the worst wave of plague to scour the island since the Black Death. Doubtless environmental and probably climatic influences also helped delay the departure of the united English fleet in the spring of 1666.⁵⁶

As the English armada finally prepared to sortie in May the overriding concern among its leadership was preventing a union of the Dutch fleet with squadrons belonging to a now openly hostile France. Both the English and Dutch were aware that a French fleet had departed Toulon, a French port on the Mediterranean coast, in late April. Prince Rupert, recently appointed with George Monck as co-commander of the English fleet, later claimed to have received intelligence that French vessels were approaching the English Channel.⁵⁷ Much to Monck's surprise and distress, on 8 June Rupert departed with 20 choice men-of-war and four fireships in an effort to intercept the French fleet before it could unite with its Dutch counterpart. Monck was left to command the bulk of the English armada. Just before Rupert left port Monck wrote a missive begging for more ships, and revealed that he had received reports informing him that the "the Holland fleet will suddainly be out."⁵⁸ His intelligence was dated, because all outgoing correspondence from the Republic had been halted when the Dutch fleet left port.⁵⁹ Moreover, he had failed to ensure that English galjoots retained position off the Dutch coast, although it is possible that the boats were driven away by persistent easterly winds.⁶⁰ The Dutch fleet had actually been ready to sortie since 31 May, and despite being briefly thwarted by westerly winds

⁵⁶ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 604.

⁵⁷ "Van Ruyven aan Williamson, 20 Mei 1666," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 310. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 139.

⁵⁸ "Albemarle aan Arlington, 7 Juni 1666," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 317.

⁵⁹ "Notes upon the June Fight, 1666," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 340.

⁶⁰ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 139.

it left port soon after, as the wind shifted to blow from the Northeast. It united with late squadrons from Friesland and North Holland, and then used the prevailing easterly winds to rapidly cross the Channel. At last alerted to the impending threat, Monck sent urgent letters to Rupert, who had assumed that any easterly wind that would bring the Dutch to the English coast would simultaneously allow him to return to the English fleet. However, he had apparently forgotten that he could not be notified of the incoming Dutch armada before a ketch found him in contrary winds.⁶¹

On the morning of 11 June the English warship *Bristol* sighted the Dutch fleet anchored in the narrow sea off the coast of Flanders, riding out a strong wind that, according to most sources, had shifted to blow from the Southwest with such velocity that it toppled the masts of a great ship commanded by the Republic's vice-admiral.⁶² The vessel's subsequent return to port

⁶¹ “The Narratives of the Duke of Albemarle and Prince Rupert, of the miscariadges of the late dutch war, 1667,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 602. “Nieuwsbericht uit Haarlem, 31 Mei 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 312. The subsequent report written by the same author on 4 June describes how the departure of the fleet was considered too soon by many, but the opportunity presented by Northeasterly winds could not be ignored (“Gelyck ick laetmael hebbe geadviseert is onse vloot hoewel tegens de opinie van veele op Dinsdag latest uytgelopen; men heeft die gelegentheyt niet willem versuymen ommedat de wint Noort Oost was”). “Nieuwsbericht uit Haarlem, 4 Juni 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 313.

⁶² The official Dutch account, written after the battle, listed easterly winds on 11 June, and a lucid recollection by Danish captain Hans Svendsen revealed that the Dutch did not initially believe that the English could close in contrary winds. Nonetheless, the official English account, in addition to many other descriptions written by both English and Dutch naval officials, reported winds from the South-southwest or, more commonly, the Southwest. More telling is the reality that Monck's decision to attack would have been even more rash – and indeed, probably impossible, despite Svendsen's account – had the wind blown from the East. Hence, I have used the opinion of the majority to reconstruct Southwesterly winds for the first day of the Four Days' Battle in this description and the graph of wind directions in the previous chapter. R. C. Anderson, “Introduction,” in *The Journal of Sir Thomas Allin, Vol. II, 1667-1678*, ed. R. C. Anderson. (London: Navy Records Society, 1939), xxiv. Hans Svendsen, “Hans Svendsen's Journal, 10-30 Juni 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 363. Both De Ruyter and Thomas Newcomb claimed that the battle begun roughly 6 leagues from the North Foreland, yet other sources suggest that the Dutch were anchored off the coast of Flanders. The confusion is understandable given the narrowness of the sea in that region. “AN ACCOUNT OF THE BATTLE between the English and Dutch Fleets, on the 11th, 12th and 14th days of June 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 334. Thomas Newcomb, “A True Narrative of the Engagement between His Majesties Fleet and that of Holland . . .”, in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum, 19. Michiel Adriaanszoon de Ruyter, “Journal kept by de Ruyter,” in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum, 24.

still left the Dutch with at least 80 large warships to 54 English vessels. Facing such odds, Monck called a council of war to debate the merits of attack or retreat. “The Generall had the wind,” an English source recounted, “and it was at his choice to fight, or saile to the Swin where he before intended; he might compell the enemy to fight, but they could not compell him.” Most of the flag officers gathered at the council of war urged Monck to avoid battle, with the most vocal advising “that the Dutch in probability had all their fleet together and wee had newly parted with so considerable a Squadron of ours, and if his Grace would fight, yet it would be convenient to defer it a little, the wind at that time blowing so hard a gale that wee could not bear out our lower tire of gunns.”⁶³

Monck dismissed the recommendations of his officers and ordered his captains to prepare for an attack, evidently undaunted either by the disparity in numbers or a wind that facilitated aggression but also exacerbated the English disadvantage. After the ensuing battle, Monck’s bizarre decision unleashed a hail of criticism, and it has stimulated much historiographical speculation. Historians like R.C. Anderson have suggested that Monck’s inexperience at sea led him to underestimate how rough winds hampered English naval technology. Still, earlier in the day Monck himself had declared that, “I do not think we shall engage today” on account of the wind.⁶⁴ Hence, the majority of scholars and contemporaries argued that Monck gravely underestimated the Dutch at a time when the Republic’s shipbuilding program had finally produced great ships that could match any fielded by the English.⁶⁵ An English review of mistakes made before and during the battle concluded that, “if the General could think still so

⁶³ “AN ACCOUNT OF THE BATTELL’ between the English and Dutch Fleets, on the 11th, 12th and 14th days of June 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 334.

⁶⁴ Anderson, “Introduction,” xxiv.

⁶⁵ The Republic’s fleet was crewed by 21,000 seamen, and fielded 4,500 guns. De Witt declared that fully 30 warships were more powerful than any Dutch vessel that had sailed the year before. Among these was the 80-gun *De Zeven Provinciën* (“The Seven Provinces”), De Ruyter’s flagship. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 138.

contemptibly of the Dutch, that might be his reason for his hasty fighting . . . nobody can imagine why he would fight them when none of his own captains thought of it a few hours before, and were not ready for it, and in so stiff a gale that he could not bear out with his lower tier of guns.”⁶⁶ In fact, four days earlier Monck had insisted that he required urgent reinforcement to expand his fleet to “70 sayle” in order to fight the Republic’s armada, and he had opposed the division of the English fleet in the face of Dutch numbers.⁶⁷

In a later defence of his decision to attack, Monck argued that his ships, many slowed by barnacles, could not have reached safety before a Dutch attack, and described how he had feared entrapment within the Thames.⁶⁸ Still, Monck’s order to commence one of the bloodiest and longest battles of the age of sail in unfavourable weather with an outnumbered fleet echoes Van Wassenaer’s reluctance to engage in beneficial winds prior to the Battle of Lowestoft. Both decisions were opposed by subordinate officers and widely derided across a diverse spectrum of each society. Both exacerbated the environmental weaknesses yielded by the tactics and technologies incorporated within each naval system, and both were taken in conditions typical of the Maunder Minimum in the North Sea. Monck’s decision, like that of Van Wassenaer, also demonstrated that the unpredictability of personal agency - particularly elite agency in the extreme hierarchy of naval command structures - complicates any attempt to unravel how weather patterns that accompany climatic trends encourage or discourage military operations. Military elites need not guide their subordinates along the paths rendered most easily traversable by environmental structures, and any attempt to link climatic developments to decision making in times of war must account for the frequent irrationality of human psychology.

⁶⁶ “Notes upon the June Fight, 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 341.

⁶⁷ George Monck, “Albemarle aan Arlington, 7 Juni 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 317.

⁶⁸ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 139.



Fig. 5.1. A Dutch painting of the Four Days' Battle, depicting high waves and high winds. The artist, Willem van de Velde the Elder, travelled with the fleet. Hellinga, *Zeehelden van de Gouden Eeuw*, 90.



Fig. 5.2. An English synthesis of major events during the engagement that incorporates the rough seas of the battle's first day. Abraham Storck, "The 'Royal Prince' and other Vessels at the Four Days Battle, 1-4 June 1666," painting, 1667, National Maritime Museum, <http://collections.rmg.co.uk/collections/objects/11778.html>.

Following Monck's order to engage the English squadrons sailed towards the Republic's fleet, with the speed of the English assault in such high winds (Figures 5.1 and 5.2) forcing many Dutch crews to cut cables and abandon their anchors. However the headlong charge allowed the Dutch, fighting in line formation for the first time, to concentrate fire on the leading English ships, and several were disabled or taken.⁶⁹ That tactical blunder was compounded when the

⁶⁹ A detailed English account of the battle describes how, "Sir William Berkley, vice admirall of the white, led the van, and venturing in too far among the enemy, lost his life, and his ship was taken, and two fourth rates that seconded him, the *Seven Oaks* and *Loyall George*." However, de Ruyter does not mention seizing any English prizes during the initial attack, and it is more likely that these vessels were disabled rather than captured. Michiel Adriaanszoon de Ruyter, "Journal kept by de Ruyter," in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum, 24. "AN ACCOUNT OF THE BATTELL' between the English and Dutch Fleets, on the 11th, 12th and 14th days of June 1666," in *Bescheiden uit Vreemde Archieven*

faster vessels around Monck's flagship were separated from their slower counterparts, undermining the force of the initial assault and allowing the Dutch to manoeuvre for the weather gage. Squadrons under De Ruyter and Cornelis Tromp, Maarten's son, surrounded Monck's division as the English struggled to avoid the coast of Flanders. Three English ships were lost to the Dutch before the coming of darkness.⁷⁰

At first light the battle resumed, with the English fielding at most 45 ships while the Dutch retained 80. Although the wind had shifted to blow from the east the English claimed the weather gage owing to the position of the fleets, and for most of the day the English and Dutch squadrons passed one another in line formation.⁷¹ Both fleets sustained minimal damage until Tromp broke the Dutch line and tacked to windward, pressing into the English lines and isolating his squadron from the other Dutch divisions. De Ruyter ordered the rest of the Dutch fleet to cut through the English divisions, and rescue Tromp's squadron. With the Dutch fleet reunited the English were left with 28 heavily damaged vessels, to the 66 that remained for the Dutch. Monck now ordered his remaining ships to turn west for a final pass in line formation. Conflicting accounts complicate any attempt to reconstruct the English retreat, but it appears that Monck called a council of war as the Dutch sailed past his line towards the east. This time Monck listened to his subordinates, opting to retreat while the Dutch, tacking for another pass, were roughly five kilometres distant. The wind, a fresh breeze from the west-southwest at 15 knots,

omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I, ed. Colenbrander, 334. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 142.

⁷⁰ Cornelis Tromp would later succeed De Ruyter as commander of the Dutch fleet. Dutch naval hierarchy was increasingly dominated by the heirs of notable admirals over the course of the Anglo-Dutch Wars and beyond.

⁷¹ An English account provided an especially vivid description of fighting in line formation: "the manner of fighting at that time was, that each fleet lay in a line, and when the ships of one fleet lay with their heads to the northward, the heads of the other lay to the southward, the headmost ships of our fleet engaging first the headmost of theirs: so passing on by their fleet in a line, firing all the way, and as soon as the rear of one fleet was clear from the rear of the other, then each fleet tacked in the van, standing almost stem for stem one with another to engage again; by which means there was at least an hour's respite between every encounter." "AN ACCOUNT OF THE BATTLE between the English and Dutch Fleets, on the 11th, 12th and 14th days of June 1666," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 335.

likely hampered the initial Dutch pursuit, allowing Monck to assemble a rear guard of perhaps 15 surviving great ships.⁷² These in turn thwarted attempts by captains and crews of the lighter, faster Dutch vessels to raid among the English fleet. In the night the wind shifted again to blow from the northeast, but in conditions of near calm neither the English survivors nor their Dutch pursuers made much progress.⁷³

The Dutch continued the chase into the morning of 13 June, growing closer but remaining out of reach until Rupert's squadron finally sailed into view at 4:00 PM. The attempted reunion of the English fleet took a disastrous turn when the *Royal Charles*, *Royal Katherine*, and *Royal Prince* were grounded on the Galloper Shoal. Although the other vessels escaped, the 94-gun *Royal Prince* was stuck, as the easterly wind and the force of the tide pressed the rest of the fleet away from the great ship, and away from the oncoming Dutch. Carried closer by the wind, the Republic's fleet soon surrounded the stricken *Royal Prince*, which was burned to prevent its retrieval by the English (Figure 5.3).⁷⁴ De Ruyter then ordered a squadron of light vessels to goad Rupert into the shoal, yet Monck dispatched a swift ketch to

⁷² Herrera et al., *CLIWOC Multilingual Meteorological Dictionary*, 44. Newcomb, "A True Narrative of the Engagement between His Majesties Fleet and that of Holland," 19.

⁷³ Thomas Newcomb described how, after the final pass on 12 June, "many of our ships being much disabled in their masts, sayles and rigging . . . stood for England without acquainting [Monck], who seeing that thought good likewise to hold our wind and make the best of our way home." That account conflicts other English sources, and considering the good order of the English retreat it was likely given for political reasons. "A True Narrative of the engagement between his Majesty's fleet and that of Holland, begun June 11th 1666 at 2 a clocke afternoone and continuing till the 14th at 10 a clocke at night," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 346. Meanwhile, Hainsworth and Churches argue that the English retreated on the third day of the battle – 13 June – but this claim is contradicted by every surviving Dutch or English primary source, all of which reveal that the English fled on the afternoon of 12 June. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 145.

⁷⁴ De Ruyter described the decision to burn the *Royal Prince*: "at four in the afternoon the Admiral of the White squadron [in the ROYAL PRINCE] ran aground on the Galloper, and was taken by Admiral Tromp and Rear-Admiral Isaac Sweers: he surrendered because he feared that they would use fireships against him. Then we sighted an English squadron of 24 fresh ships coming to succour their fellows, who later that evening, joined the flag of English. Thus they reached a strength of 61 or 62 ships, while we had 64. Then I decided I had to burn the ship of the Lord Admiral of English . . . we took the men off and burnt the flagship, as we feared that it might perhaps be retaken from us, and were now facing a strong enemy." De Ruyter, "Journal kept by de Ruyter," 24.

warn Rupert of the danger. As night fell the Dutch made for their coast, and the English fleet was united at last, if considerably diminished by the loss of the *Prince*.



Fig. 5.3. The surrender of the *Royal Prince*. The direction of the wind is clearly illustrated in this painting by Willem van de Velde the Elder. An easterly blows the English – and plumes of smoke – in the direction of England to the right, as the marauding Dutch sail in from the left. Willem van de Velde the Younger, “The Capture of the Royal Prince,” painting, 1666, Rijksmuseum Amsterdam, <http://goo.gl/xeYBrs>.

On the fourth day of the battle, the English pursued the Dutch with a fleet that was now of equal strength. Although winds blew from the south-southwest, the Republic's fleet had the weather gage as the battle resumed. After five passes the Dutch line began to disintegrate, with most of the Dutch ships trapped between squadrons commanded by Monck and Rupert.

However, just as Rupert's flagship crashed through the Dutch formations its masts and rigging collapsed, victims of Dutch gunners who still avoided hulls to target rigging. By 5:00 PM the Dutch, now benefitting from a shift in wind to the South-southeast, divided and then routed the English fleet. The Dutch pursuit was again thwarted, this time not by wind but by a heavy fog and De Ruyter's belief that his battered fleet could not sustain much more fighting.⁷⁵

Nevertheless, the Dutch armada returned victorious after the bloodiest battle of the war.

Although English sources conceded that ten English vessels were lost, including the gigantic *Royal Prince*, Dutch and Danish sources alleged that perhaps 36 English ships had been taken or destroyed. The Dutch, meanwhile, lost between four and eight ships.⁷⁶

The Four Days' Battle, as it came to be known in both English and Dutch, played a critical role in exhausting English finances in the Second Anglo-Dutch War. It was powerfully influenced by a complex pattern of weather events that was likely affected, in part, by the

⁷⁵ De Ruyter wrote that, "so many ships were heavily damaged, especially in their rigging and many had run short of powder, so that finally I decided to break off the engagement and confide the safety of the Fleet to the hazards of the sea." De Ruyter, "Journal kept by de Ruyter," 25.

⁷⁶ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 148. Jones, *The Anglo-Dutch Wars*, 170. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 607. "The Narratives of the Duke of Albermarle and Prince Rupert," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 602. "A True Narrative of the engagement between his Majesty's fleet and that of Holland, begun June 11th 1666 at 2 a clocke afternoone and continuing till the 14th at 10 a clocke at night," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 348. Hans Svendsen, "Hans Svendsen's Journal, 10-30 Juni 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 363. "Loose Reports, 11-15 Juni 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 350. "AN ACCOUNT OF THE BATTLE' between the English and Dutch Fleets, on the 11th, 12th and 14th days of June 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 337. "Notes upon the June Fight, 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 342. "Thomas Langley aan Williamson, 14 Juni 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 344.

deepening Maunder Minimum. Severe storms, along with a series of unusually cold weeks, probably helped delay English and Dutch shipbuilding and, consequently, the preparations for departure, until faulty intelligence convinced Rupert that the French would soon unite with their Dutch allies. Although storms and cold spells were more common during the Maunder Minimum in the North Sea region, it was a westerly wind rendered less frequent that momentarily thwarted the sortie of the Dutch fleet until it was impossible for the English to be alerted before Rupert's departure. Westerly winds could, of course, occur under any climatic regime, and because their influence must be attributed to the regular variations of weather they reveal how natural structures like a changed climatic regime cannot fully explain all possible connections between a fickle atmospheric environment and human activity.

Still, after a brief spell of westerlies a persistent easterly that would have been unusual in June during a warmer climate aided the Dutch fleet in crossing the Channel to intercept Monck, just as Monck's remaining vessels were en route from the Thames to the Swin, where they could not have been trapped by the Dutch. Monck's ketch to Rupert was forced to struggle against contrary winds, ensuring that Monck and his subordinates would face the Dutch alone. Monck's letters and subsequent actions suggest that he genuinely believed that his fleet could not escape the Republic's armada. Accordingly, he dismissed the advice of his officers by attacking with the element of surprise, even if his ships were hampered by high winds rendered more common during the Maunder Minimum. After the battle was joined an English retreat was probably inevitable in the face of Dutch advantages in numbers, seamanship, leadership, and meteorological conditions. However, the arrival of Rupert's fresh squadron evened the odds. Because the fleets were now equally matched, the easterly that thwarted English attempts to aid the *Royal Prince*, a first-rate, was invaluable for the Dutch.

Conversely, the thick fog that frustrated De Ruyter's pursuit on the final day of the battle contributed to, but did not directly cause, the survival of the English fleet. Unlike the spring of 1665, the summer of 1666 was unusually hot, a statistical outlier in the general trend of cool summers that characterized the Maunder Minimum. Still, water absorbs and loses heat more slowly than air. Heavy fog may have been stimulated by interactions between unusually hot air brought north by the southwesterly wind, and water previously chilled by the cool temperatures that normally accompanied a colder climate. Nevertheless, climate reconstructions cannot yet link changes in the frequency of North Sea fog during the Little Ice Age to shifts in the temperature gradient between hydrosphere and atmosphere.⁷⁷

The many missives and ship logbooks written before, during, and after the Four Days' Battle enable an unusually comprehensive reconstruction of how weather rendered more frequent or more severe during the Maunder Minimum generally benefitted the Dutch naval system while disadvantaging that of the English. Two months later, weather typical of Little Ice Age minima again hampered English attempts to defeat the Dutch at sea. On 30 July the English fleet, reassembled and reinforced at great expense, had to depart the Thames in a single group or be destroyed piecemeal by the blockading Dutch. For two days English crews waited for a sufficiently westerly wind to help them enter the Gunfleet, in a month during which westerlies had been ubiquitous during the First Anglo-Dutch War. On 31 July Sir Thomas Clifford lamented that "it is not to be expressed how impatient our Generalls are, for besides their edge to be at it they consider the Dutch doe even grow, and we have all our force, and our men are in better heart now then probably they will be after two or three nights without their hammocks, for every ship is already a cleare ship." Finally, on 1 August a westerly allowed the English to

⁷⁷ Van Engelen, Buisman, and Ijnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112.

stand for sea, but easterlies returned the following day. That night a storm damaged the fleet, and the *Jersey* was disabled by a lightning strike.⁷⁸

On 3 August the Dutch and English fleets engaged in a tacking duel to claim the Northeasterly wind, with the Dutch ultimately prevailing. Several English ships had suffered damage in attempting to match the Dutch, while many more were scattered before a lee shore. The English sailors were therefore relieved when De Ruyter decided that the coast was too close for an attack with the weather gage.⁷⁹ On the morning of 4 August the wind continued to blow from the Northeast before shifting to the Northwest. The English appear to have seized the weather gage and attacked while the wind held. De Ruyter ordered his squadrons into a crescent formation, hoping that one of its horns could regain the weather gage.⁸⁰ Both fleets engaged in

⁷⁸ “Nieuwsbericht, 23 Juli 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 400. “James Hayes aan Williamson, 30 Juli 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 412. “Sir Thomas Clifford aan Lord Arlington, 30 Juli 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 412. “Sir Thomas Clifford aan Lord Arlington, 31 Juli 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 414.

⁷⁹ Clifford believed that the Dutch could have defeated the English fleet by taking advantage of the easterly wind and the disorder of the English: “if they had not been afraid to engage soe neer our sands, they might have taken great advantages upon us, for wee were not only disordered and out of our line, but very much separated and scattered from one another by soe much endeavouring to get ahead; and in this striving, some of our ships received prejudice, the *Rainbow* lost her maine topmast and the *Happy Returne* by intanghing with another ship had her maine saile torne in the middle, and the Dutch might have been upon us, if they had had mettle in an houre, and at 9 ussure your Lordshipp our affaires looked with a scurvy face, but the enemy tackt and stood from us.” “Clifford aan Arlington, 2-7 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 428. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 150.

⁸⁰ There is much confusion regarding the beginning of the engagement. Although Hainsworth and Churches describe a “wind strong from the North,” English and Dutch primary sources mention how the wind initially blew from the Northeast or, at most, the North-northeast. Hans Svendsen claimed that the wind shifted at some point in the morning to favour the English, who prevailed in a tacking duel before attacking at noon. On the other hand, Clifford does not mention a change of wind and suggests that the Dutch attacked. A Dutch missive sent from Jacob Quack to Johan de Witt on 5 August supports that claim, although Quack described a change in winds to the Northwest after the Dutch attacked. A more detailed English narrative of the battle describes the shift in winds to the Northwest at 6:00 AM, and reports that the English attack was launched thereafter. The description given above fits the more expansive English accounts, which would certainly have included a report of a tacking contest had the English been victorious. It should be noted, however, that with Northeasterly winds the Dutch may have begun to attack the English at first light before finding themselves stripped of the weather gage, whereupon de Ruyter ordered his fleet into a defensive crescent formation. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 152. “Clifford aan Arlington, 2-7 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 428. “Hans Svendsen’s journal, 30 Juli-13 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 425. “Mr. Pierse Chyrurgeon Generall’s description of the late fight, Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte*

the line of battle, but before long the wind yielded to a complete calm. Hans Svendsen described how the opposing warships, virtually immobilized, bombarded one another “as castle to castle,” a “murderous business” that was “tragic to behold.”⁸¹

The still wind allowed the English to open all their gun tiers, and although the Anglo-Dutch fleets both fielded 88 ships the English slightly outgunned their counterparts. Owing to the calm, the three Dutch squadrons were each isolated against the three English divisions, and when Dutch vice admiral Jan Evertson died in the afternoon the ships under his command gave way. De Ruyter fired a gun to recall them, but the low wind prohibited any attempt to turn. The same calm prohibited Tromp’s squadron from reinforcing De Ruyter’s vessels, which were forced to engage two English squadrons alone. De Ruyter’s line began to give way by 4:00 PM, even as Tromp’s division badly defeated its English counterpart. During their ensuing retreat, De Ruyter and the crew of *De Zeven Provinciën* exploited a rising northeasterly to save several maimed Dutch ships. On at least one occasion, for example, they furled their sails while dropping anchor as English vessels, carried by the wind, harmlessly swept past. On 5 August the wind shifted to blow lightly from the Southwest, gently pushing the De Ruyter’s squadron across the nearby shoals and back to safety while slowing the pursuing English.

Tromp’s ships remained at sea, still engaged with the English Blue squadron. At midnight, Rupert and Monck, both aboard the *Royal Charles*, positioned the English flagship between the presumed location of Tromp’s division and the Dutch coast. However, their

Nederlandsche Zeeoorlogen, Vol. I, ed. Colenbrander, 422. “Commissaris Jacob Quack aan Johan de Witt, 5 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 427. “Narrative of the Engagement, 4-5 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 419.

⁸¹ Svendsen’s journal, never lacking in lucid detail, reports how the opposing mariners “drilled each other into the ground:” “en toen de Engelsche vloot op de Hollandsche afkwam, schip voor schip elk op zijn plaats, bleef het heel stil, zoodat men de zeilen innam en bleef liggen en op elkander schoot als van kasteel tot kasteel, zoodat het geen zeeslag leek maar moodenaarswerk, tot men elkander in den grond boorde dat het een jammer was om aan te zien.” “Hans Svendsen’s journal, 30 Juli-13 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 425.

accompanying men-of-war failed to weigh anchor, and the trap was foiled. The breeze turned again to blow from the east as Tromp's ships loomed over the horizon, struggling against the wind but unaccompanied by Blue Squadron. The *Royal Charles* was isolated and vulnerable, yet the Dutch crews declined to engage and instead sailed past to safety. Ultimately the Republic lost just two ships and the English only one, but with over 4,000 Dutch seamen killed the battle was a significant reversal in fortunes after the Four Days' Battle. For a Republic already low on manpower, the St. James' Day Fight or *Tweedaagse Zeeslag* ("Two Days' Sea Battle) may have been the bloodiest engagement of the wars.⁸²

The unstable weather that characterized the final days of July and the first week of August, 1666, complicates any attempt to isolate the influence of climate during the St. James' Day Fight. On the one hand, the English may have won far more decisively without insufficiently westerly winds contributing to their delay in leaving the Thames, and the damage inflicted by a subsequent storm. Easterlies, unusual in July or August during a warmer climatic regime, further disadvantaged the English fleet when the Dutch prevailed in a tacking battle on 3 August. As in the battle of Lowestoft, an easterly contributed to a tactical situation that strongly benefitted the Dutch, and De Ruyter's decision not to attack is curious considering his willingness to exploit the shallower draught of his vessels in subsequent engagements. Again as at Lowestoft, a sudden shift in wind direction left the Dutch to leeward on the first day of battle. In response, De Ruyter ordered his fleet to adopt a crescent formation, which was originally imagined by Jan de Witt and later described in English missives. Dutch commanders were

⁸² Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 154. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 607. "Hans Svendsen's journal, 30 Juli-13 Aug. 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 425. "Clifford aan Arlington, 2-7 Aug. 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 428. "Narrative of the Engagement, 4-5 Aug. 1666," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 419. Allin, *The Journal of Sir Thomas Allin*, Vol. I, 277.

prepared to adapt to rapid changes in wind direction, even if the character of those changes on 4 August was somewhat less likely in a generally colder climatic regime.

Still, such adaptation could only go so far, and the ploy failed when the brief westerly yielded to absolute calm. It is possible that extremes in wind as expressed in both gales and calms grew more common in the colder climate of the late seventeenth century, but such climate reconstructions have not yet been developed.⁸³ Hence the weather condition that most influenced the unique character of the St. James' Day Fight cannot yet be linked to the climatic regime of the Maunder Minimum. After the engagement a westerly wind benefitted the retreat of De Ruyter's squadron while, in an apparent paradox, a contrary easterly facilitated Tromp's escape in the same region on the next day. In both cases the characteristics of the English pursuit mediated the influence of the wind. With the English in close proximity but out of firing range the westerly of 5 August soon pushed the Republic's battered fleet over what were impassable shoals for the English, and reduced its time at sea.⁸⁴ Meanwhile Tromp's squadron struggled against contrary winds with the English regrouping in the distance. The persistent easterly and the growing remoteness of the Dutch fleet ensured that the English pursuit, when it finally began, was instantly doomed to futility. Ultimately, the St. James' Day Fight and its aftermath were influenced by a complex pattern of weather events, some strongly associated with the Maunder Minimum, others atypical of the new climatic regime. The meteorological conditions rendered more frequent by the cooler climate benefitted the Dutch before and after the engagement, while those more common in a warmer climate granted a critical advantage to the English during the battle itself.

⁸³ Wheeler, "British Naval Logbooks from the Late Seventeenth Century," 141.

⁸⁴ See the discussion in the previous chapter on relationships between naval retreat, wind direction, and wind velocity.

After the Dutch squadrons had retreated to safety, the seaworthy remnants of the English fleet struggled north against a contrary northeasterly. From the southerly shores of Zeeland the fleet sailed past the more northerly coast of Holland, the economic heart of the Republic. By the time the English finally reached a position off the entrance to the Zuider Zee, nearby Dutch merchant vessels had already escaped past the shoals that enveloped the Low Countries. It seemed that the wind had foiled English designs to leverage their victory and capture Dutch prizes. However, as the English fleet lingered offshore a Dutch traitor revealed that the northerly islands of Vlieland and Terschelling (Map 5.1), which contained storehouses for the Republic's fleet and the VOC, were poorly guarded and relatively unshielded by shoals. On 19 August Monck and Rupert dispatched a squadron of light ships under Robert Holmes. Leader of the African raid that had helped ignite the war, Holmes was ordered to oversee a daring attack on the Dutch islands. The English had now sailed in easterly winds for 13 straight days.⁸⁵

English scouts soon uncovered a richly laden fleet of perhaps 170 recently arrived merchant vessels anchored between the islands, guarded by just two men-of-war. Holmes promptly ordered his fireships to ignite the fleet, and burned all but nine vessels. Two English frigates were grounded with the coming of darkness, and Holmes intended to free them before raiding Vlieland in the morning. However, that night a severe rainstorm soaked English ammunition and damaged the squadron's artillery, while the southerly wind pushed the ships away from the Vlie.⁸⁶ Consequently, when the weather moderated in the morning of 20 August

⁸⁵ Allin, *The Journal of Sir Thomas Allin, Vol. I*, 281.

⁸⁶ The author of "A true and perfect narrative" – an English account – describe how on the night of 19 August Holmes's design on Vlieland was, "prevented, for so great a Gust and Rain hapned that night, that the arms and ammunition in the Boats, Hoys and Ketches haveing received much damage, he thought it best to weigh, and as the wind stood, to attempt something upon the Island of Schelling, which the morning proveing moderate weather, he according prosecuted." "A true and perfect narrative of the great and signal success of a part of his Majesties fleet under his Higness Prince Rupert, and his Grace the Duke of Albemarle, burning 160 Dutch ships within the Vlie, as also the Town of Brandaris upon the Island of Schelling, by some commanded men under the conduct of Sir Robert

Holmes and the remnant of his squadron attacked the less defended island of Terschelling. They razed the town of Brandaris before rejoining the rest of the English fleet.⁸⁷



Map 5.1. The islands of Vlieland (left) and Terschelling (right) on a detail of a seventeenth-century map of the Dutch Republic. The shoals that defended entrance into the Zuider Zee (shaded areas) are clearly visible. Jansonius, 1658.

Holmes, the 19 and 20 of this instant August 1666. Published by especial command,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 464.

⁸⁷ “Nieuwsbericht uit Haarlem, 20 Aug. 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. I, ed. Colenbrander, 469. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 155. “Rupert and Albermarle to the King, 10 August 1666,” in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum, 34.

Holmes's Bonfire, as it was subsequently known, was a catastrophe for the Republic that, when added to the casualties suffered during the St. James' Day Fight, helped extend the war into 1667.⁸⁸ It would not have been possible without a relentless stretch of easterly winds, which hampered the English blockade and contributed to the concentration of Dutch merchant vessels just inside the Zuider Zee. Clearly, conditions typical of Little Ice Age minima did not always benefit the Republic's war effort, even when they appeared to undermine English naval operations. On the other hand, the disastrous conclusion of the war's penultimate year for the English was also influenced by weather that was more common during the Maunder Minimum.

By 5 September the Dutch fleet was again at sea, amid reports that its French counterpart was now as close as the Bay of Biscay. As the Dutch armada sailed south the English fleet struggled to intercept, for its commanders still hoped to prevent a union of the allied fleets. On 10 September the English spotted the Dutch fleet, but in a persistent easterly wind several English great ships, including the flagship *Royal Charles*, were grounded on the Galloper sands. The *Royal Charles* had been trapped on the same shoal during the Four Days' Battle, and the consequences again hindered the English. As the easterly winds grew more intense on the next morning, De Ruyter ordered the Dutch fleet to hug the coast rather than attack, and the English ships were eventually freed without interference. The English commanders finally attempted to engage at noon, but they managed only a fleeting long-range exchange of cannon fire, and their fireships were scattered by the wind. That afternoon the wind climaxed into a ferocious gale that drove the English back into the deep water while the Dutch sheltered near the shore. Thomas Allin reported that "the *York* lost his mainmast about 5 o'clock and bore away, the *West Friesland* [a prize] after him. The *Plymouth's* two topsails flew away together and Sir Tho Teddeman's fore

⁸⁸ Thomas Allin concluded that "so great a loss the Dutch never had." Allin, *The Journal of Sir Thomas Allin, Vol. I*, 282.

topsail. Two their foresail and several others their topsails, all in half an hour. I never saw the like. We split two fore topsails that day, part of our main topsail, our mizzen.” The scattered remnants of the English fleet sailed for St. Helens at first light on 12 September, and when they arrived at sunset Allin’s squadron missed nearly ten ships.⁸⁹

After recording a northeasterly on the morning of the following day, Allin recounted that he his fellow officers had “heard . . . of a great fire begun in London.” A day earlier Pepys had climbed atop the Tower of London to survey the inferno, which had just erupted nearby at the King’s baker around the eastern edge of the city. In his diary Pepys vividly described how the flames incinerated people, animals, and property, with “the wind mighty high and driving [the fire] into the city.” The blaze might have been localized but for the same intense and persistent easterly winds that had damaged the English fleet and thwarted its attempts to engage the Dutch at sea. Owing to the geography of London and the location of the bakery enabled the easterly to drive the fire deep into the city along the shores of the Thames (Map 5.2). That night Pepys took to his boat, writing that the fire was “still encreasing, and the wind great. So near the fire as we could for smoke; and all over the Thames, with one’s face in the wind, you were almost burned with a shower of firedrops.” These embers, lofted and scattered by the easterly, accelerated the spread of the blaze by kindling many houses at a time. John Evelyn wrote that the fire ultimately resembled a “hideous storm,” with the flames thundering and the sky “like the top of a burning Oven.”⁹⁰

⁸⁹ Allin, *The Journal of Sir Thomas Allin, Vol. I*, 287. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 156.

⁹⁰ Thomas Allin, *The Journal of Sir Thomas Allin, Vol. I, 1660-1666*, 287. Samuel Pepys, “Sunday 2 September 1666,” *Diary of Sir Samuel Pepys*. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 608.



Map. 5.2. The origin of the Fire of London at a bakery in Pudding Lane, on a map printed just months before the inferno. A powerful easterly exposed most of the city to the flames. Wenceslaus Hollar, “Plan of London before the fire,” map, 1665, Thomas Fisher Rare Book Library, University of Toronto, <http://goo.gl/cqv2U>.

Although the rubble continued smoldering into March, The Fire of London was largely extinguished by 16 September, after more than 13,000 houses had been destroyed across 400 acres. Coupled with the damage inflicted upon the English fleet, the financial toll of the fire crippled the English war effort. Certainly these calamities were stimulated or greatly exacerbated by stormy, easterly winds typical of the Maunder Minimum. However, London was also rendered more vulnerable to a fire by the dry conditions of the previous summer. Changes in temperature and precipitation were not precisely matched during the Little Ice Age. Still, the drought of the previous summer was probably more unusual during the relatively wet and cool Maunder Minimum than it would have been in a warmer climatic regime.⁹¹

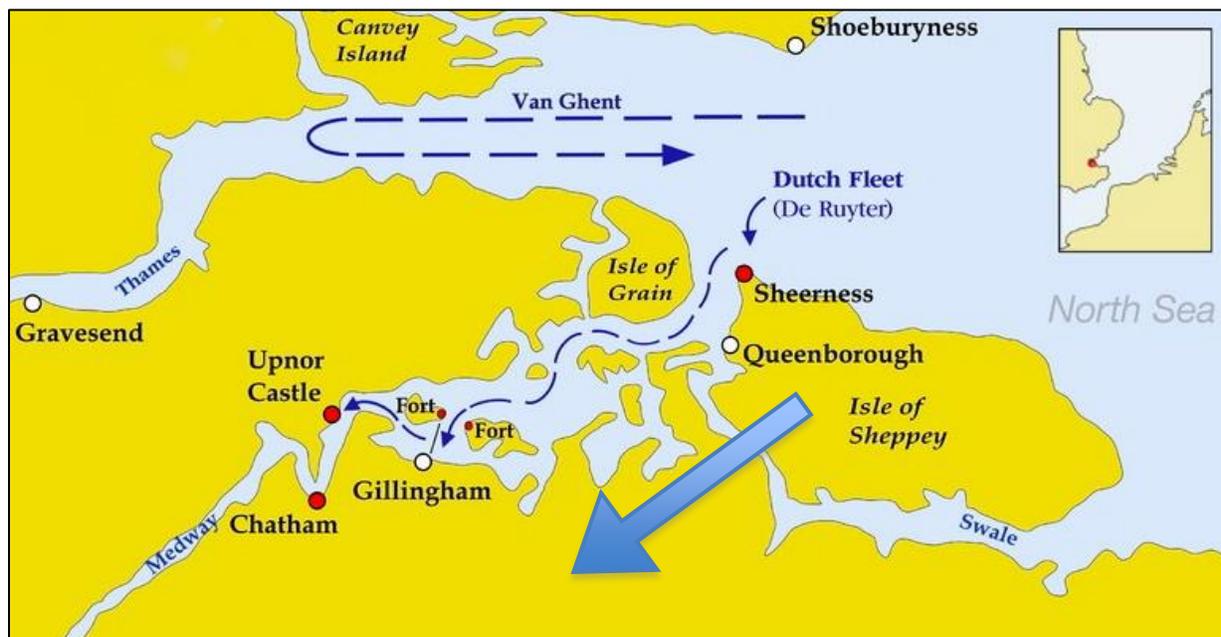
⁹¹ Further research is urgently needed into whether increased precipitation outside of winter during the coldest phases of the Little Ice Age was expressed predominantly in storms rather than more frequent wet weather. The frequency of droughts during the latter Anglo-Dutch Wars (Chapter 6) is noteworthy.

The long and severe winter of early 1667 once again delayed the assembly and departure of the Dutch fleet. However, when on 6 June the armada sortied under De Ruyter's command it had no English counterpart to challenge its supremacy of the North Sea. The Earl of Clarendon had often warned Charles that "the Dutch could endure being beaten longer than he could endure to beat them," and with parliament unwilling to approve new funds for the war the English naval system was financially exhausted. Naval vessels had been cannibalized for supplies during the cold winter while unpaid mariners deserted in droves. English diplomats proposed a peace in Breda, and the great ships of the fleet were towed up the Medway River. There they were protected by fortifications, shore batteries, and a giant chain, as light frigates continued to raid Dutch merchant shipping.⁹²

Owing to the extent of the Republic's trade with England, the approaches to the Thames and the Medway were more familiar to Dutch pilots than most of their English counterparts. Consequently, De Witt during the First Anglo-Dutch War had urged Tromp to raid up the rivers of Southeast England, and he had personally charted the mouth of the Thames during the Dutch blockade of 1665. The Republic's armada arrived off the English coast on 17 June, but De Ruyter was reluctant to commit the fleet to the Medway or the Thames. He worried that his pilots could not navigate through the rivers, and feared that the arrival of an English fleet would trap his armada. Indeed a Dutch raid against English West Indiamen in the Thames was soon foiled by a sudden change of wind. Nevertheless, Jan de Witt's brother Cornelis persuaded the Dutch admirals to harness a rising northeasterly wind to attack the partially constructed fortress of Sheerness on the mouth of the Medway (Map 5.3 and Figure 5.4). On 20 June the undermanned and demoralized garrison there was swiftly overcome. Only now, with the Dutch fleet pressing towards the Medway, did the English admiralty attempt to reinforce its defences. Monck

⁹² Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 157.

oversaw the strengthening of shore batteries at Gillingham near the mouth of the Medway, and ordered nearby great ships to be run aground. As the Dutch were carried ever closer by the wind, guard vessels were scrambled to defend the chain. However, attempts to buttress the chain by sinking ships were not completed because the *Sancta Maria*, a hulking Dutch prize, could not be scuttled in the right place owing to the force of wind and tide.



Map 5.3. Map of the raid on Sheerness, with arrow indicating wind direction. “Überfall im Medway, 19.-24. Juni 1667.” Wikipedia Commons. Available from: <http://commons.wikimedia.org/wiki/File:RaidMedwayKarte.png>.



Fig. 5.4. A contemporary painting of the raid, with the direction of the smoke revealing wind direction. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 162. Willem Schellinks, “The Dutch in the Medway,” painting, 1667, Rijksmuseum, Amsterdam.

A Dutch squadron under Admiral van Ghent arrived at Gillingham on 22 June. English sources reported that the favourable easterly wind and spring tide drove the Dutch ships forward into the chain. Monck wrote that, “one of their Fireships Struck upon the Chain, but it stopt it, then comes another great Fireship, and with the Weight of them the Chaine gave way.” After the English guard ships were captured or destroyed, the shallow-draughted Dutch vessels sailed over their sunken counterparts and passed through the gap that might have been filled by the *Sancta Maria*. The English great ships were vulnerable when De Ruyter arrived with the rest of the Dutch fleet, and the flagship *Royal Charles* was swiftly captured. By the evening of 23 June, the scale of English losses was immense, and much of the fleet’s core of “floating castles” had been

taken or burned. On the other hand, the Dutch missed the chance to weaken English naval power for decades to come by opting to spare the poorly defended dockyard at Chatham. Nevertheless, after the Dutch departed with their captured prizes on 24 June, Charles ordered his negotiators to drop the outstanding English demands at Breda. With the Dutch suffocating English trade and halting London's critical supply of coal from the Tyne a peace based on the status quo was signed on 31 July.⁹³

The Second Anglo-Dutch war was largely decided in the same watery corridor contested a decade earlier. However, the more comprehensive exploitation of the region's geography, and the greater diversity of operations across different environments at sea and, for the first time, on land, distinguished the second conflict from the first. Within Europe, English fleets ambushed Dutch convoys from Bergen to the Portuguese coast, Dutch armadas raided far inland, and battles between the armies of Münster, France, and the Republic stimulated the further geopolitical expansion of the war. Marauding in Africa and the New World hardly influenced the course of the war, although it reflected the global aspirations of its participants. A web of simmering, small-scale private and state conflict probably did contribute to the Dutch victory,

⁹³ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 163. Jones, *The Anglo-Dutch Wars*, 177. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 615. "Narratives of the Miscarriages in the Dutch War," in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum, 38. "Dutch account in deposition to Dutch magistrate," in *The Second Dutch War: described in pictures & manuscripts of the time*, National Maritime Museum, 40. "Hans Svendsen's Journaal, 22 Juni-25 Aug. 1667," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 544. "John Conny aan Williamson, 24 Juni 1667," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 549. "Chatham River. Narrative per Richard Tyler," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 549. "Leijonbergh aan Karel XI, 24 Juni 1667," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 553. "Adriaen de Haese aan zijn broeder in Indie, 18 Juli 1667," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 568. "Edward Gregory aan Pepys, 15 Aug. 1667," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 585. "James Norman aan Pepys, 17 Aug. 1667," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. I*, ed. Colenbrander, 587. Norman provided the most precise record of English losses beyond the incalculable destruction of the fleet's great ships in his account to Pepys.

but the outcome of the Second Anglo-Dutch War, like that of the first, still hinged on major battles between united fleets in the narrow seas between England and the Netherlands.

The complex influence of the weather that accompanied a shifting climate was woven through, and mediated by, the various manifestations of the war. The Dutch largely benefitted from the weather of the deepening Maunder Minimum in their struggle with Europe's other maritime power. Still, that conclusion masks the intricate, sometimes counterintuitive manner in which different expressions of climate, weather, and environment intersected with the war effort at sea and on land. Easterlies, for example, allowed Dutch admirals and privateers to set the terms for subsequent engagements, likely helped the Republic's galiot intelligence network manoeuvre responsively into position, fanned the flames that burned London, and thwarted English attempts to capture merchant prizes. On the other hand, by undermining English attempts to seize incoming convoys after the St. James' Day Fight, easterlies also encouraged the raid that culminated in Holmes' Bonfire. Meanwhile, by slightly delaying the sortie of the Republic's armada in June 1666, westerlies, generally rendered less common in the cooler climate of the late seventeenth century, actually ensured that the Four Days' Battle would be joined only after the division of the English fleet.

Ultimately, weather rendered common or atypical under a changing global climate was locally felt – in Dutch harbours that prohibited departure in westerly winds, for instance - and local circumstances both human and environmental nuanced its influence. In local settings human agency affected the immediate expressions of larger structural confluences. Rather than displacing the historical role of agency, an analysis of historical structures such as climate change in military conflict can highlight the enduring importance of decisions taken by individual human beings.

Chapter 6

Warfare in a Colder Climate: the Third Anglo-Dutch War, 1672-74

Two months before the Dutch fleet left port in 1667, French armies invaded the Spanish Netherlands. In the aftermath of the Treaty of Westphalia, the provinces of the southern Low Countries had formed a buffer between Protestant and Catholic Europe. Now, the ebbing authority of Spain was replaced by that of an ascendant France, and many within the States-General again perceived a threat to the south. After aligning with Sweden and even England, the Republic threatened to intervene unless the French withdrew. In 1668 Louis XIV consented, but never forgave the supposed treachery of his former ally.¹ In 1670 he convinced Charles II to sign the secret Treaty of Dover, in which French funds would support English participation in a decisive war against the Dutch. Louis would have free rein in the Low Countries once the Dutch were humbled, while Charles, a Catholic, hoped that a successful war would grant him true independence from England's Protestant parliament. Both Charles and Louis therefore had much to gain from the culmination of their long-standing efforts to extinguish Dutch control over European and Asian commerce.²

The plan hatched by Louis, Charles, and their advisors imagined a massive French invasion from the southeast, overwhelming the Republic's long-neglected army. Meanwhile, an Anglo-French fleet would defeat its outnumbered Dutch counterpart before suffocating the Republic's economy by blockading the coast. To that end the English fleet was reinforced with

¹ "I must confess," Louis XIV wrote ten years later, "that [The Dutch Republic's] insolence struck me to the quick and that [already in 1668] I came close, at the risk of endangering my conquests in the Spanish Low Countries, to turning my arms against this haughty and ungrateful nation." Paul Sonnino, *Louix XIV and the Origins of the Dutch War*. (Cambridge: Cambridge University Press, 2003), 23.

² Lynn, *Giant of the Grand Siècle*, 16. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 169.

seven new great ships, while little had changed for the Dutch navy since the raid on the Medway five years earlier. On the other hand, by the end of the Second Anglo-Dutch War the Dutch naval system had fully incorporated many of the most effective English innovations. In 1672, the Republic's great ships were even larger than they had been at the beginning of the second war, and their commanders were now accustomed to sailing in the line of battle. On the other hand, the Dutch naval system retained some of its distinct characteristics. Limited by the Republic's shallow harbours, Dutch shipwrights continued to design wide and shallow vessels, which were still commanded by military officers who doubled as master mariners. Furthermore, the Dutch enjoyed a continuity of effective naval leadership under the authority of Jan de Witt and Michiel de Ruyter. By contrast, the English command structure was again divided, this time between bitterly opposed factions of Catholic and Protestant officers. Following Monck's death in 1670, James, the Catholic Duke of York, was again in overall command, as French captains more readily accepted his orders than those of his brother, the Protestant Rupert. Meanwhile many of the English officers were selected for social standing rather than capability, and consequently most were inexperienced at sea. On the other hand, Pepys had transformed a previously corrupt system of pursery into the world's most efficient method of victualing warships.³

Still, the primary difference between the combatants at sea between the third and the second wars did not concern the English or Dutch naval systems. In the Second Anglo-Dutch War, Louis XIV never seriously intended to risk his nascent fleet in order to hasten the conclusion of a war between Europe's paramount Protestant powers. However, by 1670 the French navy had matured. Dutch shipyards had completed six massive warships for their then-allies in 1666, and Dutch shipwrights contributed to the construction of a further six men-of-war

³ A purser controlled the finances of a ship, and arranged for its supplies before it left port. Rodger, *The Command of the Ocean*, 106.

just two years later. In the early 1670s a further 20 great ships joined the French navy. With Louis apparently committed to joining the war at sea, the Republic's fleet of 62 large vessels faced an allied flotilla that contained 74 ships of fourth rate and higher.⁴

The First and Second Anglo-Dutch Wars were decided at sea, despite the aborted invasion of troops under Bishop von Galen in 1665. However, the unrivalled French army, which numbered 144,000 soldiers in 1672, lent a very different character to the third war. Charles initially hoped for a start to hostilities in 1671, but plans to achieve the seventeenth-century equivalent of a blitzkrieg were complicated by the futility of invading through the Spanish Netherlands. Any attack from the south would be slowed by the tedious necessity of seizing one town after another, even before the Republic's border was reached. Thereafter the Dutch river defences that had foiled the Spanish for 80 years would transform any invasion into a grinding battle of attrition. Hence the allied plan adopted in July of 1671 imagined an invasion from the southeast, which would outflank the bulk of the Republic's static defences. Efforts to secure the neutrality of Cologne and Münster, vital for any attempt on the Republic's dilapidated eastern defences, culminated in both states pledging to join the invasion.⁵

The Third Anglo-Dutch War was also the beginning of the longer and less decisive Franco-Dutch War. However, until 1674 these wars were scarcely distinguishable from one another, although the French monopolized military operations on land, while the English controlled allied activity at sea. The influence of weather rendered more likely by the Maunder Minimum was different in these environments. Persistent easterly winds again allowed De Ruyter to claim the weather gage in most battles, providing his fleet the tactical initiative that was even more important for an outnumbered force. Moreover, when the Dutch armada was

⁴ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 169. Jones, *The Anglo-Dutch Wars*, 184.

⁵ Sonnino, *Louis XIV and the Origins of the Dutch War*, 12. Lynn, *Giant of the Grand Siècle*, 46.

partially dismantled to resist the French and German invasion in 1672, severe and remarkably continuous storms protected the Republic's coast from naval invasion or blockade. On land, dry weather less common in a cooler climate initially aided the allied invasion. Heavy precipitation typical of the Maunder Minimum soon strengthened the Republic's last lines of defence, yet winter freezing later threatened to undermine them. Ultimately, relationships between weather, climate, and military operations were far from straightforward during the Third Anglo-Dutch War. Nevertheless, the weather typical of the Maunder Minimum still provided critical advantages for a Republic struggling to survive the worst disaster of its seventeenth-century Golden Age.

Beginning of the Third Anglo-Dutch War

The bitter cold of November 1671 ushered in a frigid winter that featured most of the meteorological conditions typical during the Maunder Minimum. Six days after Adriaen van der Goes described the extreme cold of 19 November, 44 ships were lost in a severe storm north of England.⁶ Thereafter, easterlies prevailed as Dutch waterways froze for nearly three months. In fact, in February easterlies accounted for 70% of all wind directions recorded by English Captain John Narbrough. Westerlies were necessary for departure from most English ports, and in February easterlies combined with heavy ice cover to keep 220 richly laden Dutch ships within English harbours. More alarming for the Dutch were the provocations of the English. On 23 March an English squadron under Holmes, who again acted as instigator, ambushed the Dutch Smyrna fleet off the Isle of Wight. The fleet's 72 vessels had been struggling against westerly

⁶ Adriaen van der Goes, "Hage, den 19 November 1671." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 305.

winds as they sailed towards the Republic. Although the Dutch merchantmen were lightly escorted, Holmes bungled the operation and seized no major prizes. Holmes' incompetence had more than compensated for the tactical advantages offered by westerly winds that had become less common in a colder climatic regime.⁷

Prospects for peace grew increasingly bleak in the spring of 1672, but the Dutch Republic was utterly unprepared for war. Easterlies, storms, and frigid temperatures may have prevailed during the winter of 1671-72, yet the increased moisture typical under the Maunder Minimum climate yielded to unusual dryness in the spring. Thawing ice hardly raised water levels, which in March were, according to Van der Goes, lower than anyone could remember.⁸ On 2 June the States-General conceded that the Republic was open to invasion, as the remarkably low water levels in the Rhine and its tributaries ensured that most could be forded with ease.⁹ The vulnerability of the Republic's natural defences, exacerbated by weather that was actually rendered less common in the wetter climate of the late seventeenth century, was compounded by political crisis.

During the Eighty Years' War the head of the House of Orange had assumed the position of captain general of the States Army, and had wielded substantial political power even in peacetime. The death of William II had ushered in the period of "true freedom," but William III

⁷ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 169. Jones, *The Anglo-Dutch Wars*, 189. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 646. "Relation of one of Sir George Downing's Domesticks, 30 Maart 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. II: 1667-1676*, ed. H.T. Colenbrander. (The Hague: Martinus Nijhoff, 1919), 80.

⁸ A year earlier, in weather more typical of the Maunder Minimum in the Republic, Van der Goes had described how many believed that, "without the abundant rainfall the Bishop of Münster would have already invaded, but with the water so unusually high people think he will have to delay the attempt" ("... en hout men voor gewisch, dat, soo dat groot regenwater hiet hadde beleth, den Bischoep van Monster ons al op het lyff soude hebben gevallen, maer dewyl de wateren soo ongemeen groot syn, geloof men dat het exploict tot een ander tyt sullen uytstellen"). Adriaen van der Goes, "Hage, den 30 January 1671," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*," 183.

⁹ In fact, at Schenckenschans cows could walk across the Rhine! Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 645. Claas Arisz. Caescoper, "10 Mart 1672," in *Nootijsye Boeck, anno 1669-1678, ofte Joernael*.

had come of age by 1672. Orangist publicists printed a diverse selection of propaganda pamphlets that were disseminated in print shops, book stores, and markets. Such pamphlets would become an important weapon for William's regime, and in 1672 they encouraged Dutch burghers to vigorously, even violently, support his ascension.¹⁰ Fearing the end of the true freedom, Jan de Witt, his allies in the States-General, and the States of Holland fervently resisted William's permanent ascension to this position, while the majority of the States-General sided with the Republic's other provinces in support of the Prince of Orange.¹¹ Further deepening divisions between Republicans and Orangists was De Witt's reluctance to accept the scale of the Republic's peril, which delayed the necessary reinforcement of its neglected land defences. Grafted onto this rift were the perpetual divisions between and within Dutch provinces and towns, all of which rendered the Republic a particularly appealing target in 1672.¹²

On 24 February the States-General finally agreed to appoint William III as captain-general for the summer, a position that would become permanent on his 22nd birthday. Then, in the second week of April 1672, England and France declared war within days of one another, plunging the Republic into its *rampjaar*, or "year of disaster." Louis XIV personally led his army through northern France and the Spanish Netherlands. In the Ardennes, dry roads quickened the advance of the 25,000 horses and 1,000 cannons that would have been bogged down during a rainy spring. In the first months of the war, two overriding objectives guided the Dutch response:

¹⁰ Burghers were citizens who had acquired special privileges after swearing an oath to the mayor. Michel Reinders, "Burghers, Orangists and 'good government': Popular Political Opposition during the 'Year of Disaster' 1672 in Dutch Pamphlets." *The Seventeenth Century*, 23:2 (2013): 315.

¹¹ Holland finally yielded in February 1672, and William was appointed captain and admiral-general on the 24th. Israel, *The Dutch Republic*, 794.

¹² Jones, *The Anglo-Dutch Wars*, 186. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 172. Femke Deen, David Onnekink, and Michel Reinders. "Pamphlets and politics: introduction," in *Pamphlets and Politics in the Dutch Republic*, ed. Femake Deen, David Onnekink and Michel Reinders. (Leiden: Brill, 2010), 3. Reinders, "Burghers, Orangists and 'good government,'" 316. See also: Michel Reinders, *Printed Pandemonium: the Power of the Public and the Market for Poplar Political Publications in the Early Modern Dutch Republic*. PhD Dissertation, Erasmus University Rotterdam, 2008.

at sea, the attempt to prevent the union of English and French fleets; on land, the struggle to reinforce defences along the IJssel, a tributary of the Rhine, so they could withstand the allied invasion.¹³ The Dutch failure to achieve either goal was influenced by a pattern of weather conditions that partially – but not entirely – reflected the climatic influence of the Maunder Minimum.¹⁴

De Ruyter and De Witt understood that an early sortie and a quick, victorious strike against either the English or the French armada was essential if the Republic was to achieve superiority at sea. However, incessant gales kept the bulk of the Dutch fleet in port until the end of April. When the weather calmed, the delay was compounded by the commanders of the admiralty of Zeeland, who feared an attack from the sea and therefore refused to add their powerful squadron to the united fleet until word arrived that De Ruyter had left Texel. By the time the Dutch fleet had crossed the Channel, its English counterpart had already departed for the Isle of Wight, and, unimpeded, it united with the French on 7 May. De Witt urged another raid on the Medway and the Thames while the allied fleet was delayed by easterly winds that persisted until the 17th. Yet when Admiral van Ghent and his squadron approached the fortress of Sheerness, they discovered that it was far better defended than it had been in 1667.¹⁵

On land the States Army fared even worse. With scarcely a quarter of the soldiers fielded by its French counterpart, it could not defend the eastern frontier from concerted attack. Troop strength along the fortifications of the IJssel was utterly insufficient, while morale and stores were both in short supply. Efforts to create a regional inundation zone foundered on the

¹³ The IJssel that winds its way from the German border towards the heart of the Republic is commonly called the Gelderse IJssel to distinguish it from its namesake in the province of Holland.

¹⁴ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 645. Jones, *The Anglo-Dutch Wars*, 186. Rodger, *The Command of the Ocean*, 82.

¹⁵ Narbrough, "Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673," 90. "Hildebrand aan Williamson, 12 Mei 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 93. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 172. Robert Fruin, *De oorlog van 1672*. (Groningen: Wolters-Noordhoff 1972), 110.

intransigence of farmers unwilling to sacrifice their land, and anyway the efficacy of inundation depended on local water levels. Given the weakness of its army, the borders of the Republic could not be defended in a spring that was remarkably dry within the climatic context of the Maunder Minimum. At sea, conditions far more typical of a colder climate afforded both advantages and disadvantages that were either compounded or nullified by human agency. Storms may have thwarted Dutch attempts to ambush the English fleet, but delays were exacerbated by the fears of the Zeeland admiralty. Easterlies might have permitted another raid on the Medway while slowing allied reinforcement, but the English had strengthened the river's fortifications. Ultimately, a distinct pattern of meteorological conditions in the spring of 1672 interacted with environmental and cultural structures to exacerbate the military threat faced by the Republic.¹⁶

In late May the allied fleet scoured the Channel for the Dutch fleet, while the French and their German allies completed preparations for an assault against the Republic's IJssel defences. When the allies sighted the Dutch armada on 29 May, De Ruyter ordered a retreat because a light westerly granted the allies the weather gage and enabled them to use all their guns. One letter sent from the Republic reported that the Dutch fleet "hath order not to fight in calm weather but in the time of a fresh gale of wind, to the end that not so much blood may be shed, as also that the English may not be able to use their lower tire of guns, which they say here they cannot doe if the wind blow hard." The Dutch fleet sailed back to the Flemish coast, but De Ruyter's subsequent attempt to lure the deeper-draughted allied ships into the nearby shoals proved

¹⁶ Israel, *The Dutch Republic*, 794. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 645.

unsuccessful. The westerly intensified during the night, and on the next day it blew too hard for battle. With the Dutch out of sight the allied fleet sought shelter off Sole Bay on 31 May.¹⁷

On 5 June the three allied squadrons were loosely strung out along the coast, as the English and French crews cleaned and provisioned their warships. In his log, captain Narbrough wrote that he suspected the Dutch “will be with us in a morning, if the wind hang easterly.” Indeed at 3:00 AM the wind turned to blow from the east, rendering Sole Bay a lee shore. Inexplicably, the allied crews continued their work, and many sailors remained on land. Their vulnerability was known to De Ruyter after it was disclosed by the crew of a captured English coal transport. Consequently the Dutch fleet made for Sole Bay as soon as the wind shifted. De Ruyter ordered each of his squadrons to form a spearhead of six warships and six fireships, which he hoped would sow chaos among the allies and overcome their superior numbers. However, when the Dutch surprised the allies on 6 June the easterly suddenly died to a light breeze. While still in disorder, the allies could prepare for a battle in which Dutch fireships were rendered ineffectual by the gentle wind, and they could use their lower tier of guns. Still, the Dutch harnessed the light wind to successfully surround the scattered English flagships. Meanwhile, miscommunication between English and French commanders helped the Zeeland squadron isolate and severely damage the French fleet. The Dutch lost two middling vessels yet sunk the 100-gun *Royal James* before deepening fog, a rising gale, and the coming of darkness ended the battle.¹⁸

¹⁷ “Hildebrand aan Williamson, 12 Mei 1672,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 93. John Narbrough, “Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673, 93. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 646. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 173.

¹⁸ Vonk, *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*, 57. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 176. Jones, *The Anglo-Dutch Wars*, 191. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 646. Narbrough, “Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673, 95. Brandt, *Uit het Leven en Bedrijf van den here Michiel de Ruiter*, 236. Rodger, *The Command of the Ocean*, 82.

The Dutch fleet enjoyed substantial advantages on the morning of 6 June. A driving easterly, rendered more common in the Maunder Minimum, encouraged tactics that nullified the Anglo-French numerical advantage, exacerbated allied disarray with the prospect of a lee shore, heightened the influence of surprise, and allowed the Dutch to determine the order of battle. The easterly helped the Dutch surround English flagships and divide the allied fleet, while the afternoon gale dissolved the battle before allied numbers could prove decisive. Nevertheless, the sudden drop in wind velocity as the Dutch sailed into view removed a crucial variable from De Ruyter's plan, and helped deprive the Republic of a decisive victory. In the North Sea easterlies are especially uncommon in June during a warmer climate, yet the weather that shaped the Battle of Sole Bay reveals the complexity of establishing relationships between human affairs, general climatic trends, and hourly, local weather. Easterly winds grew more frequent during the Maunder Minimum, and these winds allowed the Dutch to commence the Battle of Sole Bay. They also allowed De Ruyter to claim the weather gage, granting him the tactical initiative that was critical for an outnumbered fleet. On the other hand, the sudden drop in wind velocity on the morning of 6 June cannot be tied to the influence of the Maunder Minimum, and it was equally critical for the outcome of the battle.

Dutch tactics before and during the Battle of Sole Bay reflected how De Ruyter and his subordinates perceived the relationship between the environment of the North Sea and the Republic's naval system. De Ruyter understood that the allies needed to destroy the Dutch fleet in order to invade the Republic from the sea, because its existence rendered an invasion too risky to attempt. Consequently, the outnumbered Dutch fleet did not necessarily need to defeat the allied armada outright: it had only to survive and occasionally check the free reign of the French and English in the North Sea. Fortunately for the Republic, the shallow hulls of Dutch vessels

allowed De Ruyter to employ shoals as cover for one of the most effective guerrilla wars ever fought at sea. After the engagement at Sole Bay, the Dutch fleet remained near the shoals that protected the Republic's coast. Before long, the shoals around Schooneveld, near the mouth of the Scheldt, were known to the English as De Ruyter's "narrow hole." Remaining behind underwater walls allowed De Ruyter to attack only in high, easterly winds, when the advantage of the weather gage compounded the inability of allied great ships to open all their gun tiers.¹⁹

In the Third Anglo-Dutch War, easterlies were not quite as common as they had been in the second war, although they were still more frequent than they had been in the first war. Instead, storms and high winds were now the dominant expression of the Maunder Minimum in the North Sea region. It is telling that De Ruyter and the rest of the Republic's naval leadership, so attuned to maritime weather, developed strategies and tactics that helped the fleet maximize the advantages of high, easterly winds precisely when these were more common. Admittedly, De Ruyter, De Witt, and their subordinates probably had no conception of climate as a product of interactions between the atmosphere, hydrosphere, and cryosphere that were subject to change. There is also no written evidence that anyone within the Dutch naval command realized that easterlies and high winds had become more common in a way that heightened the effectiveness of De Ruyter's guerrilla war. However, their contemporaries did cite oral and sometimes written histories of past meteorological events to contextualize remarkable weather. Moreover, ship logbooks written aboard naval vessels were meticulously compiled and preserved. Consequently, it is possible that De Ruyter developed and fought a guerrilla war that he knew was rendered more effective by prevailing weather patterns. Regardless, awareness of a shifting climate need not accompany exploitation of the opportunities it provided.

¹⁹ Vonk, *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*, 113. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 180.

The Dutch fleet returned to port after the Battle of Sole Bay, where a third of its ships were decommissioned, its guns were unloaded, and its marines were disembarked to resist the Franco-German invasion.²⁰ The Republic had, at worst, fought the allies to a standstill at sea, but the Dutch fleet had effectively been defeated on land. The coastal provinces were now nearly as vulnerable from the sea as the English had been in 1667, yet no invasion was forthcoming. According to historian Jonathan Israel, the Dutch fleet had, in the Battle of Sole Bay, “damaged enough of the . . . English ‘first rates’ to prevent a full-scale descent on the Republic, from the sea, during the ensuing months.” However, the rugged wooden construction of early modern warships allowed most damage to be repaired relatively quickly, provided materials and labour were available. With war recently declared, both were plentiful in English shipyards. Moreover, the brevity of the battle of Sole Bay meant that damage inflicted to the allied fleet was far less severe than it had been after the Four Days’ Battle, when the repaired and reinforced English fleet left port just six weeks after the Dutch victory. The engagement was also fought early in the year, and nearly five months remained in the campaigning season. That left more than enough time for even the most difficult repairs. Finally, the allied naval command was aware that the Dutch fleet was in no state to resist Anglo-French supremacy at sea, and English first rates would not be needed to secure a naval invasion.²¹

In fact, the allied fleet was ready to leave port by 4 July, although Narbrough reported that, “the blowing weather hinders the taking in our provisions; otherwise the fleet might have been out.” The wind relented on the following day, but when it resumed it blew at a stormy 37 knots. On 8 July, Rupert penned a letter to allied commanders that contained secret instructions should their vessels be scattered by storms. Ironically, by thwarting travel between ships the

²⁰ “Samuel Tucker aan Williamson, 17 Juni 1672,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. II*, 131.

²¹ Israel, *The Dutch Republic*, 795.

tempestuous weather prevented the letter's dissemination until the 10th. On the 11th the wind rose again to blow at approximately 37 knots. It persisted until, on 14 July, a ferocious storm with winds at 60 knots hurled the allied ships forward while inflicting damage and casualties. At sunset on the 15th, with the gale continuing, Narbrough related that, "the clouds this evening . . . were dark, heavy, hanging like great fleeces of wool . . . throughout the whole hemisphere."²²

In the first weeks of July 1672, unrelenting storminess, not damage sustained in the Battle of Sole Bay, thwarted allied naval operations. Basic communication between contemporary vessels was possible through the use of flags, guns, or even shouts if ships had grown dangerously close. Still, at sea detailed information, like any other good or service, could only be exchanged in person and delivered by nimble craft that traveled between ships. These boats, usually propelled by oar, could make headway in contrary winds yet were vulnerable in heavy seas. By cutting the vital links of supply and information provided by boats, stormy weather could paralyze a fleet lacking victuals or clear orders. Moreover, gales routinely inflicted damage that ranged from severed anchor cables to collapsed masts, undermining ship control that was already compromised by the violence of wind and sea. As equipment failed, sailors suffered. Beyond the psychological toll inflicted by threatening weather, in every storm injuries were inevitable, illness was common and compounded by delayed victuals, and several men aboard each vessel were routinely swept to sea. Worse, the high density of naval fleets increased the risk of ships colliding and sinking. Such disasters usually claimed the lives of most, or even all, sailors aboard the ship, and in a strong gale any vessel, however seaworthy, could founder anywhere at sea. However, shoals and lee shores were particularly threatening, especially for the deep-draughted allied great ships. More frequent easterlies during the Maunder Minimum

²² Narbrough, "Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672 Pepysian MS. 2555," in *Journals and Narratives of the Third Dutch War*, 114.

rendered much of the British coast a lee shore for allied vessels, and the more common storms of the period presented nearly insurmountable obstacles for Anglo-French mariners.²³

The intensity of the wind, which prohibited ketches from traveling between ships on 17 July, had moderated by the following morning to a fresh breeze of roughly 18 knots. However, on the next evening Narbrough reported “rainy, dirty, gusty weather all this day,” with “so base a sea . . . that no boat could stir.” The wind, now blowing at 37 knots, rose into another gale on the evening of the 21st that sustained winds of between 48 and 73 knots for nearly a week. By the evening of the 28th the wind subsided for roughly 24 hours, before intensifying into yet another storm in the following evening, as anchor lines snapped across the allied fleet. High winds finally relented on 1 August, but, remarkably, strengthened in a severe gale on the 2nd. Despite a brief interruption on the 9th, that storm would endure until the morning of the 12th.²⁴

John Narbrough’s detailed account of English efforts to seize an inbound VOC fleet during the gale reveals how tempestuous weather in the summer of 1672 crippled allied naval operations. With large swaths of the Dutch trading empire asphyxiated by allied control of the sea, Dutch merchant crews took to the sea as privateers. Crown revenues collapsed as Dutch privateers outnumbered and outclassed their English counterparts, while French subsidies, mostly squandered to enhance the glory of the English court, utterly failed to finance the war effort. James hoped to attack what remained of De Ruyter’s fleet when the weather calmed, but Charles commanded his brothers to seize the VOC convoy. Without wealth gleaned from captured East Indiaman an irate parliament would soon require consultation, undermining the king’s motives for war.²⁵

²³ Jones, *The Anglo-Dutch Wars*, 191. Vonk, *De Victorieuze Zeeslag op Schoneveld*, 112.

²⁴ Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672,” 130.

²⁵ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 179.

On 4 August, Narbrough reported that “the frigate *Bristol* came amongst the fleet” after its crew, and that of the *Cambridge*, had spotted and unsuccessfully engaged the returning VOC fleet. The *Bristol*’s captain managed to come aboard the flagship *Prince* and inform Rupert, who resolved to dispatch the great ship *York* and three third-rate frigates to aid the *Cambridge* off the entrance to the Zuider Zee. In the mounting wind Narbrough, captain of the *Prince* and Rupert’s direct subordinate on board the ship, dispatched a boat to Rear Admiral Beach aboard the *York*. After coming aboard the *Prince* to retrieve his orders, Beach would return to the *York* and set sail immediately. However, Narbrough wrote that the “weather was so stormy no boat could row to windward or steer, the sea was so high.” With the wind exceeding 48 knots the *Prince*’s boat was lost as its crew struggled to return, while Beach remained aboard the *York*. Writing several hours later, Narbrough described how the English fleet had been paralyzed in the face of the gale:

The weather increasing more violenter, I could not possibly send to Rear Admiral Beach by boat or smack, it being so much wind no vessel could get to windward, the wind at S.W. and rain; neither was it possible for the Flag Officers to get aboard to his Royal Highness. We made all preparations to heave ahead our ship, to weigh, but dared not unbitt the cable by no means, for fear of turning the ship adrift and losing the cables and anchors [Rupert], seeing it was impossible to advise with the Flag Officers, and to get the ships under sail without losing their cables and anchors, and when under sail it would be a hard matter to keep the fleet together, and to divide the fleet it would be dangerous, in case the enemy’s fleet should at the same time meet with either division, concluded to wait for the first opportunity of better weather and get the fleet under sail.

That evening the wind abated slightly, and for the first time in many days the sky was clear. It may have seemed as though the VOC fleet could still be seized before it passed through the shoals that protected the Zuider Zee. However, in the night the gale resumed, and in the morning the fleet encountered the battered *Cambridge*. With no men-of-war guarding the entrance to the Zuider Zee, the VOC fleet was safe from capture, and its seaworthy vessels

survived the storm.²⁶ Their return, facilitated by a remarkable stretch of summer storminess rendered more likely in the climate of the Maunder Minimum, was as much a blow to the English crown as it was a financial stimulus for the beleaguered Dutch. For the allied fleet the gale continued with little respite.²⁷

When the storm finally yielded to calmer winds on the 12th the damage sustained by the allied warships was immense. Worse, the provisions fleet was scattered, and the scouting ships were lost. On 13 August the English commanders decided to return to port with nothing but damage and casualties to show for their time at sea. High winds and two further storms beset the fleet on its return to England, until over a thousand sick men could be brought ashore on 23 August. Beyond seasickness likely prompted or exacerbated by continually violent weather, the stricken were victims of scurvy caused by short rations. On the following evening Narbrough observed “a small air of wind at E.N.E.,” before concluding: “thus ended this 24 hours – fair weather – a miracle.”²⁸ It was not to last. As Narbrough’s tenure aboard the *Prince* came to a close in the first weeks of September, his log recorded how a lengthy gale disrupted English plans to return to sea. The wind strengthened on 8 September, and Narbrough wrote that it was “very bad weather for this time of year,” and concluded that “we could not do any business in fitting our ships.” For more than a week the storm prohibited English vessels from provisioning despite Narbrough’s desire “to get ready with all speed.” Only on the 18th did the weather calm enough for victuals to be brought aboard.²⁹

²⁶ Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672,” 124.

²⁷ Vonk, *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*, 59. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 652.

²⁸ Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672,” 146. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 179.

²⁹ Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672,” 151. On 10 September: “we could not do any business, it blew so hard.” On 14 September: “We could not get any provisions aboard, it being so much wind and sea, the vessels could not lie by our sides. I caused the

The remarkably severe and persistent storms that safeguarded the Republic from blockade and naval invasion were likely influenced by the colder climate of the Maunder Minimum. However, very different interactions between weather, climate, and the various expressions of warring military systems on land actually exacerbated the consequences of the Republic's failure to achieve its initial tactical objectives. Admittedly, a frigid winter and late spring had delayed the beginning of the French advance through the Spanish Netherlands until early April, but the States of the divided Republic did not use the extra weeks to their advantage. As the French army approached the Republic's southern borders in May several thousand civic militiamen were belatedly assembled in Holland, Utrecht, and the eastern province of Gelderland to reinforce the IJssel line. These frantic measures, already inadequate in the face of the overwhelming quantitative and qualitative superiority of allied armies, were undermined by historically low water levels. Stimulated by enduring dryness, shallow water levels dramatically reduced the effectiveness of the IJssel as a barrier to invasion.³⁰

Meanwhile, the failure to strengthen watery defences through inundation reflected a disastrous relationship between human agency and meteorological conditions that were rare during the Maunder Minimum. When the IJssel was higher in April the Dutch commander of Doesburg, a town in Gelderland, had opened nearby sluices to flood the region. Unfortunately for the Republic, he forgot to close the sluices when the inundation was complete. The water flowed back when the IJssel dried in May, again exposing Doesburg to the French. Ultimately, fluctuations in temperature and precipitation, not changes in wind direction and velocity, were

Third, Fourth and Fifth Rate frigates to get ready with all speed, weather permitting, which bad weather at present hinders us much." On 15 September: "we could not pass from ship to ship in boats; no business could be done." On 16 September: "'much wind most part of this day, so we could not do any business, the weather being so extremely bad . . . The boats could not pass from one ships to another but in the time of the windward tide." On 17 September: "this day it blew very much in the afternoon; we could not do anything in our business of fitting our ships." Narbrough, "Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672," 150.

³⁰ Caescoper, "30 Maij 1672," in *Nootijsye Boeck, anno 1669-1678, ofte Joernael*.

the expressions of the Maunder Minimum that most affected warfare on land. However, while the meteorological conditions of the first half of 1672 generally reflected the climate of the Maunder Minimum, the calamitous influence of unusually dry conditions again demonstrated the military significance of seemingly random variability in weather.³¹

On 18 May the Bishop of Münster declared war on the Republic, as did the Elector of Cologne soon thereafter. On 22 May, the French under Louis and his general Condé used a bridge of ships to cross the shallow Maas at Visé, bypassing the fortifications of Maastricht. As the Dutch fleet checked the allies at Sole Bay in June, the French invaded the Republic. Dutch garrisons east of the IJssel at Rheinberg, Orsoy, Emmerich, Rees, and Wesel fell within a week, and would never rejoin the Republic. Meanwhile Münsterite troops seized Lingden, invaded Overijssel, and joined the more numerous French in the conquest of Grol on 9 June. However, a relatively small force of Dutch soldiers held the Rhine near Lobith, the town that straddled its traditional entrance into the Republic. Condé had planned to employ ship bridges in a crossing of the Rhine near Lobith, but French engineers and soldiers would be under constant fire while the bridges were assembled. Fortunately for the French, Condé soon learned from farmers that the dry weather had left the Rhine crossable further upstream. On the morning of 12 June, 6,000 French cavalry crossed the Rhine with Louis watching from atop Eltenberg (Figure 6.1). The horses only needed to swim for a brief stretch, yet they were engaged by hastily assembled Friesian defenders as soon as they reached the shore. Condé was injured in the battle before the French prevailed. Thereafter, bridges were hastily constructed to accommodate the army's artillery and innumerable infantry. Were the Rhine less shallow the French cavalry could not

³¹ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 647.

have crossed so easily, and the Republic's defenders might have hindered the construction of the bridge and, in turn, the French crossing.³²



Fig. 6.1. A contemporary Dutch painting depicts Louis XIV and his army crossing the unusually shallow Rhine. Adam Frans van der Meulen, “Louix XIV passing the Rhine,” painting, 1672, Deutsches Historisches Museum, <http://goo.gl/JLrCXL>.

Upon hearing that the French had crossed the Rhine, the States-General and the States of Holland decided to abandon the suddenly outflanked IJssel line and concentrate all resources on defending the provinces of Utrecht, Zeeland, and Holland. Meanwhile the allied conquests continued unabated: Arnhem surrendered to the French on 15 June, before Doesburg, Zutphen, and the other IJssel towns fell to the armies of Münster and Cologne. The French pursued the

³² “Samuel Tucker aan Williamson, 17 Juni 1672,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 131. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 647. Israel, *The Dutch Republic*, 797. Jones, *The Anglo-Dutch Wars*, 187.

remnant of the States Army as it retreated north under William III, and seized Amersfoort on 19 June.³³ Morale collapsed across the remaining Dutch provinces, and in Utrecht the citizenry rioted, preventing any defence of the city. William was forced to order a second retreat towards the “five posts,” the last bastions for the defence of Holland. On 23 June the French army seized Utrecht without a fight, while allied troops overwhelmed Zwolle and Kampen to the Northeast. On 7 July, torrential rain that was far more typical of the Maunder Minimum than the preceding dryness drowned French ammunition stores, but it came too late for the Republic’s central and eastern provinces.³⁴

With the IJssel line crumbling on 8 June the order was given to engage the *Hollandse Water Linie* or “Hollandic Water Line” (Map 6.1). The vast crescent of sluices, fortresses, and inundated land that together constituted the water line would provide the Republic with its last and best defence. The first wing of inundated land stretched from Muiden on the Zuider Zee to Bodegraven, completely surrounding the great bastion of Amsterdam.³⁵ From William’s headquarters at Bodegraven, a relatively narrow strip of flooded land connected the Rhine with

³³ On 17 June Samuel Tucker, an Orangist merchant from Amsterdam, described how “the neere approach of the French doth soe much amaze us, and put us into confusion here, that wee are all in an uproare, the common people tumult, and will permit noe goods to goe out, pretending the great ones send away their many and best things to Amsterdam, Antwerp, Zealand and Hambourgh, and intend to follow after, and leave the people to the mercy of the French.” Lamenting the French march on Utrecht, Tucker concluded that Louis, “will have a ritch country full of merchants shippes together with the whole Dutch fleet, and other materialls for warr, for the reward of his army without fighting, because noe preparations hath been made against him.” Tucker ended his letter by writing that, “to apprehend the misery we are in you must thinck of the destruction of Troye, Jerusalem, and Rome besieged by Haniball.” “Samuel Tucker aan Williamson, 17 Juni 1672,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II: 1667-1676*, 130. The miller Caescoper wrote that, “the plight of our beloved fatherland goes from bad to worse . . . nobody doubts that the French will overrun the country . . . never in my life have I been more anxious.” Caescoper, “20 Junij 1672,” in *Nootijsye Boeck, anno 1669-1678, ofte Joernael*.

³⁴ Johan de Witt, “Aan Cornelis de Witt. 20 Juni 1672,” in *Brieven van Johan de Witt: Vierde Deel, 1670-1672*, ed. Robert Fruin. (Amsterdam: Johannes Müller, 1913), 387. “Nieuwsbericht uit Amsterdam, 20 Juni 1672,” in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II*, 132. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 647. Israel, *The Dutch Republic*, 798. Jones, *The Anglo-Dutch Wars*, 188. Petra Dreiskämper, *Redeloos, radeloos, reddeloos: de geschiedenis van het rampjaar 1672*. (Hilversum: Uitgeverij Verloren, 1998), 47.

³⁵ Amsterdam actually fielded 26 walled bastions, a moat and over 300 cannons. It was defended by its own water line with additional fortifications, safeguarded from the sea by a Zuider Zee fleet, and guarded by over 12,000 soldiers.

the IJssel, from where the inundations broadened to encompass Schoonhoven and heavily defended Gorinchem.³⁶ From the river Waal before Gorinchem the inundations continued past the waters of the Biesbosch, before halting west around Geertruidenberg and east at 's Hertogenbosch. Inundation was a traumatic and expensive process that, for many Dutch citizens, was more destructive than invasion and defeat. Dikes were breached and sluices opened in some areas while new dikes were constructed in others, and great swaths of farmland were inundated by water that, when brackish, destroyed their productivity.³⁷

³⁶ Also spelled "Gorcum."

³⁷ Dreiskämper, *Redeloos, radeloos, reddeloos*, 45. Vonk, *De Victorieuze Zeeslag op Schoneveld*, 60. Israel, *The Dutch Republic*, 798. Luc Panhuysen, *Rampjaar 1672. Hoe de republiek aan de ondergang ontsnapte*. (Amsterdam: Atlas, 2009), 12.



Map 6.1. The Old Hollandic Water Line. Right: map of the Hollandic Water Line in 1672. Further inundations would broaden the northern waterline in 1672. Left: a map, likely drawn in the eighteenth century, demonstrating the complexity of the waterline near the fortified town of Woerden (highlighted in the map to the right). The immediate vicinity of Woerden was in the hands of the French and therefore dry in 1672, but it was underwater in 1673. “De Oude Hollandse Waterlinie.” Waterlinie Werelderfgoed. Accessed 14 February 2014, <http://www.oudehollandsewaterlinie.nl>. “Kaart van het ontwerp van een waterlinie tot dekking van de provincie Holland van Muideren aan de Zuiderzee langs de Vecht naar Weesp, Uitermeer, Hinderdam, langs Woerden, Oudenwater, Schoonhoven, Everdingen, Asperen tot Gorinchem aan de Mewede.” Kaartcollectie Ministerie van Oorlog, Situatiekaarten. Reference code: 4. Nationaal Archief (Den Haag, Netherlands). Gottschalk, *Stormvloed en rivieroverstromingen in Nederland, Vol. III*, 240.

Opening the sluices did not immediately engage the water line. Many peasants, fearful that their livelihoods would be destroyed in a hopeless conflict, bitterly resisted the inundations. Fearing peasant mobs, the magistrate of Gouda delayed opening nearby sluices until the States-General finally threatened to use force, while the farmers of Lek repeatedly drained inundated land under cover of darkness. Peasant resistance ended only when the death penalty was imposed for sabotaging the water line. Even then, critical fortifications remained in poor repair, and low water levels stimulated by enduring dryness continued to hamper the inundations. Overall, the

Hollandic Water Line was easily crossable for two critical weeks after the opening of its first sluices. However, by the end of that period precipitation was finally beginning to reflect the influence of the wet Maunder Minimum, and favourable winds were fanning the artificial floods. The window of Dutch vulnerability available to the French and Germans was therefore fleeting, and it was not exploited. In fact, Louis XIV and his high command, ignorant of the water line's purpose, believed that their war was already won. Once again, human agency interacted in counterintuitive ways with a network of environmental, social, and cultural structures to shape the course of war. When the water line was finally completed the character of the war within the Republic's borders was fundamentally altered. The amphibious struggle that characterized the rest of the *rampjaar* would be fought on terms more familiar to the Dutch.³⁸

Nevertheless, most of the Republic was gripped by social unrest. Refugees poured into coastal towns, farmers rioted against inundation, and city councils considered surrender. Popular fury at the Republic's lack of preparation for invasion ultimately ended the period of "true freedom." In June, Jan de Witt had been wounded in an attempt on his life, and could no longer work as grand pensionary. It was no coincidence that, in July, William III was formally appointed as *stadthouder* by the States of Holland and Zeeland. In the following month a mob brutally murdered the De Witt brothers, an act that was perhaps directed and certainly inspired by William. In late July, German troops continued their advance, and the borders of the northerly provinces of Friesland and Groningen remained unsafe because farmers refused to inundate their land with water rendered brackish by continuing dryness. However, the rainy weather

³⁸ De Witt, "Aan Cornelis de Witt. 20 Juni 1672," in *Brieven van Johan de Witt: Vierde Deel*, 387. Baron de W., "Baron de W. aan Arlington, 14 Aug. 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. II: 1667-1676*, 174. Adriaen van der Goes, "Den 1sten Augusti 1672," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 389. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 649. Dreiskämper, *Redeloos, radeloos, reddeloos*, 46. Fruin, *De oorlog van 1672*, 174.

characteristic of the Maunder Minimum prevailed for most of August, foiling a French invasion of Holland from the territory of North Brabant and strengthening the water line as a defensive barrier. The city of Groningen was besieged by German troops, yet cold, wet, and stormy conditions rendered roads impassable, filled trenches dug by the invaders, and may have worsened the outbreak of disease. Inundations drowned as many as 2,000 Münsterite troops, and with enough provisions within the city on 28 August the siege ended in failure. As weather conditions rendered more likely during the Maunder Minimum helped provide crucial breathing room, the Republic's internal divisions were violently resolved.³⁹

Conclusion of the Third Anglo-Dutch War

By September, most of the Republic beyond the Hollandic Water Line had been seized by allied armies. Nevertheless, the inundations had created a shallow sea around the provinces that together housed the vast majority of the Republic's demographic and financial resources. At great cost Holland had become an artificial island, with the largely natural islands of wealthy Zeeland to the south and Friesland, isolated by marshland, to the North. With the front temporarily stabilized, the most immediate danger in this watery environment came from the sea. On the one hand the late season precluded invasion, and the Dutch armada had been restored to its former strength. On the other, the fleet was outnumbered and would be hard-pressed to resist a blockade.⁴⁰ It was provisioned only until September, as Dutch naval commanders believed that

³⁹ Adriaen van der Goes, "Den 1sten Augusti 1672," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 388. Huneken, "Huneken aan den Raad van Lubeck, 22 Aug. 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. II*, 184. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 649. Israel, *The Dutch Republic*, 800.

⁴⁰ Nevertheless, reports that the allied fleet had been battered by storms encouraged plans for another engagement at Sole Bay, although no further battles would be fought between the united armadas for the rest of 1672. Baron de.

the storm-ravaged campaigning season would end with the early arrival of winter. Whether reflecting a reaction to the summer's stormy weather, or an awareness of new climatic conditions, the gamble was justified in subsequent months.⁴¹

On 28 September, Narbrough, now captain of the *Fairfax*, left port with an English squadron under the command of Admiral Edward Spragge. The vessels struggled against an easterly wind, and two days later were beset by a powerful easterly gale that raged until the 31st. Winds, now from the west, continued with little respite at a driving 37 knots until 8 October, when another storm whipped the sea into such a frenzy that the *Fairfax's* ketch, tied to the hull, strained the ship to the point of breaking. Narbrough ordered the ropes cut and the boat released, while Spragge's ship vanished from sight. The *Fairfax*, now alone, was afflicted by yet another, even more ferocious gale on the 10th. In his log, Narbrough reported that he was "doubtful of my mainsail holding," yet he refused to anchor because the bows could not endure the heavy seas. Still under sail, the *Fairfax* passed by a Dutch vessel riding at anchor, and Narbrough wrote that the weather was "so bad we could not meddle with him." Scattered and paralyzed by relentless storms, the squadron that left port under Spragge captured just 20 small herring buses, a tiny portion of the Dutch fleet and not nearly enough to improve the increasingly dismal state of the English treasury.⁴²

As autumn yielded to winter, weather typical of the Maunder Minimum in the North Sea continued to undermine allied naval operations. In October and November Narbrough recorded winds from the east in 42% of his morning and evening measurements, describing westerlies in

W., "Baron de W. aan Arlington, 14 Aug 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 177.

⁴¹ Ibid. Baron de. W., "Baron de W. aan Arlington, 17 Aug 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 180. Huneken, "Huneken aan den raad van Lubeck, 13 Aug. 1672," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 173.

⁴² Narbrough, "Journal of John Narbrough, Lieutenant and Captain of the *Fairfax*. September 18, 1672, to July 1, 1673. Pepysian MS. 2556," in *Journals and Narratives of the Third Dutch War*, ed. 126. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 179. Jones, *The Anglo-Dutch Wars*, 192.

an unusually low 53% of entries. Meanwhile at least 12 gales troubled the *Fairfax*, and their sustained winds of between 48 and 63 knots drove the vessel from the Dutch coast. After 1 December the weather moderated until, on 6 December, Narbrough was ordered to join a convoy of 78 merchant ships bound for the Baltic. The wind was calm until the 9th, when a wind of 37 knots rose and culminated in yet another severe gale on the 12th. Tempestuous fall weather is endemic to the North Sea during warm or cool climates, yet the autumn storminess of 1672 was exceptional even in the more violent conditions that prevailed during Little Ice Age minima.⁴³

On 16 December, the convoy experienced a powerful gale that endured until the morning of the 23rd. In a log entry written on 20 December, Narbrough described how severe easterly winds and repeated storms rendered convoy duty a risky enterprise. High winds and heavy seas increased the danger of collisions between ships or against the coast, and damaged merchant vessels even more than their relatively seaworthy escorts. By the 23rd the English convoy contained only 40 merchant vessels, with the rest scattered or destroyed by the storm. When the gale subsided, another storm rose on the morning of the following day. Before long its winds moderated, but on 28 December the fleet encountered a storm that raged for perhaps 13 days. During the gale, Narbrough's apparently rushed entries provided less meteorological data. Still, on 10 January Narbrough revealed that no work was possible owing to the heavy seas, and wrote that, "on board fifty five men very sick of a violent fever, some distracted with it."⁴⁴

On 3 January work was again impossible. While passing through Denmark on the 4th Narbrough recorded "a great rolling sea in the Sound, [so] that provisions could not get off to the

⁴³ Narbrough, "Journal of John Narbrough, Lieutenant and Captain of the *Fairfax*. September 18, 1672, to July 1, 1673," 232.

⁴⁴ *Ibid.*

ship.”⁴⁵ The convoy left Denmark and sailed out of the Baltic, bearing south towards Portugal as another storm blew between the 16th and the morning of the 20th. In a driving easterly on 2 and 3 February the *Fairfax* and other ships in the convoy lost their topmasts. As the fleet approached Lisbon that week, fever, likely stimulated or worsened by violent weather and irregular victuals, spread among the crew. Four men died aboard the *Fairfax* on 5 February, and two more perished on the 8th, including John Mayweather, an officer. Overall the logbooks kept by English captains Narbrough, Richard Haddock, and George Legge reveal an extraordinary frequency of storms and high winds in 1672 and 1673 (Figure 6.2). Of 930 morning and evening weather measurements taken during sorties between 7 January 1672 and 21 September 1673, 49%, or 452, recorded winds at or above 34 knots.⁴⁶ Storms with winds at or above 48 knots, a ferocious 89 km/hour, were described on 136 days, in nearly 15% of entries!⁴⁷

⁴⁵ Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Fairfax*. September 18, 1672, to July 1, 1673,” 241.

⁴⁶ The term “stout gale” could not be related to a Beaufort figure, and is here included among measurements below BF 8.

⁴⁷ George Legge, “Journal of George Legge, Captain of the *Royal Katherine*. March 9 1672/3 to September 14, 1673. Dartmouth MS. II,” in *Journals and Narratives of the Third Dutch War*, 298. Richard Haddock, “Journal of Richard Haddock, Captain of the *Royal Charles* and the *Sovereign*. May 11 1673 to June 29, 1673. Egerton MS 2521,” in *Journals and Narratives of the Third Dutch War*, 334. John Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672. Pepysian MS. 2555,” in *Journals and Narratives of the Third Dutch War*, ed. 108. John Narbrough, “Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673. Pepysian MS. 2556,” in *Journals and Narratives of the Third Dutch War*, ed. 200. John Narbrough, “Journal of John Narbrough, Captain of the *St. Michael*. July 1, 1673 to September 21, 1673. Pepysian MS. 2556,” in *Journals and Narratives of the Third Dutch War*, ed. 339. Herrera et al., *CLIWOC Multilingual Meteorological Dictionary*, 32.

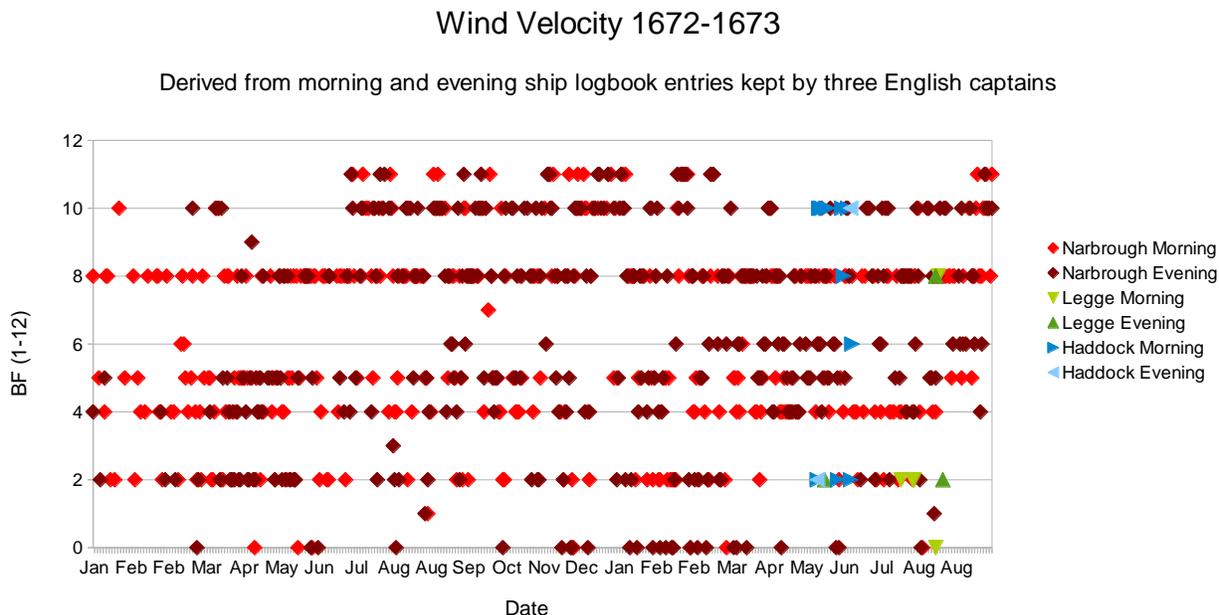


Fig. 6.2. Measurements of wind velocity recorded by Narbrough, Legge, and Haddock between 7 January 1672 and 21 September 1673, converted to the Beaufort Scale. The particular frequency of storms in 1672 after the repaired allied fleet left port in July is clearly demonstrated.

The Third Anglo-Dutch War at sea was contested in conditions where nearly half of all days were accompanied by winds so severe that they prohibited battle and constrained the possibilities open to naval commanders. In the warmer North Sea climate of the twentieth century, average days with winds at or above 34 knots range from just over 12 in December to approximately two in June and July. In the late Maunder Minimum, this gradient was less steep and storms were, in general, more common, as days accompanied by high winds ranged from roughly eight in March to nearly four in July. It is therefore probable that, in 1672 and 1673, persistent high winds in all seasons were rendered more likely by the onset of a colder climatic regime. During any early modern naval war the campaigning season from the late spring to early fall was particularly important, and storms in the warmer months were therefore especially influential. However, the journal kept by Captain Narbrough demonstrates that storms in colder months could also have substantial military consequences. Overall, the extraordinary frequency

of gales in 1672-73 was remarkable even for the tempestuous climate of the late seventeenth century.⁴⁸

High winds and incessant gales paralyzed allied naval operations while the Republic's fleet was generally diminished and less capable of resisting naval invasion. Indeed, on 24 August a Dutch traitor informed his English masters that, "this foule weather by sea and land [the Dutch] attribut (as they have reason) to a great providence."⁴⁹ Dutch advantages in stormy weather appear to have extended beyond the activities of major state fleets. In months accompanied by incessant gales, Dutch privateers captured far more prizes than their counterparts, crippling Anglo-French merchant shipping. With a third of the Dutch fleet decommissioned in the summer of 1672, and maritime trade ground to a halt, many of the Republic's seamen had few options beyond privateering. In September, the Republic's naval command, likely encouraged by unrelentingly violent weather, concluded that the Republic faced little threat from the sea and endorsed privateering. Thereafter mariners flocked to Dutch ports from Ostend, Dunkirk, Flanders, the Republic's remaining provinces, and the Holy Roman Empire. They took to sea in privateering squadrons that, accompanied with a fireship, could engage allied convoys. As in the Second Anglo-Dutch War, Dutch privateers, who lurked near sheltered coasts while sailing in ships that handled better in rough weather than those of their Anglo-French counterparts, may have benefitted when storms damaged allied merchant vessels.⁵⁰

Many of the gales that helped thwart allied operations in the North Sea were also felt across the Low Countries. In the last week of September 1672, William planned a combined land

⁴⁸ Wheeler, "British Naval Logbooks from the Late Seventeenth Century: New climatic information from old sources," 141.

⁴⁹ Baron de. W., "Baron de W. aan Arlington, 14 Aug 1672," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II*, 176.

⁵⁰ Baron de. W., "Baron de W. aan Arlington, 14 Aug 1672," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II*, 178. Baron de. W., "Baron de W. aan Arlington, 17 Aug 1672," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II*, 180. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 179. Jones, *The Anglo-Dutch Wars*, 30.

and sea assault on the French garrison in Naarden, a fortified town bordering the water line where it reached the Zuider Zee. On September 28th, William hoped to exploit persistent storms and torrential rain during the Dutch attack. High winds yielded to absolute calm on the night of the 27th, forcing the Prince to cancel the operation. In the evening of 10 October 8,000 soldiers under William's command attempted to retake the town of Woerden, which was defended by 1,500 French soldiers and bordered the front near Utrecht (Map 6.1). The effort failed when torrential rain brought by a severe gale drowned torches, filled trenches, and hampered attempts to take the town walls. Prolonged stormy weather stimulated by the climate of the Maunder Minimum generally benefitted the Dutch war effort by strengthening the water line and impeding the allies at sea. However, interactions between local environments and variations in hourly weather stymied the Republic's first counteroffensives in the fall of 1672.⁵¹

Across the front, wet, stormy weather continued through much of October. On 17 October, Adriaen van der Goes informed his brother that "the rain continues almost every day; tonight severely, as though it has not rained in a year."⁵² Persistent rain typical of the Maunder Minimum deepened the water line, but Van der Goes described how wet conditions also ruined harvests and flooded cellars in coastal provinces that depended on imported food even before the allied invasion. Despite strong winds, windmills could not dry the waterlogged landscape behind the water line, and Van der Goes predicted a winter of extreme hardship.⁵³ Indeed unusually cold weather in October and November encouraged soldiers on both sides of the water line to

⁵¹ Adriaen van der Goes, "Hage, den 13 October 1672," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 419. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 656.

⁵² "Het blyft noch al dagelicx regenen, desen nacht soo vervaerelyck offt in een jaer niet geregent hadde." Adriaen van der Goes, "Hage, den 17 Octob. 1672," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 425.

⁵³ "Hoewel het waeyt, connen het met de molens niet droogh houden; de beesten vertrappen al het gras, soodat een elendige winter voor de handt is." Adriaen van der Goes, "Hage, den 17 Octob. 1672," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 425.

dismantle houses, uproot trees, destroy fences, and undermine fortifications in the quest for firewood. Far more alarming for the remnant of the Dutch Republic was the threat posed by winter freezing. With December approaching, continually cold weather raised the prospect that the Hollandic Water Line would soon become crossable by the French and German armies.⁵⁴

In November, the French general Luxembourg resolved to launch an offensive when winter freezing had sufficiently thickened the ice of the water line. Thereafter he planned to lead 10,000 infantrymen across the narrow stretch of inundated land at the Lange Weide, south of Woerden and east of Gouda. From there, the allies would follow the dike that bordered the Rhine to reach Leiden, before marching over the coastal dunes to The Hague and forcing a Dutch surrender. In early December, William led a large army to the conquered territories of North Brabant and Limburg, but frigid temperatures threatened to freeze large swaths of the water line. Holland's hydraulic engineers struggled to keep the water from freezing by setting it in motion across the inundated lands, while farmers were mobilized to shatter the ice that did form. Few farmers volunteered, however, as easterly winds ushered in sub-zero temperatures that persisted for weeks. By the 18th the ice was crossable on the IJ before Amsterdam, and it was only with difficulty that warships were broken from the ice on the 22nd. On the 23rd thawing and rain briefly hindered allied plans for invasion, yet on the 24th the wind resumed from the east, with frigid temperatures in its wake. Crossing the Lange Weide remained perilous on the 26th and the 27th, yet over the Meijepolder the water froze more quickly than the ice could be broken. At 10:00 PM, Luxembourg and his troops abandoned their horses and artillery to cross the Meijepolder, beginning their march on The Hague.⁵⁵

⁵⁴ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 657.

⁵⁵ *Ibid*, 658.



Fig. 6.3. Detail of a Dutch propaganda pamphlet that depicts the French raid on Zwammerdam and Bodegraven in December, 1672. Left of centre, French troops march through the ice and water. Romeyn de Hooghe and Govard Bibloo, “Franse wreedheden in Bodegraven en Zwammerdam,” print, 1673, Rijksmuseum Amsterdam, <http://goo.gl/5XjR8k>.

In the early morning 12 allied soldiers drowned at Zegveld, yet the invaders pressed on. They constructed a bridge over the open water of the Haakwetering, then assembled another to cross the Slimmen Wetering. The second bridge initially collapsed, yet the French reached the towns of Zwammerdam and Bodegraven in the afternoon (Figure 6.3). After the towns were brutally sacked, cold weather yielded to rain and thawing, threatening to isolate the allied army behind Dutch lines. Luxembourg ordered a retreat to Utrecht, yet his army might have been trapped before the Rijndijk at Nieuwerburg had the Dutch garrison there kept its post. Instead, the main allied force successfully returned to Utrecht on the 30th, and stragglers were retrieved by boat in the face of Dutch naval superiority on the water line. On 1 January, persistent mild

weather melted most of the remaining ice, and the coastal provinces were again safe from invasion.⁵⁶

While the allies prepared for invasion in the cold temperatures that endured for most of December, the States Army marched across frozen marshes that would have impeded attack in warmer weather to retake the town of Coevorden near Groningen. A larger army under William also reclaimed Maastricht, yet between 16 and 22 December its siege of Charleroi, a critical French depot, was hampered by bitter cold. Frustrated, on 30 December William abandoned the siege and led his forces back to Gorinchem. Three days later, Van der Goes summarized his view of the Republic's plight by writing that "all earthly help is hopeless, and as soon as the freezing resumes we will surely be lost."⁵⁷ Soon after freezing did resume, provoking panic across the Republic's remaining provinces. However, following the first week of January storms, rain, and winds from the Southwest endured for two weeks, thawing ice and flooding additional land. In late January and early February, another cold spell required further breaking of ice throughout the water line, yet the weather warmed before the ice thickened enough for another allied crossing. A wet, stormy spring finally ended the danger of an allied invasion over the Hollandic Water Line.⁵⁸

While rainy, stormy, and accompanied by prolonged cold spells, the winter of 1672-73 was, on the whole, of moderate intensity relative to twentieth-century averages. The trekvaart, was halted for just two stretches, each totalling two weeks, and westerly winds frequently

⁵⁶ Adriaen van der Goes, "Hage, den 2 January 1673," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II*, 443. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 665. Israel, *The Dutch Republic*, 812. Vonk, *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*, 65.

⁵⁷ Adriaen van der Goes, "Hage, den 2 January 1673," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol. II*, 444.

⁵⁸ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 661.

accompanied periods of thawing.⁵⁹ The moderate severity of the winter, coupled with the arid spring of 1672, demonstrated that seasonal weather rarely featured all the meteorological conditions rendered more common during Little Ice Age minima. The weather of the Third Anglo-Dutch War was more complex than that of the second, when unusually cold temperatures, increased precipitation, easterly winds, and enhanced storminess had accompanied most seasons. In 1672-73 the weather experienced by soldiers and civilians generally reflected the climate of the Maunder Minimum, yet conditions rendered less common under the new climatic regime influenced both the collapse of the Republic's outer defences in the spring and the resilience of its inner defences in the winter. That reality underscores the limits and possibilities of climatic fluctuations as a category of analysis in the study of military history, for within the borders of the Republic in 1672 it was precisely when the homogeneity of weather accompanying a climatic regime faltered that local environments most affected the conduct of war.

In the spring of 1673 the Republic had survived its *rampjaar* and recovered enough to retake some of its losses. However, the success of the war launched by the English crown depended on quickly destroying the Dutch fleet and reducing the Republic. Persistent gales, the Dutch success at Sole Bay, and the resilience of the water line in a wet and relatively warm winter had rendered this impossible. By 1673 the initial funds gathered by the English crown could no longer finance its increasingly unpopular war. Charles resorted to summoning parliament in February, yet its ministers refused to release further funds unless all office holders swore an oath against Catholicism. James declined, thrusting his brother Rupert into overall command of the allied fleet. Once again allied commanders aimed to defeat the Dutch fleet at sea, and for the first time this desire was accompanied by a concrete plan for naval invasion. In May, merchant shipping was hired to land 10,000 infantry and 5,000 marines on the coast of

⁵⁹ Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 660.

Zeeland, where French cavalry would join them from the west. With the water line and its fortifications outflanked, the Republic's remaining provinces would have little choice but to surrender.⁶⁰

When the Dutch armada entered the North Sea in the second week of May, De Ruyter intended to sink flutes in the Swin, the narrowest point of the Thames. Thereby De Ruyter hoped to trap the deep-draughted English fleet and prevent its union with the French, yet remarkably his pilots were unaware of the existence of two other channels out of the Thames.⁶¹ This second attempt to prevent the union of the allied fleet was again hampered by the late arrival of the Zeeland squadron. Moreover, the first weeks of May were relatively dry after the torrential rains of the preceding months. As water levels declined the fleet was further delayed when the largest Dutch warships struggled to clear the Pampus before Amsterdam's harbour. On 12 May, the Republic's fleet arrived at the Thames in south-easterly winds, yet a spirited English defence foiled the Dutch operation, and the allied fleet united soon after.⁶²

Now outnumbered 2:3, the Dutch fleet retired to Schooneveld, covering the coast on which the English hoped to land.⁶³ The allied armada arrived off the shoals on 1 June, its commanders aware that the invasion was impossible while the Republic's fleet remained intact.

⁶⁰ Jones, *The Anglo-Dutch Wars*, 201. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 180.

⁶¹ The Barrow Deep and the Black Deep: less than ideal channels for a large fleet, but still useable in an emergency. Rodger, *The Command of the Ocean*, 83.

⁶² "Nieuwsbericht uit Antwerpen, 6 Mei 1673," in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, Vol. II, 176. Narbrough, "Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673," 282. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 662. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 180. Jones, *The Anglo-Dutch Wars*, 205. De Vries and Van der Woude, *The First Modern Economy*, 44.

⁶³ Accounts vary wildly as to the strength of the Dutch and allied fleets. Buisman and van Engelen, relying on de Jonge, describe 105 ships in the Dutch fleet to 140 in the allied armada. Hainsworth and Churches list just 52 vessels for the Dutch, compared with 76 for the allies. Legge, eyeing the Republic's fleet from afar, recorded "about 80 sail." Different numbers reflect a reliance on different sources, and, in particular, different ways of counting fleet strength. Smaller total likely reflect the number of great ships in each fleet, while far larger tallies probably account for ketches and other supporting craft. Overall, however, most accounts consistently describe a 2:3 ratio of Dutch to allied vessels. Legge, "Journal of George Legge," in *Journals and Narratives of the Third Dutch War*, 300. Rodger, *The Command of the Ocean*, 83.

Calm winds initially thwarted a battle, and then a lengthy gale forced both fleets to lie at anchor. The Dutch ships waited in relatively sheltered waters while the allied fleet, further to sea, suffered substantial damage.⁶⁴ When the wind moderated on 6 June, Rupert decided that his fleet would brave the shoals and attack in the morning. He emulated De Ruyter's tactics in the Battle of Sole Bay by organizing a vanguard of smaller ships.

However, in the morning the Dutch employed north-easterly winds to attack before the allied squadrons could be properly organized. When the battle was joined, Rupert's vanguard, inadequately brought to bear, lacked ships powerful enough to break the Dutch line. A squadron under Cornelis Tromp fought both the vanguard and the English red squadron to a standstill while drifting toward shallower water. The wind shifted to blow from the west-northwest, and Anglo-French crews were forced into frantic manoeuvres to avoid the shoals looming nearby. Meanwhile squadrons led by De Ruyter and Banckert sailed through the French division, cutting the allied fleet in two and regaining the weather gage. At nightfall the allies retreated to sea while the Dutch returned to Schooneveld. Despite the allied numerical advantage both sides lost only fireships, and both were burdened with an equal number of disabled vessels. After the battle George Legge concluded that allied captains feared running aground more than enemy fire, and when Rupert described the danger of shoals to Charles the allied fleet was forbidden from entering Schooneveld a second time. A tactical stalemate, the Battle of Schooneveld was a significant strategic victory for the Republic, thwarting invasion and damaging Anglo-French prestige.⁶⁵

⁶⁴ Edward Spragge, "Journal of Sir Edward Spragge," in *Journals and Narratives of the Third Dutch War*, 319. Legge, "Journal of George Legge," in *Journals and Narratives of the Third Dutch War*, 300. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 180. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 662.

⁶⁵ Edward Spragge, "Journal of Sir Edward Spragge," in *Journals and Narratives of the Third Dutch War*, 320. Legge, "Journal of George Legge," in *Journals and Narratives of the Third Dutch War*, 301. Brandt, *Uit het Leven en Bedrijf van den here Michiel de Ruiter*, 285. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de*

De Ruyter probably would have avoided battle on the morning of 7 June without a summer easterly rendered more common in the climate of the Maunder Minimum. The wind initially helped the Dutch foil Rupert's ill-conceived attempt to emulate De Ruyter's tactics in the Battle of Sole Bay, yet before long a change of wind temporarily granted the allies the weather gage. However, with the shoals nearby the westerly threatened to ground the deep-draughted allied ships, and therefore presented as much a danger as an advantage for the English and French. Frequent course adjustments attempted by allied captains to avoid the shallows likely helped De Ruyter's squadron outmanoeuvre the French division to regain the weather gage. Gales and an easterly, both atypical in June during a warmer North Sea climate but quite common during the Maunder Minimum, granted the outnumbered Dutch an initial advantage in the Battle of Schooneveld. Still, it was the complex and, for Dutch mariners, well-understood relationship between local environments and variable weather, only partially overlaid with the telltale signatures of a cooler climate, that helped the Republic's fleet thwart a naval invasion.

Following the battle, a week of renewed gales hindered allied attempts to mend their damaged ships, while the Dutch fleet, sailing near the sheltered coast, repaired and recruited more easily.⁶⁶ De Ruyter, aware of these advantages, employed three days of persistent easterly winds to surprise the allies on 14 June. Spragge was on a ketch, halfway towards Rupert's flagship, while the Dutch armada bore towards the Anglo-French fleet with the weather gage. Spragge inexplicably pressed on towards Rupert's vessel, delaying his return to his squadron and throwing the allied fleet into confusion. Meanwhile, the Dutch employed the north-easterly winds to bombard the allies at range, eventually forcing a retreat back to Sheerness. At dawn, De Ruyter commanded his subordinates to give chase, writing that "[the allies] will fight with me

Lage Landen, Vol. IV, 662. Jones, *The Anglo-Dutch Wars*, 206. Rodger, *The Command of the Ocean*, 83. Dreiskämper, *Redeloos, radeloos, reddeloos*, 76.

⁶⁶ Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 185.

when I desire, but I will not when they please.”⁶⁷ With French and English vessels still undergoing repairs, on 6 July the Dutch fleet appeared off the Thames, possibly to attempt a raid up the river. However, after five days an outbreak of plague forced its sailors to return to Schooneveld.⁶⁸

In England, public support for the war had been eroded by Dutch propaganda, losses to Dutch privateers, rising anti-Catholicism, mounting suspicion regarding French ambitions, and the obvious reality that victory was not forthcoming. Meanwhile, the army intended for naval invasion, crowded on requisitioned coal transports in a fleet that overflowed the harbour of Yarmouth, was forced to retire to Harwich to avoid storms and the risk of a Dutch attack. Consequently an invasion was impossible on short notice, ensuring that the war would continue for weeks even if the Dutch fleet could be defeated at sea. With English finances teetering on the brink of collapse and the war effort in disarray, Charles visited Rupert aboard the *Royal Sovereign* on 26 June. Rupert was ordered to present the allied fleet to the Dutch before Schooneveld, attacking only if the position of the enemy and the state of the weather provided an advantage. If battle could not be forced on allied terms, Rupert and his subordinates would sail north to Texel, where an inbound VOC fleet was expected. Plundering East Indiamen would help finance the war, and if the Dutch were drawn out from Schooneveld there were few shoals immediately off the western coast of Texel that would hinder the allies.⁶⁹

⁶⁷ Haddock, “Journal of Richard Haddock,” in *Journals and Narratives of the Third Dutch War*, 336. Spragge, “Journal of Sir Edward Spragge,” in *Journals and Narratives of the Third Dutch War*, 322. Legge, “Journal of George Legge,” in *Journals and Narratives of the Third Dutch War*, 303. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 662. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 185. Jones, *The Anglo-Dutch Wars*, 206.

⁶⁸ Haddock, “Journal of Richard Haddock,” in *Journals and Narratives of the Third Dutch War*, 338. Edward Spragge, “Journal of Sir Edward Spragge,” in *Journals and Narratives of the Third Dutch War*, 323. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV*, 662. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 185. Jones, *The Anglo-Dutch Wars*, 206. Rodger, *The Command of the Ocean*, 84.

⁶⁹ “Besluit, 26 Juli 1673,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen, Vol. II*, 288. Jones, *The Anglo-Dutch Wars*, 202.

On 31 July the allied fleet of 86 men-of-war appeared before Schooneveld, claiming the weather gage in calm north-westerly winds and drawing out the 60 ships in the Dutch armada. A sudden wind shift to the southwest helped the Dutch claim the weather gage, but De Ruyter opted to avoid battle and instead protect the coast from naval invasion. Accordingly the allied fleet sailed north for Texel, and the Republic's admirals rightly feared a trap. However, on 2 August William III instructed De Ruyter to engage anyway, believing that the exhausted English naval system would not survive another costly battle. The Dutch fleet therefore bore north for Texel, yet a severe gale rose on 14 August and continued for six days, preventing battle. Narbrough, now captain of the *St. Michael*, wrote on the 14th that "we had much water on the gundeck," which, pouring down into the hold, "wet all the sails in the Boatswain's store-room . . . wet the stores in the Carpenter's store-room . . . wet 20 pounds of paper cartridges filled with powder in the powder-room and some barrels - at present we cannot tell the quantity - and wet most of the match and several other things in those rooms." The loss of these critical provisions was compounded on the following day when high winds inflicted further damage. On 17 August the storm precluded travel between ships, but the winds finally moderated on the 19th. Shortly thereafter, the Dutch fleet was spotted on the horizon. At daybreak on 20 August the wind blew from the north-east, and the direction of the wind, which did not initially favour either the allies or the Dutch, encouraged their sailors to engage in a race for the weather gage.⁷⁰

⁷⁰ These numbers, given by Hainsworth and Churches, do not include fireships and may understate the size of both fleets. Narbrough claimed that 60 ships, in addition to fireships, constituted only the Dutch divisions that engaged the English red and white squadrons. In that case Tromp's squadron of 26 ships, and an additional 7 vessels belonging to the Zeeland squadron, should be added to Dutch fleet, which would then number 93 vessels (again, not including fireships). What is certain, however, is that the allied armada was significantly larger. Narbrough, "Journal of John Narbrough, Captain of the *St. Michael*," in *Journals and Narratives of the Third Dutch War*, 352. Some of Spragge's last entries describe the fury of the storm. Spragge, "Journal of Sir Edward Spragge," in *Journals and Narratives of the Third Dutch War*, 329. "The true relation of the battle fought between the English and French against the Dutch near the Texell, the 21 of August 1673," in *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II*, 288. Jones, *The Anglo-Dutch Wars*, 201. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 186.

The ships furthest east would claim the weather gage and, in turn, dictate the terms of battle. Accordingly at sunset both fleets braved the confusion of darkness and continued to sail towards the Republic's coast. However, with the shoals approaching, the French squadron twice disobeyed Rupert's orders and shortened sail, forcing the English to hang back and, at 1:00 AM, allowing the Dutch to shoot ahead. With first light at 6:00 AM, the allies tacked while the Dutch bore down with a rising south-easterly wind. Having claimed the weather gage, De Ruyter could employ his tactics for engaging a superior force, which allowed the Dutch to concentrate on the enemy's main body while sending smaller squadrons to occupy the remaining allied divisions. At 8:00 AM the majority of the Dutch fleet under admirals De Ruyter and Banckert attacked Rupert's red squadron and the centre of the allied line. Tromp's division engaged Spragge's blue squadron, while just seven men-of-war with three fireships from the Zeeland squadron assaulted the entire French armada. As the battle was joined the easterly wind blew the black cannon smoke west from the Dutch vessels to enshroud the allied men-of-war. Unable to see beyond their immediate surroundings, allied commanders were forced to fight three scattered battles, and the bulk of the opposing fleets therefore engaged on relatively equal terms.⁷¹

At 9:00 AM a thick layer of fog further isolated each engagement. In the resulting confusion, Tromp's division and its superior gunners devastated blue squadron, while the French ships sailed south-west for so long before tacking that they effectively abandoned the battle. At noon, red squadron, the core of the English fleet, began to give way as it was bombarded on three sides by Dutch divisions under De Ruyter and Banckert. At 2:00 PM the wind shifted to blow hard from the south-southwest, lifting the veil of smoke and revealing the plight of blue squadron. Rupert ordered his remaining seaworthy ships to relieve Spragge's division, but the

⁷¹ Narbrough described how the Dutch, "being to windward, caused so great darkness with their smoke, that I could not see any of our Red Squadron what they did, there being a continual smoke." Narbrough, "Journal of John Narbrough, Captain of the *St. Michael*," in *Journals and Narratives of the Third Dutch War*, 355.

majority of the Dutch fleet followed, and again both armadas sailed east in parallel. Red squadron arrived before Tromp's vessels could seize or destroy Spragge's disabled flagship, but Spragge had perished while in transit to another vessel. The French, nearly ten kilometres distant, ignored Rupert's signal to engage the Dutch, and by nightfall the English were forced to retreat west with many crippled vessels. Miraculously, neither fleet had lost a ship, although the allies ultimately captured four VOC vessels before and after the battle.⁷² On the other hand, a simultaneous Dutch raid on Anglo-French colonies in the Americas was spectacularly successful, and in the North Sea the badly damaged allied fleet would take months to repair. For the allies, retaining command of the sea – let alone attempting a naval invasion – was now impossible. As if to underscore the new reality, the Republic's fleet reappeared off the Thames on 3 September.⁷³

Rendered more likely by the climate of the Maunder Minimum, the gale that delayed the Battle of Texel or *Slag bij Kijkduin* likely damaged both fleets, although the allies, sailing farther from shelter, may have suffered more. More important for the course of the battle, and the war, was the easterly that persisted from the morning of the 20th to the afternoon of the 21st. Blowing

⁷² One was seized on the 20th, while three more were taken when the English recaptured the island of St. Helena in the southern Atlantic. Jones, *The Anglo-Dutch Wars*, 212. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 186.

⁷³ After recording south-westerly winds that evening, Narbrough reported that “the enemy and our fleet parted; we having the weather gage of the enemy, stood away from them, a sight unpleasant to the English seamen. I hope never to see nor not hear of the like again. I had rather fall in the battle than ever to see the like more, that so mighty a fleet of ships as ours is to stand away, as now we do, from so mean a fleet as the Dutch fleet is to ours.” Narbrough, “Journal of John Narbrough, Captain of the *St. Michael*,” in *Journals and Narratives of the Third Dutch War*, 361. “Nieuwsbericht uit Amsterdam, 21 Aug. 1673,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen*, Vol. II, 303. “A relation of the battle fought,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen*, Vol. II, 306. “A briefe relation of the engagement,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen*, Vol. II, 309. John Narbrough, “Captain Narbrough's relation of the battle,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen*, Vol. II, 312. “A relation of the French squadron,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen*, Vol. II, 325. “Nieuwsbericht uit Amsterdam,” in *Bescheiden uit Vreemde Archieven omtrent de Grooten Nederlandsche Zeeoorlogen*, Vol. II, 330. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 664. Jones, *The Anglo-Dutch Wars*, 209. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 187.

in a month in which westerlies prevailed during warmer climates, and part of four-day stretch during which logbook entries recorded easterlies, the wind that helped shape the battle was probably stimulated by the colder climate of the Maunder Minimum. Its influence was, of course, mediated by the unique nature of both naval systems, and indeed the wind blew from a direction in which either fleet could theoretically have claimed the weather gage. Still, even if the French squadron had not twice shortened sail, the superior seamanship of the Republic's mariners, and the shallow hulls of their ships, likely would have granted them the weather gage.

For crews aboard warships, the weather gage was important before, during, and sometimes immediately after any naval battle in the age of sail. However, it was especially critical for the Dutch before the Battle of Texel, because it allowed De Ruyter to deploy his tactics for engaging a superior force. These tactics depended, in part, on separating each engagement, and the smoke that blew from windward ships to isolate the English divisions was therefore also of particular significance. The effect of the smoke was exacerbated by fog, which was probably stimulated by the south-easterly wind blowing warm air over water likely chilled in a cool summer typical of the Maunder Minimum. When the wind did shift to the southwest in the afternoon, it blew at approximately 37 knots for 24 hours, preventing the allies from opening all their gunports and further tilting the odds in favour of the less numerous Dutch. The relationship between weather associated with the Maunder Minimum, and the marine environment off Texel, maximized the effectiveness of De Ruyter's tactics and helped the Republic claim another improbable victory.⁷⁴

Reports sent by Rupert and other English officers in the wake of the battle were sharply critical of the French. Fanned by Dutch propaganda, they helped intensify anti-Catholic and anti-

⁷⁴ Narbrough, "Journal of John Narbrough, Captain of the *St. Michael*," in *Journals and Narratives of the Third Dutch War*, 361.

French sentiment in England that increasingly bridged all social strata. English commerce was halted by the Republic's fleet as Dutch trade finally resumed, and William organized an alliance against France. Brandenburg, Lorraine, the Emperor of the Holy Roman Empire, Spain, and later Denmark joined the Republic in resisting the territorial ambitions of Louis XIV. Meanwhile, the States Army under William III had grown into a large and effective force. On 1 October, Münsterite troops attempted to retake the fortress at Coevorden by damming the river Vecht, yet persistent torrential rains raised water levels so high that the dam was swiftly breached. As the broader war transformed into a conflict between Habsburg and Bourbon, the Republic's army seized the critical French supply depot at Bonn on 12 November. On 23 November the core of the French army, its position in the Republic increasingly untenable, was forced to retreat from Utrecht to the IJssel line. They travelled by foot, because easterly winds and unseasonal freezing impeded travel by boat. The majority of the Republic was swiftly restored and Bernhard von Galen soon sued for peace, although the war with France would continue until 1678.⁷⁵

England concluded its Third Dutch War by signing the Treaty of Westminster on 19 February 1674. The Dutch annexed Surinam and the English reclaimed New Amsterdam, but for the financially exhausted English government the treaty was a humiliating confirmation of the status quo. The Dutch did not recognize England's "sovereignty of the seas," and regained the right to fish in the North Sea without compensating the English government. The success of the Dutch privateers had devastated English merchant shipping, significantly delaying the rise of England's supremacy in global commerce. Worse, the terms of the secret Treaty of Dover could be revealed by the French at any time, destabilizing the English monarchy. By undermining the

⁷⁵ Israel, *The Dutch Republic*, 813. Buisman and Van Engelen, *Duizend jaar weer, wind en water in de Lage Landen*, Vol. IV, 666.

credibility of Charles and the Duke of York, the war ultimately contributed to the success of Dutch propaganda prior to the Glorious Revolution of 1688.⁷⁶

Conclusions: Climate, Weather, and the Anglo-Dutch Wars of the Seventeenth Century

In 1980, Jan de Vries argued that most “historians of climate” placed “excessive emphasis on identifying changes in meteorological magnitudes.” For De Vries, “the consequences of climate changes do not flow only, probably not even primarily, from differences in *level*; they also flow from differences in *variance*.”⁷⁷ Certainly meteorological variability, often expressed in weather that was unusual during different climatic regimes, affected the course of military operations in every Anglo-Dutch War. In the first war, an easterly storm raised tensions between the Anglo-Dutch fleets by encouraging Tromp to seek shelter near the English coast, and in the second war westerly winds helped prevent the Dutch armada from leaving port before the Four Days’ Battle until after the English fleet was divided. Later, calm winds during the St. James’s Day Fight allowed the English to safely open all their gunports, while a westerly quickened the retreat of De Ruyter’s squadron after the Dutch line disintegrated. In the third war, unusual dryness in the first months of 1672 helped the French cross the Rhine and outflank the IJssel line, then initially slowed the pace of inundation so that the heart of the Republic lay open to invasion for two critical weeks. Finally, the moderate intensity and frequent thawing of the winter of 1672-73 aided Dutch efforts to maintain the Hollandic Water Line as a barrier to invasion.

⁷⁶ Jones, *The Anglo-Dutch Wars*, 216. Hainsworth and Churches, *The Anglo-Dutch Naval Wars*, 190.

⁷⁷ De Vries, “Measuring the Impact of Climate on History,” 626.

The long climatic history of the Little Ice Age in Northern Europe can be defined less as a prolonged period of cold, wet, and stormy weather than a turbulent stretch of meteorological variability following the relatively stable warmth of the Medieval Climatic Anomaly. However, changing relationships between climate, weather, and competing military regimes in the Anglo-Dutch Wars reveal the limits of meteorological variability as a useful trope for the synthesis of environmental and military histories. While westerly winds, warm days, or droughts were hardly rare during the Maunder Minimum, ship logbooks, diaries, and correspondence written by both Dutch and English authors reflected a pronounced shift to a generally colder, wetter, stormier climate that stimulated more easterly winds. Between 1652 and 1674, the influence of such weather rippled through every level of the military systems that contested each Anglo-Dutch War.

In the first war, persistent westerlies allowed English privateers to set the terms of battle, plausibly contributing to their remarkable successes. Westerlies also enabled supply ships to easily leave port and quickly provide victuals to English blockades. In battles, English ships of unprecedented size, guided into line of battle tactics by artillery commanders, were most effective when calm, westerly winds allowed bombardment at range with all gunports open. Not only did the English win more than twice as many major battles in the first war than in the latter wars combined, but prevailing westerlies also discouraged Dutch raids into the Thames Estuary and beyond. Storms with westerly winds also inflicted an unequal toll, and repeatedly scattered Dutch vessels or destroyed them on lee shores while English armadas sheltered nearby. Admittedly, the weather common under the slightly warmer climate that divided the Grindelwald Fluctuation from the Maunder Minimum did not directly cause the English to prevail during the First Anglo-Dutch War. For example, it was England's deep harbours, easy access to iron, earlier

civil war, and distinct maritime culture that encouraged the leaders of its naval system to develop the revolutionary fleet that defeated the wealthier Dutch. Weather shaped by a warmer climate was therefore one influence among many. It stimulated changes in local environments that, in turn, interacted differently with the unique maritime expressions of competing Anglo-Dutch naval systems.

However, by 1664 both the Dutch naval system and the regional environment had changed. Although they retained their wide lines and shallow draughts, many of the Republic's new vessels increasingly pushed the limits of ship size imposed by shallow Dutch harbours, and Dutch naval commanders adopted elements of English line of battle tactics. Moreover, the coming of the Maunder Minimum had altered the patterns of prevailing weather that benefitted the English a decade earlier. In the Second Anglo-Dutch War, the Republic's privateers were likely assisted to their prey by persistent easterlies, and elements of the Dutch galiot intelligence network could probably manoeuvre more rapidly to new positions. Frequent high winds often persuaded English captains to close their lower gunports, while easterlies helped the Dutch claim the weather gage during major battles and, most famously, the triumphant raid on the Medway.

Meteorological conditions differ from year-to-year during any climatic regime. The weather that influenced the Third Anglo-Dutch War, while generally typical of the Maunder Minimum, was not identical to that which had prevailed five years earlier. Gales and high winds were more common, thwarting allied attempts to exploit their superiority at sea when the Dutch fleet was partially dismantled. Easterlies were less frequent than they were in the second war, but still more common than they had been in the first, and it is likely that this again benefitted Dutch privateers preying on storm-damaged merchantmen. Despite an ill-timed dry spell in early 1672, precipitation, which had been abundant in the second war, was also plentiful in the third. The

invasion of a Münsterite army under Bernhard von Galen had been slowed by torrential rain in 1665, and in 1672 the Bishop's siege of Groningen was undermined by a similar deluge. On land, as at sea, Dutch commanders and ordinary soldiers, working within the context of their distinct military system, exploited unique relationships between regional environments and the weather rendered more common during the Maunder Minimum. Elevated land underwater, combined with high easterly winds, allowed De Ruyter to exploit the advantages of Dutch ship design by developing revolutionary tactics aimed at defeating a superior force. Meanwhile, the low-lying Dutch landscape encouraged the design of watery defences that, when strengthened by persistent precipitation, provided a formidable barrier against invasion.

Competing military systems also reflected broader structures that were equally influenced by weather rendered more common in different climatic regimes. Cold winters and damaging storms delayed ship construction and fleet assembly in the Second and Third Anglo-Dutch Wars, while persistent easterlies fanned the great fire of London in 1666. Overall, it may be that the flexible networks of trade that contributed so much to Dutch prosperity adapted more easily to climatic transition than the agricultural economies of England and, in particular, France. On the other hand, history is about people, and people, while influenced by structures, are not inevitably bound by them. At sea and on land, civilian and military leaders were pressed towards particular decisions by the weight of interactions between cultural and environmental structures. Still, Van Wassenaer did not attack in easterlies before the Battle of Lowestoft, the Duke of York's gentleman-in-waiting instructed his captain to shorten sail in the battle's aftermath, Rupert departed before the Four Days' Battle while Monk engaged a superior force, and Luxembourg dithered as the Hollandic Water Line was filled. A structural analysis can shed new light on why

historical actors felt compelled to act in one way or another, but every historical narrative must acknowledge the enduring importance of human agency.

In 1622, Francis Bacon ended his *Historia Ventorum*, or “History of the Winds,” with a list of desiderata stemming from his investigation. Desideratum III advised that “ways be found to predict the risings, fallings, and times of winds; this would be useful for navigation and agriculture, and most of all for choosing times for sea battles.”⁷⁸ Bacon’s call for action suggests that military commanders sought ways of predicting weather, although long-term weather forecasts would not be developed until the nineteenth century. Moreover, most early modern soldiers believed that demonic or divine influences were behind the meteorological conditions that influenced military success or failure. Still, in the First Anglo-Dutch War, Commonwealth naval strategists developed line of battle tactics that, for the English, were especially effective in calm, westerly winds. After the coming of the Maunder Minimum, Dutch commanders attacked from shoals, raided English rivers, and inundated land to form a defensive barrier. These strategies were facilitated by more frequent easterlies, more common high winds, and generally increased precipitation.

Many Dutch mariners had spent decades at sea, and even the most unseasoned commanders in the fleets that contested the Anglo-Dutch Wars respected how weather influenced success or failure. On land, generals and their subordinates understood, for example, how rain rendered roads impassable, cold winters hampered sieges, storms thwarted attack, and drought compromised waterways as defensive barriers. Certainly soldiers at sea and on land remembered exceptional weather, but when recording daily weather did officers discern long-term changes in average daily weather and plan accordingly? Unfortunately, neither surviving

⁷⁸ Thanks to Sam White of Ohio State University for bringing this passage to my attention. Francis Bacon, *Historia Ventorum*, Vol. 12. (Oxford: Oxford University Press, 2007), 129.

correspondence nor ship logbooks reveal if the tactics of the Anglo-Dutch Wars emerged from a growing awareness among military officers that North Sea weather patterns had changed. Still, it is probable that, at the very least, these tactics were unconsciously shaped by the weather that accompanied the transition from the warmer climate of the mid-seventeenth century to the cooler Maunder Minimum.

PART III: CONCEPTUALIZING CLIMATE CHANGE

Dutch Culture and the Little Ice Age, 1565-1720, and Modern Understandings of Climate History

The changes in prevailing weather that accompanied the Little Ice Age in the Dutch Republic were perceived, understood, and exploited in the context of a culture that was distinct within early modern Europe. To contemporaries, the culture of the Dutch Golden Age was most importantly expressed through the nebulous, frequently violated, but influential concepts of freedom, equality, and toleration. These ideals informed a thriving intellectual life that was sustained by commerce, informed by scholarship, and most spectacularly reflected in visual art. The freedom, equality, and toleration experienced by the citizens of the Republic were substantial in the context of conditions elsewhere in Europe. Visitors to the Republic routinely expressed their horror at its relatively relaxed class distinctions and religious heterogeneity. However, freedom of expression was, in practice, circumscribed in a plutocracy that largely adhered to Calvinist norms. Moreover, the Republic's large but rarely studied urban *lumpenproletariat* scarcely experienced the benefits of their supposedly enlightened culture, not to mention the victims of the Dutch slave trade.¹

Nevertheless, substantial freedoms did exist for many Dutch citizens relative to conditions elsewhere in Europe. The cultural values that informed these freedoms largely predated Dutch pre-eminence in trade but ultimately contributed to the efficiency of the world's most dynamic commercial economy. They also reflected the atavistic decentralization of the Dutch state, which, although possessed of a generally orderly and stable civic culture, nevertheless recognized a bewildering number of local privileges. Comparative freedom and toleration encouraged the Republic's remarkable intellectual life, even if the latitude given to open expression was limited by modern standards. Moreover, the dynamism of Dutch scholarship was not divorced from broader Dutch society. In the context of seventeenth-century

¹ Israel, *The Dutch Republic*, 4, 565, 637. Israel, *Dutch primacy in world trade*, 355. Harold J. Cook, *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age*. (New Haven: Yale University Press, 2007), 10.

Europe, the Republic, and particularly Holland, was exceptionally urbanized, highly literate, and possessed of a striking variety of technological innovations that, like the *trekvaart*, improved the lives of ordinary citizens.²

The Republic's culture, industry, commerce, and military power were mutually constitutive, as cultural attitudes enabled commercial expansion that, when supported by military force, sustained new and evolving industries that could kindle fresh cultural approaches. The order of these interactions could change, but entanglements between Dutch culture, industry, and commerce consistently shaped the history of the Republic's Golden Age. Commercial pressure encouraged mapmaking, for example, which stimulated the Dutch paper industry, spurred the rise of cartography in Amsterdam, and informed the military and commercial expansion of Dutch trading interests that, in turn, had cultural ramifications.³

The following chapter, and the conclusion, explore how climate change can be understood. The chapter investigates how different groups within the Republic's distinct culture perceived weather, discerned climate change, and responded culturally. It probes to what extent the Dutch cultural reaction to early modern climate change reflected its material influence. The conclusion examines how an analysis of the Little Ice Age in the Dutch Republic can refine how historical climatologists today understand relationships between climate change and human history. It also considers how the major findings of this dissertation can inform both the scholarly understanding of early modern Europe, and interdisciplinary projections of life on a warmer planet.

² Israel, *The Dutch Republic*, 6. Price, *Dutch society, 1588-1713*, 55. Haley, *The Dutch in the Seventeenth Century*, 49. De Vries and Van der Woude, *The First Modern Economy*, 15, 60. Prak, *The Dutch Republic in the Seventeenth Century*, 5. Israel, *Dutch primacy in world trade*, 70. Karel Davids, *The Rise and Decline of Dutch Technological Leadership Vol. I*, 12.

³ De Vries and Van der Woude, *The First Modern Economy*, 73. Price, *Dutch society, 1588-1713*, 54. Marika Keblusek, *Boeken in de Hofstad: Haagse boekcultuur in de Gouden Eeuw*. (Hilversum: Uitgeverij Verloren, 1997), 27.

Chapter 7

Understanding Weather and Climate Change in the Dutch Republic

Two major case studies have here explored how climatic fluctuations during the Little Ice Age influenced the production and defence of wealth during the height of the Dutch Republic. Culture in the Republic informed, and was shaped by, these military and economic enterprises. Accordingly, this dissertation concludes with an analysis of the cultural perception and reception within the Republic of what is today known as the Little Ice Age. “Culture” is a broad, contested term, prone to slip from the grasp of historians whose cultural history has grown to encompass all aspects of human experience. In this chapter, “culture” is limited to a way of structuring thought. It incorporates ways of perceiving weather, understanding the atmosphere, and conceptualizing climate change. It also includes methods of responding to weather that became more or less likely under different climatic regimes. Some of these intellectual responses were reflected through behaviour, and such behaviour can shed light on mental landscapes influenced by weather, if surviving sources explicitly describe a connection. However, the development of cultural norms and values usually reflect centuries of complex interactions between human and natural structures. This chapter explores the brief disruptions in these relationships, but identifying the influence of climatic fluctuation in their long-term evolution is beyond its scope.⁴

In the Dutch Republic, diverse understandings of weather and climate change informed dramatic but occasionally ambiguous cultural responses. The attitudes expressed and shaped by conceptions of, and responses to, weather may have contributed to the resilience of the Republic

⁴ Peter Burke, *What is Cultural History?* (Cambridge: Polity Press, 2008), 3. Anne Goldgar, *Tulipmania: Money, Honor, and Knowledge in the Dutch Golden Age*, 14. Dena Goodman, *The Republic of Letters: A Cultural History of the French Enlightenment*. (Ithaca: Cornell University Press, 1996), 2.

during the climatic fluctuations of the Little Ice Age. Nevertheless, the cultural reception of weather and climate change was complicated by the social heterogeneity of the Low Countries.⁵ Although popular culture and scholarly culture were less sharply differentiated in the Republic than they were elsewhere in Europe, weather was differently understood by members of groups that were divided by education and affluence. This general distinction was sharpened in the course of the seventeenth century. Dutch scholars gradually developed a more secular natural philosophy, but supernatural explanations for weather persisted much longer among other literate observers, while particularly practical attitudes dominated among the less educated. Still, conceptions of weather developed by citizens of similar social status were hardly homogenous. For example, the persecution of witches believed to be responsible for bad weather was rare in the Republic, but trials, when they did occur, were the product of local beliefs held by different social groups that did not necessarily reflect broader social attitudes.

As Dutch observers sought to identify the spiritual significance, natural origin, and practical consequences of weather, they compared meteorological conditions in their present with events in the past. While limited to extreme weather, these comparisons were remarkably accurate, and they allowed some scholars to identify long-term meteorological patterns. Such academic inquiry contributed to an emerging understanding in the Republic that patterns of prevailing weather were unstable and had changed. That understanding was an important first step towards the perception of climate change, if not the scientific comprehension of the physical processes involved. However, surviving sources record no explicit awareness of changes in average weather patterns over the decadal scales relevant for climate history, although such changes were certainly recorded in ship logbooks and weather diaries.

⁵ Indeed, as it is in all societies, past or present.

Artistic responses to weather in the Republic demonstrate the importance for Dutch citizens of storms, cold winters, and other meteorological conditions rendered more common during the minima of the Little Ice Age. On the other hand, depictions of such weather events in contemporary literature and visual art were shaped not only by the whims or commercial instincts of each artist, but also by social, economic, and cultural structures. Consequently they hint at, but do not necessarily reflect, the influence of contemporary climatic fluctuations. Like art, the concurrent development of new technologies and practices that exploited weather conditions more common during Little Ice Age minima was shaped by, and in turn helped shape, ways of structuring thought. These material expressions of culture may have been more directly encouraged than art by weather that accompanied the minima of the Little Ice Age, without which they would have been less effective. However, they were also mediated by a web of human structures, and, like contemporary art, do not necessarily demonstrate the influence of climatic fluctuation. Overall, some cultural responses to weather and climate change were fairly transparent in the Dutch Republic, while others were much more uncertain than many historians of climate have allowed.

In some respects this chapter follows recent trends in the large and dynamic historiography of the Republic's culture; in other aspects it resists them. Cultural historians, art historians, and historians of science interested in the Dutch Golden Age increasingly explore social networks that were often transnational and included more than just the learned elite. Knowledge, in particular, was created and eagerly absorbed by artisans, merchants, sailors, soldiers, farmers, and labourers, who could, in turn, communicate their discoveries to those of greater social standing. This chapter explores the way conceptions of weather were developed and received by members of diverse "social networks," primary in the Republic but also in

England.⁶ Nevertheless, it is limited by the unique constraints of historical climatology. References to weather abound in sources written by a diverse range of Dutch citizens, yet reflections on the significance of weather, let alone its long-term trends, were luxuries largely limited to the diaries and correspondence of the predominantly male elite.⁷

This chapter investigates diaries, correspondence, chronicles, and poetry written by Jan de Witt, Anthonis Duyck, Nicolaes van Wassenaer, Pieter Christiaanszoon Bor, Gerard Brandt, Michiel Adriaanszoon de Ruyter, Hans Svendsen, Cornelis Cornelis, Pieter Janszoon Twisck, the brothers Van der Goes, Claas Caescoper, Coenraad van Beuningen, Balthasar Bekker, Jan de Pottre, Pier Winsemius, Lieuwe van Aitzema, Hugo de Groot, Gustaaf Van Imhoff, Joost van den Vondel, Ralph Josselin, Robert Hooke, John Narbrough, and Francis Bacon. All of these men, even the miller Caescoper and the English captain John Narbrough, were relatively prosperous and respected in the context of their societies. The main source examined for the insights of the poor were thousands of letters written to sailors in the Republic's fleet and intercepted by English vessels during the Anglo-Dutch Wars. Within that correspondence, only letters written by Janneke Aengenendt and Jan Tijssen Eikenboom described weather and its consequences with any detail.

Pamphlets, popular poetry, illustrations, paintings, and newspaper articles have also been analyzed, and these were likely read or admired by Dutch citizens across boundaries of class and gender. However, much of the cultural responses to weather and climate explored in this chapter were composed by the Republic's male elite. Certainly, the creation and reception of weather and

⁶ In this it builds on Lisa Jardine's analysis of the increasingly networked intellectual cultures of England and the Dutch Republic. Jardine, *Going Dutch: How England Plundered Holland's Glory*, 266.

⁷ Anne Goldgar, *Tulipmania: Money, Honor, and Knowledge in the Dutch Golden Age*, 15. Anne Goldgar, *Impolite Learning: Conduct and Community in the Republic of Letters, 1680-1750*. (New Haven: Yale University Press, 1995), 10. Cook, *Matters of Exchange*, 2. Simon Schama, *The Embarrassment of Riches: An Interpretation of Dutch Culture in the Golden Age*. (Berkeley: University of California Press, 1988), 4.

perhaps climate knowledge may have been a product of communication between diverse social networks in the Republic. However, this chapter suggests that the interpretation, and to a lesser extent the communication, of weather knowledge was still restricted by class and gender, especially when it had little practical relevance.⁸

The character of knowledge developed in the Republic is also explored in this chapter. Eric Jorink has argued that historians like Jonathan Israel and Harold Cook have long described the intellectual culture of the Dutch Golden Age as “primarily rational, pragmatic, utilitarian and non-metaphysical, if not anti-metaphysical.”⁹ In making this claim Jorink simplified the arguments of Israel, Cook, and many other Dutch historians of science.¹⁰ Israel, for example, carefully considered the fiercely contested origin of the Enlightenment in the universities of the Republic. Cook examined utilitarian knowledge not because it characterized all intellectual life in the Republic, but because he was concerned with its connection to Dutch commerce. Still, neither Israel nor Cook examined the enduring importance of theology in the development of the new intellectual attitudes of the seventeenth century, and this is the focus of Jorink’s work. While this chapter does identify an increasing secularism in the meteorological attitudes of seventeenth-century Dutch scholars, it broadly supports Jorink’s conclusions. Well into the seventeenth century, supernatural explanations for weather and speculation as to its consequences remained influential among educated Dutch citizens.¹¹

⁸ There is also a troubling aspect to the historiographical turn towards narratives that problematize divisions between class, gender, and ethnicity. In blurring these distinctions, historians can miss historical power inequalities and risk obscuring divisions that contextualize modern social problems.

⁹ Eric Jorink, *Reading the Book of Nature in the Dutch Golden Age*. (Leiden: Brill, 2010), x.

¹⁰ Not all Dutch historians of science, however. In 1981 Dirk Jan Struik typified the attitudes of some of these historians by writing that “the attempt to understand and control nature by reason and experiment has remained typical of all phases of capitalism,” including the phase that was pioneered by the early modern Dutch Republic. Struik, *The Land of Stevin and Huygens*, 72.

¹¹ Cook, *Matters of Exchange*, 136. Jorink, *Reading the Book of Nature in the Dutch Golden Age*, 5. Jonathan I. Israel, *Radical Enlightenment: Philosophy and the Making of Modernity, 1650-1750*. (Oxford: Oxford University Press, 2001), 67. See also: Barbara M. Benedict, *Curiosity: A Cultural History of Early Modern Inquiry*. Chicago:

Some historians have expressed considerable, and justified, skepticism about scholarship that identifies relationships between large material structures – like the environment – and broad cultural developments.¹² Studies that discern relationships between environment and culture too often assume that the artistic representation of the natural world follows straightforwardly from its perception. In fact, the rich historiography of art¹³ in the Dutch Republic has revealed to what extent superficially realistic depictions of reality were never direct transcriptions of the natural world. Like literature, paintings and illustrations, usually created in studios far removed from depicted events, often had many meanings. Art reflected or defied cultural norms, and forged, disseminated, and resisted popular values. Time and space was altered even in many naval paintings, which represented environmental structures with unusual faithfulness but frequently portrayed major events in battles as if they occurred simultaneously. This chapter tests to what extent artistic reflections of weather in the Dutch Republic can be linked to early modern climate change, in light of the conclusions of Dutch art historians.¹⁴

The chapter opens by identifying understandings of weather in correspondence, diaries, ship logbooks, academic treatises, newspaper accounts, pamphlets, and chronicles written between the sixteenth and eighteenth centuries. It then investigates the extent to which climate change was perceived by contemporary observers. It continues by exploring whether visual art,

University of Chicago Press, 2001. Klaas van Berkel, Albert van Helden, and Lodewijk Palm, eds. *A History of Science in the Netherlands: Survey, Themes, and Reference*. Leiden: E.J. Brill, 1999. William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture*. Princeton, NJ: Princeton University Press, 1994. Andrew C. Fix, *Prophecy and Reason: The Dutch Collegiants in the Early Enlightenment*. Princeton: Princeton University Press, 1991.

¹² Although many art historians have also increasingly examined the broader social and indeed structural motivations for art. Morgan Kelly and Cormac Ó Gráda, “The Waning of the Little Ice Age: Climate Change in Early Modern Europe.” *Journal of Interdisciplinary History* 44:3 (2014), 314. Westermann, *A Worldly Art*, 9.

¹³ Which could be literary, visual, and very often both literary and visual. Westermann, *A Worldly Art*, 57.

¹⁴ Westermann, *A Worldly Art*, 10. See also: Christopher Brown, *Dutch Paintings*. London: National Gallery Publications, 1983. Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century*. Chicago: University of Chicago Press, 1983. Willemijn C. Fock, “Kunst en rariteiten in het Hollandse interieur,” in *De wereld binnen handbereik: Nederlandse kunst- en rariteitenverzamelingen, 1585-1735*, ed. Ellinoor Bergevelt and Renee Kistemaker, 70-91. Zwolle: Waanders Uitgevers/Amsterdam Historisch Museum, 1992.

popular poetry, and literature written in the Dutch Republic reflected, and responded to, the climatic fluctuations of the Little Ice Age. The chapter concludes by examining possible connections between culture and practice that allowed the Dutch to adapt to the weather that accompanied Little Ice Age minima.

Understanding Weather in the Dutch Republic

In the sixteenth century scholarly conceptions of weather still rested on an uneasy synthesis of Aristotelian philosophy and Biblical exegesis, although cracks in this foundation had grown increasingly obvious. In the Bible, the fashioning of man completed creation, the corruption of Adam and Eve ruined its perfection, and the salvation promised by Jesus ensured its restoration. Clerics and scholars whose Christian worldview situated man at the centre of creation naturally supported Aristotle's deduction that Earth lay at the centre of the universe. According to Aristotelian cosmology, the Earth is encircled by the moon, sun, known planets, and a celestial sphere of stars, above which Christian adaptations situated heaven (Figure 7.1). The moon's orbit distinguishes the stable perfection of the celestial realm from the inconstant tumult of terrestrial domains, which are roiled by the circulation of the four elements and their different exhalations. The elements and their wet and vaporous, or hot and smoky, exhalations are the material, or first, causes of meteorological phenomena. The efficient cause – the ultimate source of movement – lay in the motion of celestial bodies, especially the sun.¹⁵

¹⁵ Arist. Phys. I.1, trans. Webster. Available online: <http://classics.mit.edu/Aristotle/meteorology.mb.txt>. Craig Martin, "Experience of the New World and Aristotelian Revisions of the Earth's Climates during the Renaissance." *History of Meteorology* 3 (2006): 6. Harold L. Burstyn, "Early Explanations of the Role of the Earth's Rotation in the Circulation of the Atmosphere and the Ocean." *Isis* 57:2 (1966): 169. Eric Jorink, *Wetenschap en wereldbeeld in de Gouden Eeuw*. (Hilversum: Uitgeverij Verloren, 1999), 13. Edward Grant, "Celestial Orbs in the Latin Middle Ages," *Isis* 78:2. (1987): 153.

Schema huius præmissæ diuisionis Sphærarum .



Fig. 7.1. Aristotle's cosmology. The elements circulate between Earth and moon. Peter Apian, *Cosmographia*. Landshut, 1524.

The authority of Aristotelian cosmology was most famously challenged in the fifteenth through seventeenth centuries by the deductions of Copernicus, the observations of Galileo, and the discovery of civilizations beyond the southerly “torrid zone” that Aristotle thought was uninhabitable. However, the influence of Aristotelian meteorology endured well into the seventeenth century, in part because Aristotle’s conceptualization of meteorology was explicitly conjectural and provisional, and consequently malleable in the face of new experience. Of meteorological phenomena Aristotle confessed that “some puzzle us, while others admit of explanation in some degree.” These and other admissions of doubt inspired scholars across

Europe to challenge Aristotle's meteorology long before the broader principles of his cosmology were called into question. Such challenges had yielded a complex hybrid of classical and experiential meteorological understanding among sixteenth-century scholars in the Low Countries.¹⁶

The scholars of the Golden Age increasingly perceived themselves as belonging to an age distinct from, and intellectually superior to, the classical world. This belief encouraged, and was encouraged by, ever more rigorous observations that were enabled by increasingly sophisticated instruments. The relationship between apparatus and analysis was demonstrated with particular clarity in the study of meteorology during the Little Ice Age. In December 1624, as thermoscopes¹⁷ were developed across Europe, physician Nicolaes van Wassenauer of Amsterdam described his construction of a device that he named the "Drebbeliaans." The Drebbeliaans faithfully responded to changes in temperature, and on 23 February its readings suggested to Van Wassenauer that a shift in the wind was the first cause of a cold wave that chilled the Republic. Van Wassenauer's conclusion demonstrates not only the impulse to build instruments that could contribute to experiential knowledge of weather, but also the enduring influence of Aristotle's hierarchy of causes.¹⁸

Van Wassenauer's artisanal tinkering reflected a more or less scholarly preoccupation with meteorology in the Dutch Republic that aligned with general European trends. On the other hand,

¹⁶ Arist. Phys. I.5, trans. Webster. Available online: <http://classics.mit.edu/Aristotle/meteorology.mb.txt>. Martin, "Experience of the New World," 6. Burstyn, "Early Explanations of the Role of the Earth's Rotation," 169.

¹⁷ Thermoscopes are devices that depict changes in temperature, but do not display temperatures as measurable quantities. Dario Camuffo and Chiara Bertolin, "Recovery of the early period of long instrumental time series of air temperature in Padua, Italy (1716-2007)." *Physics and Chemistry of the Earth*, 40-41 (2012): 25.

¹⁸ The Drebbeliaans was named after the notorious scholar Cornelis Jacobszoon Drebbel of Alkmaar. Nicolaes van Wassenauer, *Historisch Verhael aller gedenckwaerdiger geschiedenis . . . Vol. 8*. (Amsterdam: Jan Janszoon, 1625): 144. Pamela H. Smith, "Art, Science and Visual Culture in Early Modern Europe." *Isis* 97:1 (2006), 90. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 373. Jan Golinski, "Time, Talk and the Weather in Eighteenth-Century Britain," in *Weather, Climate, Culture*, ed. Sarah Strauss and Benjamin S. Oorlove. (London: Bloomsbury Academic, 2003), 18. Rienk Vermij, *The Calvinist Copernicans: The reception of the new astronomy in the Dutch Republic, 1575-1750*. (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2002), 93.

the studies of René Descartes helped revolutionize European conceptions of weather. Descartes, then living in the Dutch Republic, was the last natural philosopher to dominate the emerging science of meteorology. His theoretical understanding of weather emerged not from observation, or Aristotle's cosmology, but rather his own scientific method. It was as factually incorrect as its intellectual forebears, yet for European scholars it encouraged a definitive and enduring break with Aristotle's meteorology. Moreover, Descartes did not dismiss experiential knowledge. He developed barometers that were later constructed by Christiaan Huygens, and wrote a meticulous study of snow crystals during the lengthy blizzards of February, 1635 (Figure 7.2). In subsequent decades scholars across Europe refined the instruments that enabled new observations and ultimately helped overturn the deductive natural philosophies of both Aristotle and Descartes. New instruments included more than just reliable barometers and thermometers. For example, in 1665 Robert Hooke used a recent Dutch invention – the compound microscope – to explore the full complexity of snow crystals.¹⁹ In the first decades of the eighteenth century, clocks were increasingly employed to bring weather events further into the realm of the rational, the orderly, and the quantifiable.²⁰

¹⁹ The compound microscope is essentially the modern light microscope, which revolutionized science when applied to biology. Clara Sue Ball, "The Early History of the Compound Microscope." 51. *Bios* 37:2 (1966): 51. Edward G. Ruestow, *The Microscope in the Dutch Republic: The Shaping of Discovery*. (Cambridge: Cambridge University Press, 2004), 7.

²⁰ Robert Hooke, *Micrographia: or some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon*. (London: Martyn and Allestry, 1665), 7. F. C. Frank, "Descartes' Observations on the Amsterdam Snowfalls of 4, 5, 6 and 9 February 1635," *Journal of Glaciology* 13:69 (1974), 537. H. Howard Frisinger. "René Descartes: The Last of the Old, and the First of the New Meteorologists." *Weather* 21:12 (1966): 443. Dario Camuffo, Claudio Cocheo and Giovanni Sturaro, "Corrections of Systematic Errors, Data Homogenisation and Climatic Analysis of the Padova Pressure Series (1725-1999)," *Climatic Change* 79 (2006): 500. Jorink, *Reading the Book of Nature in the Dutch Golden Age*, 5.

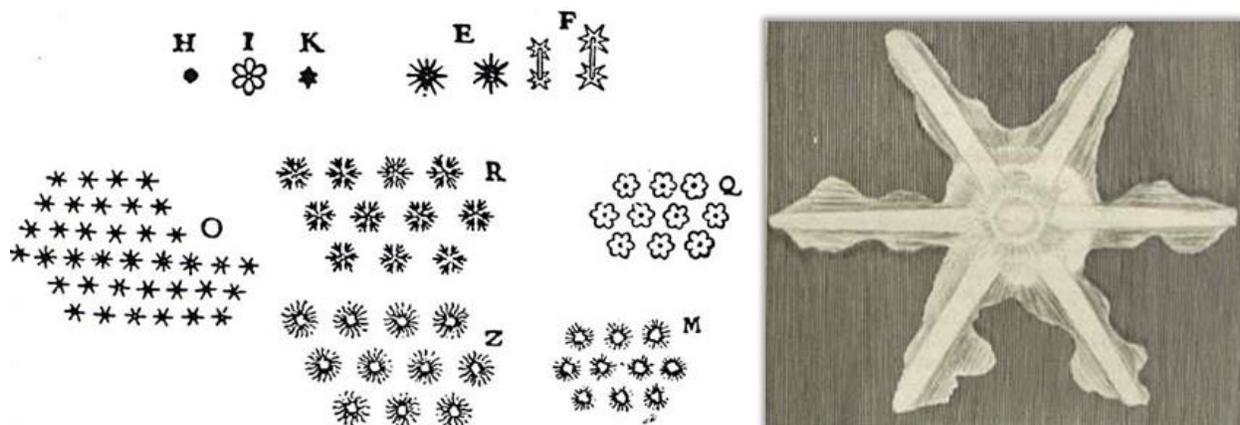


Fig. 7.2. Illustrations of snow by Descartes (left) and Hooke (right), both dating from cold winters. Hooke, *Micrographia*, 7. Frank, “Descartes’ Observations,” 537.

Such developments may have been encouraged by the distinct intellectual culture, and social structures, of the Republic. The relative tolerance of intellectual attitudes in the Dutch Republic allowed Descartes, for example, to develop ideas that were widely condemned in Catholic France. Moreover, historians have recently argued that careful observation was essential to the culture of the Republic’s Golden Age. Dutch scholars hoarded curiosities acquired through global commerce, and by the end of the seventeenth century their collections were increasingly composed of natural, rather than entirely cultural, artifacts. Eric Jorink has demonstrated that the assembly and interpretation of these collections, most of which were freely accessible to all, encouraged an empirical attitude towards nature that, in turn, stimulated the culture of observation in the Republic. Indeed, the acquisition, observation, and interpretation of rarities was an important expression of early modern Dutch affluence, encouraging not only the famous boom and bust of “Tulipmania” in the 1630s, but also such hobbies as the collection of exotic dogs. The culture of collection also contributed to the importance of visual art in the Republic, which often depicted the riches and rarities gleaned from Dutch commerce. Collection and detailed observation usually required leisure time and substantial wealth. It is therefore no

surprise that Dutch scholars, many of whom lived in the Republic's coastal cities, were often relatively affluent members of the bourgeoisie.²¹

Collections might have gradually contributed to increasing secularism in the Dutch Republic, but in the seventeenth and early eighteenth centuries they were often interpreted for what they revealed about God's organization of nature. Indeed, the familiar teleology of increasing secularization, rationalization, and experimental sophistication in the development of early modern science is undermined by the complex but enduring influence of magical and religious belief in the meteorology of the contemporary Low Countries.²² Meteorology during the Dutch Golden Age was advanced by scholars who pursued ostensibly secular knowledge to better understand the workings of God. Moreover, most literate Europeans in the sixteenth and seventeenth centuries still adhered to a metaphorical conception of the natural world, and extreme meteorological events in particular were often assigned to the will of God or the agency of the Devil. Learned conceptions of the demonic or divine meaning behind weather were informed by the teachings of Augustine, and especially Thomas Aquinas. Both Augustine and Aquinas drew some distinction between natural marvels and genuine miracles, which were distinguished by the explicit message they communicated. Aquinas in particular identified sharp divisions between the supernatural expression of God's unmediated will, rare preternatural events incited by created beings, and the natural normality of everyday life. Preternatural marvels included unusual manifestations of the atmosphere in Aristotelian cosmology, which

²¹ Jorink, *Reading the Book of Nature in the Dutch Golden Age*, 344. Goldgar, *Tulipmania: Money, Honor, and Knowledge in the Dutch Golden Age*, 104. Israel, *The Radical Enlightenment*, lxxvii. Schama, *The Embarrassment of Riches*, 350. Jardine, *Going Dutch*, 120. Peter Burke, "Viewpoint: The Invention of Leisure in Early Modern Europe." *Past & Present* 146 (1999): 140.

²² The definition here employed for "magic" is that given in 2006 by Christopher Mackay: "procedures and practices that were intended by those who used them to bring about some result in the natural physical world on earth that could not otherwise be caused through the normal, recognized properties and behaviour of physical entities." Christopher S. Mackay, "General Introduction," in Henricus Institoris and Jacobus Sprenger, *Malleus Maleficarum Vol. I: The Latin Text and Introduction*, ed. Christopher Mackay. (Cambridge: Cambridge University Press, 2006), 37.

encompassed not only meteorological conditions as they are understood today but also comets, meteors, and other astronomical phenomena.²³

The approximate scholarly consensus of the sixteenth century closely followed the distinction identified by Aquinas, and in theory supernatural miracles were recognized only when all other explanations failed. However, in practice the preternatural event was difficult to distinguish from the truly miraculous, even by the highly educated. For example, in the wake of catastrophic river floods during the frigid winter of 1595, Anthonis Duyck, head of the powerful Council of State, concluded his description of the disaster by explaining that the scale of human and animal misery “undoubtedly” reflected “the punishment of human excesses by the hand of God.” Writing in January during the severe winter of 1625/26, just over a year after his description of the Drebbeliaans, Van Wassenaer lamented that days of fasting and prayer in Amsterdam had done nothing to relieve the cold. Van Wassenaer determined that the citizens of Amsterdam had not prayed with all their hearts, but pastors had now resolved this problem. Of course, these attitudes were hardly confined to the Dutch Republic. On 1 February 1662, the vicar Ralph Josselin in Essex described “a publick fast to seeke god” encouraged not by cold conditions typical of the Maunder Minimum, but rather “warm moist unkindly” weather believed to raise the likelihood of disease and famine. Duyck, Van Wassenaer, and Josselin did not suggest that preternatural events were miracles, nor indeed that only miracles could answer their

²³ Including earthquakes and volcanoes. Richard C. Hoffmann, *An Environmental History of Medieval Europe*. (Cambridge: Cambridge University Press, 2014), 311. Stephen Wilson, *The Magical Universe: Everyday Ritual and Magic in Pre-modern Europe*. London and New York: Hambledon, 2000. Glacken, *Traces on the Rhodian Shore*, 287. Lorraine Daston, “Marvelous Facts and Miraculous Evidence in Early Modern Europe.” *Critical Inquiry* 18:1 (1991): 98. Henricus Gerardus Maria Jorink, *Het boeck der natuere: Nederlandse geleerden en de wonderen van Gods schepping, 1575-1715*. (PhD Diss, University of Groningen, 2004).

prayers. Nevertheless, all identified the influence of God beyond the narrow constraints in which His influence could be proven according to contemporary theologians.²⁴

In this they adhered to the older and more broadly influential concept of the “sin economy.” According to this belief, extreme weather and other preternatural phenomena reflected God’s punishment for a negative imbalance in the virtue of a community. Members of a community could restore balance by curbing their ostensibly sinful behaviour and atoning through prayer or fasting. Alternatively, a religious, ethnic, or gendered minority was associated with demonic corruption and violently purged from the community. In particular, vulnerable members of a community could be charged with witchcraft, which many contemporaries believed provided the power to conjure meteorological extremes like hailstorms, frost, or torrential rain. Often God was appeased by a combination of inner renewal and external aggression, and as meteorological extremes are extreme precisely because they are short-lived, relief usually followed such traumatic housekeeping.²⁵

Nevertheless, God’s influence in natural phenomena involved more than punishment or even communication, especially for literate Dutch citizens who were nevertheless not scholars. In December during the frigid winter of 1572/73, the contemporary historian Pieter Christiaanszoon Bor wrote that a fleet manned by Dutch rebels had been trapped in the ice of the Zuider Zee, where it was in danger of being captured by the Spanish. As the Dutch sailors prepared to scuttle their ships, God sent a northerly wind that broke open the ice. The Dutch

²⁴ Anthonis Duyck, *Journal van Anthonis Duyck, advocaat-fiskaal van den raad van state: (1591 - 1602) Uitgegeven op last van het departement van oorlog, met inleiding en aantekeningen door Lodewijk Mulder, Vol. I.* (Nijhoff, 1862), 145. Nicolaes van Wassenauer, *Historisch Verhael aller gedenckwaerdiger geschiedenis . . . Vol. 12.* (Amsterdam: Johannes Janssonius, 1627): 57. Ralph Josselin, *The Diary of Ralph Josselin, 1616-1683.* (Oxford: Oxford University Press, 1991), 486.

²⁵ Davis, “The Rites of Violence: Religious Riot in Sixteenth-Century France,” 59. Behringer, *A Cultural History of Climate*, 128. Behringer, “Climatic Change and Witch-Hunting,” 336. Christian Pfister, “Climatic Extremes, Recurrent Crises and Witch Hunts,” 57. Dean Phillip Bell, “The Little Ice Age and the Jews: Environmental History and the Mercurial Nature of Jewish-Christian Relations in Early Modern Germany.” *AJS Review* 32:1 (2008): 11.

vessels escaped, and God closed the ice behind them to prevent a Spanish pursuit. Similarly, as Spanish delegates arrived in The Hague to sign the Twelve Years' Truce in 1608, Pastor Johan van de Sande described a cold wave of remarkable severity and duration that had frozen water across the Republic. The innermost citadels of the Republic were now exposed to the enemy, but it was a sign of the "marvelous workings of Almighty God that the frost arrived just as the truce was agreed to." Indeed, Dutch citizens most frequently discerned the will of God when weather influenced military affairs. During the Second Anglo-Dutch War in 1665, Michiel de Ruyter and a small squadron of battered ships slipped by an English armada to successfully unite with the main Dutch fleet in the Republic (Chapter 5). Gerard Brandt, a contemporary Dutch biographer of De Ruyter, wrote that dense fog and variable winds frustrated English attempts at pursuit. According to Brandt, the fickle breeze and thick fog were clearly sent by God, and De Ruyter acknowledged that they were solely responsible for his homecoming.²⁶

However, God did not always take sides. At the conclusion of the Four Days' Battle in June 1666, Dutch ships pursuing the broken English lines were thwarted by fog that was, to De Ruyter, "manifestly the work of Almighty God." According to Hans Svendsen, a Danish captain in the Dutch fleet, De Ruyter heard a voice from Heaven that cried: "Back! Enough blood has been spilled." On other occasions the preternatural expression of God's will was less clear. According to a surviving pamphlet, a meteorite, then believed to be a rare meteorological phenomenon, fell on the town of Kampen on 7 March 1610. The pamphlet described how this particular meteorite descended on a young man who was surrounded by fire but emerged

²⁶ Pieter Christiaanszoon Bor, *Oorsprongk, begin, en vervolgh der Nederlandsche oorlogen, Vol I.* (Amsterdam: Joannes van Someren, Abraham Wolfgangh, Hendrick en Dirck Boom, 1679-1684), 420. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 249. Brandt, *Uit het Leven en Bedrijf van den here Michiel de Ruiter*, 153.

unharmful. “What Almighty God wishes to communicate [with this sign],” the pamphlet concluded, “time will tell.”²⁷

Alongside the widespread conviction that preternatural events manifested God’s will, across Western Europe belief in their demonic origin, which adhered to the theological consensus, grew more common in the closing decades of the sixteenth century.²⁸ This trend is reflected in Dutch documentary evidence. On 18 August 1586, a chronicle written in Ghent recorded a storm in which “many evil spirits were seen, like black crows, [which] inflicted much damage.” In the town of Emden on the northeastern fringe of the Republic, the farmer and chronicler Abel Eppens wrote that the frigid winter of 1586/87 was accompanied by gruesome apparitions in the sky that included a bloody arm above Groningen. On 16 August 1610, Cornelis Corneliszoon the Younger in Utrecht described a severe hailstorm in Amsterdam, Haarlem, and elsewhere that left behind a massive hailstone that was shaped like a skull. Like interpretations of severe weather that identified God’s displeasure, these darker conceptions of the preternatural often encouraged the persecution of the vulnerable for witchcraft or other sins.²⁹

In the context of the social turmoil of the sixteenth and seventeenth centuries, scholars and the popular press fuelled a widespread obsession about which preternatural wonders were miraculous, and which were demonic or entirely natural in origin. After all, the divine manipulation of the atmosphere could communicate not only displeasure or favour but also the

²⁷ Michiel Adriaanszoon de Ruyter, “Journal kept by De Ruyter.” In *The Second Dutch War: described in pictures & manuscripts of the time*, 25. Svendsen, “Hans Svendsen’s Journal, 10-30 Juni 1666,” in *Bescheiden uit Vreemde Archieven omtrent de Grootte Nederlandsche Zeeoorlogen*, 366. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 269.

²⁸ Daston, “Marvelous Facts and Miraculous Evidence,” 98.

²⁹ Andreas van Heule (ed.), *Memorieboek der stad Ghent van ’t jaar 1301 tot 1793, Vol. III*. (Gent: Annot-Braeckman, 1854), 107. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 420. Cornelis Cornelis. the Younger, *Utrechtsch kronijkjen, Vol. VI*. Archief voor Kerkelijke en Wereldsche Geschiedenissen. Utrecht (1846). Emily Oster, “Witchcraft, Weather and Economic Growth in Renaissance Europe.” *The Journal of Economic Perspectives*, 18:1 (2004), 218. Behringer, *A Cultural History of Climate*, 128. Behringer, “Climatic Change and Witch-Hunting,” 336. Christian Pfister, “Climatic Extremes, Recurrent Crises and Witch Hunts,” 57.

imminent future. Here magical epistemologies – particularly divination – blended uneasily with religious frameworks and Aristotelian cosmology in the interpretation of weather. For example, in the fall of 1607 the church official Pieter Janszoon Twisck associated the appearance of Halley’s Comet in Ursa Major with the impending onset of frigid temperatures and flooding. Since comets were atmospheric phenomena as much as storms or cold temperatures in Aristotelian meteorology, it was natural to assume that their appearance heralded a change in the weather (Figure 7.3).³⁰

³⁰ Pieter Janszoon Twisck, *Comeet Boecxken*. (Hoorn: Jan Jansz. Deutel, 1665), 108. Daston, “Marvelous Facts and Miraculous Evidence,” 98. Arist. Phys. I.6, trans. Webster. Available online: <http://classics.mit.edu/Aristotle/meteorology.mb.txt>. Jorink, *Reading the Book of Nature in the Dutch Golden Age*, 114.



Fig. 7.3. A comet during the Maunder Minimum. In this painting, one of several on the same theme by artist Lieven Verschuijter, citizens of Rotterdam gather in the snow to discern the significance of comet C/1680 V1. Lieven Verschuijter, “The Great Comet of 1680,” painting, 1680, <http://goo.gl/7F5piV>.

Guided by the same natural philosophy, astrologers followed the movement and alignments of the planets. Because these were ostensibly the efficient causes of meteorological phenomena, the annually published predictions of astrologers typically included weather forecasts. These predictions were often wrong, and on 26 December 1662 the lawyer Adriaen van der Goes complained to his brother that frigid temperatures had not conformed to the astrological forecast. On the other hand, most astrological prophecies were so broad that they were bound to contain some truth. Before 1652, for example, astrologers predicted “hunger,

starvation, floods, storms, war and unrest” across Europe, a prognosis that would have been at least partially accurate for almost any year during the crisis-ridden seventeenth century. The enduring influence of Aristotelian meteorology also influenced attempts to link unrelated natural phenomena even where no omen was perceived. Earthquakes in particular were associated with a confluence of subterranean wind and elemental interaction that mirrored circulation in the atmosphere and could therefore accompany storms above ground. For example, in April 1640 Wolter Joelinck in Zutphen marvelled over an earthquake that was somehow not accompanied by surface winds, and in April 1665 a ferocious storm on both shores of the North Sea was associated with simultaneous earthquakes in letters and newspaper reports.³¹

Exploring the complex religious and magical epistemologies with which literate Dutch citizens understood weather events reveals the limitations of the increasing rationalization and, to some extent, secularization that accompanied emerging “scientific” conceptions of weather during the Republic’s Golden Age. Still, some accounts of preternatural meteorological events written by educated, but not scholarly, sources in the Republic did describe only observable, natural phenomena. For example, on 24 January 1666 English Ambassador Dudley Carleton wrote from The Hague that:

I cannot omit a popular vanity of prognosticating change upon the coming here on shore of three whales 60 feet or thereabouts in length, and 30 in compass; whereof two of them being stranded upon the Brill island, and one here by Scheveling, in the very places and instant time of these tumults, they cause the more surprise; the rather because it is remembered, that at the first breaking out of these country war [sic], there were two of the like bigness driven on shore in the river of Schelde below Antwerp, and the framing of the truce one here in Holland.

³¹ “The Dutch bloody almanack, conteyning the exact astrological predictions, for the yeare of our Lord 1653.” (London: printed by John Clowes, 1653). Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 521, 600. Van der Goes, “Hage, den 26 December 1662.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 166. Hoffmann, *An Environmental History of Medieval Europe*, 311.

But these are effects of the long and continual storms we have had here at the West, which have caused likewise many wrecks upon this coast.³²

Carleton's rejection of the supernatural origin of the preternatural was unusually explicit, and perhaps counterintuitively linked to the increasingly influential belief that extreme natural phenomena were wrought by the Devil to deceive humans with counterfeit miracles. Indeed, even as some writers described the divine or demonic nature of the preternatural, many emphasized its entirely natural character in order to undermine Satan's attempts at misleading the naïve. The ultimate effect of such writing in the seventeenth and eighteenth centuries may have been to naturalize all preternatural phenomena, including the unusual weather events that received most attention from contemporary authors. Some educated elites therefore joined scholars in identifying even extreme weather events with entirely natural processes. For example, letters between Jan de Witt and leading Dutch diplomat Coenraad van Beuningen in the 1660s repeatedly mentioned storms, but never reflected the belief that that they were God's will. The contemporaneous Van der Goes correspondence includes countless references to severe gales and floods, but little suggestion that they were influenced by divine or demonic agency. Nevertheless, in the seventeenth century understandings of extreme weather among educated, literate Dutch citizens remained heterogeneous, and hardly demonstrated a general trend towards secularism.³³

Unfortunately, it is difficult for historians of climate to reconstruct perceptions of weather among illiterate, lower-class Europeans. On the other hand, some sources written between the

³² Sir Dudley Carleton, "January 14/24. The Same to the Same." *Letters from and to Sir Dudley Carleton*. (London: C. Herring, 1757), 90.

³³ Daston, "Marvelous Facts and Miraculous Evidence," 107. De Witt, "Aen de Heer Extr. Minister C. Van Beuningen, den 30 December 1665." De Witt, "Aen de Heer Extr. Minister C. Van Beuningen, den eersten October 1666. 't Dubbel." C. van Beuningen, "Aen de Heer Raedt-Pensionaris J. De Witt, in't Bosch van Vincennes den 28. Augusty 1666," in *Brieven geschreven ende gewisselt tusschen Johan de Witt ende de gevolmagtigden van den stad der Vereenigde Nederlanden*, 136, 294, 333, 360.

sixteenth and eighteenth centuries include generally scornful references to beliefs held among the rural poor. Such accounts suggest that proverbial weather lore, most often associated with classical writers like Theophrastus, Aratus, and Seneca, endured among rural peasants and artisans for centuries after it lost most of its “scientific” appeal. Historians like Stephen Wilson have associated popular superstition and magical custom with the traditional agrarian economy in early modern Europe. Certainly the Dutch economy was less traditional and less agrarian than those of its neighbours, but the modernity of the Republic was limited to its coastal cities. In the illiterate margins of the Low Countries, it is likely that the rich and sometimes paradoxical mix of religious, magical, and ancient weather beliefs lingered with the rest of popular magical wisdom until deep into the nineteenth century.³⁴

The most destructive aspect of those beliefs intersected with influential theological ideas to encourage witchcraft persecution. Between 1560 and 1630, the great witch hunt in Western Europe punished those allegedly responsible for harmful weather and transcended the boundaries of religion and class. Across Catholic and Protestant Europe, the persecution of witches was usually instigated by peasants, exacerbated by clergy, and encouraged by sympathetic magistrates. Here, too, the Dutch Republic was different. In the Low Countries, witchcraft persecution was concentrated in the Spanish Netherlands, and peaked with the brutal aftermath of the Roermond witch trials in 1613. In the Republic, death sentences for witchcraft were only rarely imposed after 1595, in the wake of the witch trials and executions in Amersfoort and Utrecht. In fact, at the *Hekenswaag* (“Witches’ Scales”) in the town of Oudewater, Utrecht, accused witches from across Europe were granted a relatively fair trial, and many seized that opportunity. Overall, the total number of trials in the Republic was low compared to the rest of

³⁴ Golinski, “Time, Talk and the Weather,” 30. Wilson, *The Magical Universe*, xxvii.

Europe, although witchcraft still fascinated Dutch citizens across different social groups and classes.³⁵

The relative scarcity of trials and convictions for witchcraft in the Republic suggests that the zeal for witchcraft prosecution was limited among Dutch citizens. Some of the skepticism towards witches expressed by literate thinkers like the Mennonites Jan Jansz Deutel, Antonius van Dale, and Abraham Palingh in the seventeenth century may have influenced popular attitudes. It is also possible that opportunities provided by the commercial and industrial prosperity of the coastal, urbanized Republic, even for the comparatively poor, diminished some of the impetus for witchcraft persecution. In the rest of Europe, persecution was predominantly rural and often fueled by festering antagonisms over the rights to land. Indeed witchcraft persecution was particularly muted in Holland or Zeeland, and there is little evidence of previous antagonism between accuser and accused in trials held elsewhere in the Republic. The weather that accompanied Little Ice Age minima may have also played a role. Historical climatologist Wolfgang Behringer has argued that the great witch hunt was stimulated by cold, stormy, rainy weather that grew more likely and more severe during the contemporaneous Grindelwald Fluctuation and was widely blamed on witches. Indeed, frigid weather coincided with economic depression in Amersfort and Utrecht during the witch trials there. In general, however, the distinctively ambiguous influence of the Little Ice Age in the Republic likely contributed to mitigating some of the stimulus for witchcraft persecution felt elsewhere in Europe.³⁶

³⁵ Claudia Swan, *Art, Science, and Witchcraft in Early Modern Holland: Jacques de Gheyn II (1565-1629)*. (Cambridge: Cambridge University Press, 2005), 3. Lene Dres-Coenders, *Het verbond van heks en duivel. Een waandenkbeeld aan het begin van de moderne tijd als symptoom van een veranderende situatie van de vrouw en als middel tot hervorming der zeden*. (Baarn: Ambo, 1983), 227. Gary K. Waite, *Eradicating the Devil's Minions: Anabaptists and Witches in Reformation Europe, 1525-1600*. (Toronto: University of Toronto Press, 2007), 90. Henricus Institoris and Jacobus Sprenger, *Malleus Maleficarum Vol. II: The English Translation*, ed. Christopher Mackay. (Cambridge: Cambridge University Press, 2006), 43.

³⁶ Dres-Coenders, *Het verbond van heks en duivel*, 196. Marijke Gijswijt-Hofstra, "The European witchcraft debate and the Dutch variant." *Social History* 15:8 (2008): 186. Pfister, "Climatic Extremes, Recurrent Crises and Witch

Certainly the Republic's illiterate poor were not necessarily more inclined to secular reason than their counterparts in neighbouring countries.³⁷ Still, letters dictated by illiterate but urban Dutch citizens, sent to and from the Republic's warships, reflect a pragmatic and dispassionate approach to weather. Such correspondence followed a common template written by scribes according to the conventions of the time. Letters could be quite long, and many abound with repetitive expressions of affection that stand in stark contrast to shorter and less standardized gestures in elite correspondence. It is therefore especially noteworthy that such letters communicate a particularly practical concern with the consequences, rather than the abstract origins, of meteorological conditions. For example, in a letter written on 5 April 1672, Janneke Aengenendt curtly informed her son that the family could not bring many supplies to the farm, that winter was cold, and that local commerce was halted. Similarly, in a letter written on 17 April 1663, Jan Tijssen Eikenboom informed his friend that unusually cold temperatures were hurting his wounded knee. Lingering ice also impeded his ability to use a walking stick, and he hoped that temperatures would warm soon. These sources do not indicate that illiterate, lower class Dutch citizens ignored the significance of the preternatural. However, such fragments of their correspondence as survive suggest that their consideration of weather was most concerned with the practical consequences of ordinary meteorological conditions.³⁸

Hunts," 57. Behringer, *A Cultural History of Climate*, 128. Alan Charles Kors and Edward Peters (ed.), "The Trail of Marie Cornu (1611)," in *Witchcraft in Europe, 400-1700: A Documentary History*. (Philadelphia: University of Pennsylvania Press, 2001), 345. Stuart Clark, *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe*. (Oxford: Oxford University Press, 1999), 543.

³⁷ Although priests in the Republic may have been. One of the most effective critiques of witchcraft persecution and demonology was written in 1690 by Balthasar Bekker, a Dutch pastor and Cartesian rationalist. Kors and Peters (ed.), "Balthasar Bekker: *The Enchanted World* (1690)," *Witchcraft in Europe*, 430. Benjamin J. Kaplan, "Possessed by the Devil? A Very Public Dispute in Utrecht." *Renaissance Quarterly* 49 (1996): 740.

³⁸ Janneke Aengenendt, "To Johan Verhoeven, 5 april 1672." *Corpus Brieven als Buit*. Instituut voor Nederlandse Lexicologie. Accessed 20 December 2013, <http://brievenalsbuit.inl.nl/zeebrieven/page/search>. Jan Tijssen Eikenboom, "To Martintie Cornelis, 17 april 1663." *Corpus Brieven als Buit*. Instituut voor Nederlandse Lexicologie. Accessed 21 December 2013, <http://brievenalsbuit.inl.nl/zeebrieven/page/search>.

Perceiving Climate Change in the Dutch Republic

Conceptions of weather are very different from the perception of climate change. Because a particular climatic regime influences humans through weather events, the ways in which weather is understood shape attitudes towards, and awareness of, climatic fluctuation. The relationship between the understanding of weather and climate remains implicit without a more or less systematic means of assessing the past. In order to clearly perceive changes in their climate, human beings must possess some understanding of meteorological conditions several decades prior. Continuous, quantified records of average weather across three or more decades are ideal, but not always strictly necessary. Indeed, statistical thinking, essential for the interpretation of long-term trends in average weather, need not accompany a partial understanding of climate change.³⁹ Memories of extreme weather events in past decades can provide limited but still significant awareness that prevailing meteorological conditions have changed. Conceptions of past weather in surviving Dutch sources are often expressed through such memories of the preternatural. For the climate historian, these recollections can complicate attempts to distinguish anecdotal references to past weather from genuine awareness of climate change.

³⁹ Ian Hacking has argued that statistical thinking and probability theory was a development of the nineteenth and twentieth centuries. Among others, historian of mathematics Ivo Schneider has disputed this notion. Schneider identifies a concept of probability, and with it some form of statistical thinking, that stretches back to Aristotle. In an important book, Raine Daston identified the important role of “proto-quantification” in seventeenth-century thought. To Daston, quantification was “a process of mutual accommodation between mathematics and subject matter to create and sustain the analogies that make applications possible.” Proto-quantification “thrusts these analogies to the fore,” yet it was probably still sufficient for at least the limited reconstruction of long-term trends in average weather. There is little evidence, however, that such reconstruction was attempted in the Republic. Ian Hacking, *The Taming of Chance*. (Cambridge: Cambridge University Press, 1990), 36. Ian Hacking, “Introduction 2006: The Archaeology of Probable Reasoning,” in Ian Hacking, *The Emergence of Probability, Second Edition*. (Cambridge: Cambridge University Press, 2006), 6. Lorraine Daston, *Classical Probability in the Enlightenment*. (Princeton: Princeton University Press, 1988), xv. See also: Ted Poter, *The Rise of Statistical Thinking 1820-1900*. Princeton: Princeton University Press, 1986. Steve Stigler, *The History of Statistics: The Measurement of Uncertainty before 1900*. Chicago: Chicago University Press, 1986.

For instance, many letters, diary entries, and newspaper reports that describe particularly extreme weather events in the Low Countries conclude that none could remember events of similar scale. Such observations suggest that the authors, and the locals usually consulted for their memory, possessed at least some awareness that meteorological events had happened, and could possibly happen again, that did not occur in decades past. Severe winters during the minima of the Little Ice Age were most frequently described in these references. On 22 March 1586, for example, Abel Eppens in Emden wrote that even older people could not remember a winter of the severity they had just experienced. Following the frigid winter of 1594/95, the merchant Jan de Pottre in Brussels recounted that “we had as cold a winter as anyone has ever survived.” Johan van de Sande wrote in 1608 that January and February in The Hague were marked by bitter freezing that was colder than any could recall. In February 1621, the wealthy farmer Dirck Janszoon in Friesland observed that ice cover during the frigid winter was more extensive than any could remember or read about. In the same month Pier Winsemius, a lawyer in the Court of Friesland, described the travails of sailors whose ships were trapped by the ice before concluding that no one had ever heard of such extensive winter freezing.⁴⁰

Just four years later, Van Wassenaer rhetorically asked who had ever experienced such widespread winter ice cover. According to Claas Ariszoon Caescoper, in March 1667 the Zuider Zee was still closed by ice, which even the very old could not remember. As the Republic suffered though a prolonged stretch of unusually cold weather, Adriaen van der Goes on 19 November 1671 wrote that his ink was freezing in his pen, “which is unheard of.” Such reflections on particularly severe winters were also written in the cities of England. On 19 March

⁴⁰ Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 87. Jan de Pottre, *Dagboek van Jan de Pottre, 1549-1602*, ed. B. de St. Genois. (Ghent: C. Annoot-Braeckman, 1861), 191. Dirck Janszoon, *Het aantekeningenboek van Dirck Jansz. (1578-1636)*, ed. Pieter Gerbenzon. 120. (Hilversum: Uitgeverij Verloren, 1993), 120. Winsemius, Pier Winsemius, *Chronique ofte historische geschiedenis van Vrieslant*, 910.

1658, for example, the writer John Evelyn in London recalled that “this had ben the severest Winter, that man alive had knowne in England.”⁴¹

References to unprecedented weather were hardly confined to reports of especially frigid winters. Jan de Pottre introduced his account of the summer of 1590 by writing that it was “hotter than anyone could remember.” In 1599, the physician Dirck Velius in Hoorn wrote that the weather in April was warmer and more “beautiful” than even the elderly could recall. Velius used a nearly identical phrase in his description of the warm autumn of 1616. Similar reflections were elicited by many different kinds of precipitation across all seasons. In 1615, Velius wrote that more snow had fallen on Hoorn in February than anyone could remember. In a letter sent on 25 November 1659, Van der Goes recalled no autumn that had ever been wetter. In December 1664, the writer Tobias van Domselaer wrote that so much freezing rain had fallen on Amsterdam that a layer of ice the thickness of an arm had coated the trees, which nobody had ever seen.⁴²

Severe storms also prompted many across the North Sea region to scour their memories. On 5 July 1652 Evelyn wrote that “so violent a Tempest of haile, raine, wind, Thunder & Lightning,” had afflicted London “as no man alive had seene the like in this age.” A chronicle written in Flanders recalled that the ferocious storm of 5 May 1661 had been “such a dreadful storm of wind, thunder, lightning and hail, as anyone could find depicted in writing.” In December 1665, an article in the *Hollantsche Mercurius* newspaper reported a gale that affected both shores of the North Sea and was so severe that “two of the oldest inhabitants near the

⁴¹ Van Wassenaer, *Historisch Verhael Vol. 12.*, 57. Van der Goes, “Hage, den 19 November 1671.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II*, 305. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 612, 549.

⁴² De Pottre, *Dagboek van Jan de Pottre, 1549-1602*, 185. . Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 186, 301, 591. Van Wassenaer, *Historisch Verhael aller gedenckwaerdiger geschiedenis . . . Vol. 10*, 116. Van der Goes, “Hage, den 25 Novemb. 1659.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 48.

Thames said they never heard of such a storm.” Similarly, on 22 September 1671 Van der Goes described a storm in the Republic that was more ferocious than any could recall. Even unusually thick and persistent fog could strike some as unprecedented. Van Wassenauer wrote that from Christmas until 17 January, 1626, thick mist shrouded the sun from view in a way that none could remember.⁴³

References to unprecedented weather were not unique to sources written on land, although the meteorological conditions that most concerned sailors were largely limited to the velocity and direction of wind. As the allied Franco-English fleet struggled through a summer of nearly unrelenting storms in 1672, Captain John Narbrough repeatedly described high winds and their consequences. In a logbook entry written on 6 August 1672, Narbrough reported more “gusty, stormy” conditions before concluding that, “never [was] such weather known in these seas at this time of the year before now.” Perhaps because their operations usually kept them in specific geographical regions for many years, naval officers were more likely to write such weather memories than civilian adventurers, or officers aboard East India Company ships.⁴⁴

The frequent recurrence in Golden Age documents of the claim that extreme weather had never happened before raises the possibility that such phrases were literary tropes written to express little more than the severity of contemporary weather. However, multi-proxy climatic reconstructions suggest that popular memory was a real and effective tool for ascertaining the severity of, and the lack of precedent for, extreme weather events. For example, the winter of 1585/86 was as cold as any had been in two decades, while the winter of 1594/95 was even

⁴³ Van Wassenauer, *Historisch Verhael aller gedenckwaerdiger geschiedenis Vol. 12.*, 57. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 186, 522, 601. *De Hollantsche Mercurius*. (Haarlem: Pieter Casteleun, 1666), 157. Van der Goes, “Hage, den 8 October 1671.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II*, 279.

⁴⁴ John Narbrough, “Journal of John Narbrough, Lieutenant and Captain of the *Prince*. January 7, 1671/2, to September 18, 1672,” 126.

colder, indeed the coldest in thirty years. The winters of 1607/08 and 1620/21 were equally frigid, and the three winters were colder than any had been since the first winter of the Grindelwald Fluctuation, in 1564/65. Meanwhile, the winters of 1657/58, 1666/67, and 1671/72 were all as cold as any had been since 1620/21. Occasional references to written meteorological records might explain some of the impressive accuracy of the early modern contextualization of severe weather in the Republic.⁴⁵

For those who experienced them, extreme weather events were also appreciated for their rarity, and they could interact with cultural or social structures to become chronological landmarks that attained lasting cultural meaning.⁴⁶ On 22 March 1658, the historian Lieuwe van Aitzema in The Hague described the frigid winter and wrote that “everyone let their children stand on the ice, so they could say that the weather had really been so cold.” Even more striking was the response of Roemer Visscher to the Christmas Eve storm of 1593, which shattered many ships on the coast of Texel, the largest island in the Zuider Zee. Visscher’s daughter was born shortly after the tragedy, and accordingly he gave her the rather macabre name of Tesselschade, or “Texel Damage.” Memory of the severity of the 1593 storm was therefore woven into the core identity of the Visscher family. Moreover, the potential pitfalls of memory were not unappreciated by contemporary writers. After the moderate winter of 1660/61, Josselin in Essex wrote that “I observe how apt wee are to account a harsh time the hardest wee ever felt and a

⁴⁵ Van Engelen, Buisman and IJnsen, “A Millennium of Weather, Winds and Water in the Low Countries,” 112.

⁴⁶ In an examination of the eastern Alps, Christian Rohr has developed criteria that help explain why some natural disasters become such landmarks while others do not. His criteria include the availability of aid, and the simultaneous occurrence of war and other events that could exacerbate the impact of natural disaster. However, not all of this information is always available for the sixteenth and seventeenth centuries, and so Rohr’s criteria can be more subjective than they at first appear. Consequently they are not employed here. Christian Rohr, *Extreme Naturereignisse im Ostalpenraum: Naturerfahrung im Spätmittelalter und am Beginn der Neuzeit*. (Wien: Böhlau Verlag Köln Weimar, 2007), 56. Jacques Berlioz, *Catastrophes naturelles et calamités au Moyen Âge*. (Florence: Edizioni del Galluzzo, 1998), 25. Pfister, “Climatic Extremes, Recurrent Crises and Witch Hunts,” 57.

mild the best.”⁴⁷ Caution was therefore required, and it appears as though that caution was respected in at least some contemporary records of extreme weather.⁴⁸

It is therefore no surprise that memories of severe weather in Dutch documentary evidence often included specific references to the dates of past weather extremes. When Dutch citizens employed dates, they demonstrated knowledge that went beyond mere awareness that experienced weather was abnormal in the context of the past. By using dates, weather observers revealed an understanding of the history of severe weather events that may have amounted to a vague form of climate history. Detailed references to dates are most common in descriptions of remarkably high or low water levels, particularly when such extremes were affected by weather events like drought, severe storms, or rapid thawing in the wake of unusually cold winters. For example, as the Zuider Zee region was lashed by severe storms on 12 January 1594, pensionary François Maelson explained to grand pensionary Oldenbarnevelt that water levels “have not been so high in eight years.” On 23 January 1610, Velius in Hoorn reported that “high Northwesterly winds have driven the water to levels we have not seen in 40 years.” In the midst of massive flooding across Holland in January 1624, Van Wassenauer wrote that water levels were also high along the Maas near the city of Venlo, in the southeastern periphery of the Republic. Van Wassenauer described how water levels had risen above the summit of a stone erected to commemorate water levels in 1571.⁴⁹

Natural or artificial landmarks were not always mentioned in descriptions of water levels that referenced the past, but it is likely that they were normally consulted. Stones and other landmarks were crude forms of instrumental record keeping that could supplement and improve

⁴⁷ Josselin, *The Diary of Ralph Josselin*, 472.

⁴⁸ Lieuwe van Aitzema, *Saken van staet en oorlogh van Lieuwe van Aitzema*. (The Hague: Johan Veekym Johan Tongerlos and Jasper Doll, 1669), 125. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 140, 567.

⁴⁹ Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 141, 266. Van Wassenauer, *Historisch Verhael aller gedenckwaerdiger geschiedenis . . . Vol. IV.*, 74.

oral and written histories of past water levels. Following the All Saints' Flood in 1675, Johannes Hudde, a scholastically-inclined mayor of Amsterdam, organized the daily measurement of water at The Waag, a fifteenth-century city gate. He also ordered the deployment of eight marble stones to record water levels at the sluices to the IJ. Less standardized examples of such landmarks were used elsewhere in the Republic, even if they were not always erected to record water levels. In March 1625, for example, Van Wassenaer wrote that houses built on dunes were swept away at Egmont aan Zee, a village on the western coast of North Holland, and the survivors were therefore able to discern that water levels were higher than they had been in 1570. Meanwhile, in the nearby city of Enkhuizen on the Zuider Zee, water levels had risen above the high water mark recorded in 1610 on the tower of the Drommedaris, which defended the entrance to the harbour. Similarly, during the severe river floods that accompanied the generally frigid winter of 1650/51, water levels in Nijmegen exceeded the highest level ever recorded on the city walls. While referring to extreme water levels, contemporary observers therefore did note when water levels had reached an unprecedented point, but they usually wrote such observations with precise reference to the past.⁵⁰

Far more common were references to extreme water levels that cited a specific year in which water levels had been at least equally unusual. On 5 December 1665, for example, Adriaen van der Goes described the devastation of the St. Nicholas Flood. Waves fanned by Northwesterly winds swept across the coast at Scheveningen near The Hague, until they reached the guest house at the De Goes estate. According to De Goes, water levels were therefore higher than they had been in 80 years. Given the importance of water in the Republic, it is not surprising that the context and consequences of high water levels were remembered in many different

⁵⁰ Van Wassenaer, *Historisch Verhael aller gedenckwaerdiger geschiedenis . . . Vol. III.*, 150. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 376, 511. "Wat is het NAP?" Stichting Normaal Amsterdams Peil. Accessed March 13, 2014: <http://www.normaalamsterdamspeil.nl>.

media. In 1696 historian Mattheus Smallegange and illustrator Jan Luyken collaborated on an illustration of Reimerswaal, a Dutch town that had been inundated during the great floods of November 5, 1530 (Figure 7.4). Reimerswaal was never reclaimed, and the illustration depicted the town at its height before the flood, and in its drowned, abandoned condition in 1696. As surely as correspondence, diary entries, or newspaper reports, the illustration reflects a detailed awareness of historical water levels and flooding. Floods, like all natural disasters, were a consequence of both environmental stimulus and social vulnerability. However, the illustration plausibly if not exclusively reflects a desire to compare the meteorological past with the meteorological present.⁵¹

⁵¹ Van der Goes, "Hage, den 8 December 1665." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, 221.



Fig. 7.4. A depiction of changed water levels. Top: Reimerswaal in 1696. Bottom: the town before the flood of 1530. Mattheus Smallegange and Jan Luyken, “Panorama op Reimerswaal,” print, 1696, Amsterdam Museum, <http://goo.gl/w0rt7d>.

Water levels were precisely contextualized using landmarks not only when they were abnormally high, but also when they were unusually low. On Christmas, 1652, the painter Vincent Laurenszoon Van der Vienne remarked that the level of the Rhine had sunk beneath all the low water marks on city walls and ports. In December of 1669, observers described water levels so low that the receding water exposed ruins of which no memory existed. However, unusually dry conditions were most commonly described and contextualized by referring to transportation across landscapes that were once covered by water. Caescoper, for example, wrote

that June, July, and August in 1707 were so dry that people could travel by mule along the beds of former waterways. Strangely, the specific references to past events that are common in descriptions of high water levels are absent in observations of unusual dryness. Descriptions of cows walking across the former riverbeds in 1672, for example, make no mention of the conditions described by Van der Vienne just three years earlier.⁵²

According to multi-proxy flood reconstructions, when Dutch observers contextualized water levels in the present by citing water levels in the past they did so with great accuracy. For instance, regional storm surges did occur in 1586 and 1587, eight years before the flood Maelson experienced, although the more severe flooding in those years was actually stimulated by a dike breach near the city of Nijmegen, to the Southeast. Velius's reference to floods 40 years before 1610 corresponds to the devastating All Saints' Flood of 1 November 1570, in which similarly high Northwesterly winds coincided with the spring tide. The stone described by Van Wassenaer marked high water levels during the catastrophic river floods that followed the frigid and snowy winter of 1570/71. Meanwhile, when Van der Goes referred to high water levels 80 years before 1665, he likely referenced storm floods that affected the northern coastal provinces in February, 1585.⁵³

Unlike extremes in water levels, most severe or mild winters were not remembered using memorial devices that recorded unusual meteorological conditions and increased the accuracy and likelihood of recollection in the future. On the other hand, natural structures could contextualize winter severity with impressive accuracy. In December 1607, for example, Velius in Hoorn recorded the destruction of trees by freezing and concluded that a stretch of cold temperatures was unprecedented for as long as those trees had lived. In a sense, the lives of trees

⁵² Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 141, 629. Caescoper, *Dagboek van Claes Arisz. Caescoper*, 188.

⁵³ Gottschalk, *Stormvloed en rivieroverstromingen Vol. II*, 700, 714, 771, 780.

were used as proxies for cold weather by contemporary observers in the Republic, in a way that foreshadowed the development of dendrochronology in the twentieth century. However, the extent of ice cover provided the most useful context for winter freezing. During the frigid winter of 1599/1600, Hugo de Groot wrote that Hollanders had not experienced such a winter in 35 years. While only 16, De Groot likely accessed oral or written histories of extensive ice cover, snowfall, and hardship during the landmark winter of 1564/65, which can be considered the first of the Grindelwald Fluctuation. De Groot demonstrated the deep impression frigid winters and ice could leave on contemporary observers by describing how “beer was transformed into a solid mass, better as food than drink. Even our breath turned to ice. Across preternatural bridges horse hooves trample where ships once sailed.”⁵⁴

In the Republic, extensive ice cover was usually linked to changes in the kind, and possible extent, of available modes of mobility. Such changes were the most common proxies for the winters of the past. During the winter of 1620/21, Pier Winsemius wrote that horse-drawn sleighs could now be taken to the Republic’s North Sea islands of Terschelling, Ameland and Griend, which had not been possible since the equally frigid winter of 1607/08. Winsemius marvelled at how people were required to walk 12,000 steps from Harlingen on the coast of Friesland before they could see water. Similarly, during the severe winter of 1657/58 Van Aitzema described how people could walk over ice on the North Sea that stretched from Zandvoort to Schagen along the coast of Holland, which had not been seen in 50 years.⁵⁵

Multi-proxy climate reconstructions of winter severity indicate that sixteenth- and seventeenth-century Dutch references to past winters, while generally accurate, were

⁵⁴ Hugo de Groot, *Batavi, Mirabilium Anni MDC*. Den Haag: 1600, 137. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 246.

⁵⁵ Winsemius, *Chronique ofte historische geschiedenis van Vrieslant*, 910. Van Aitzema, *Saken van staet en oorlogh*, 125.

nevertheless less precise than the contextualization of water levels.⁵⁶ The winter of 1599/1600 that De Groot described was, for example, slightly milder than the winter of 1672/73, although it was indeed one of the coldest of the Little Ice Age. Similarly, the winter of 1620/21 was as frigid as the winter of 1607/08 and therefore slightly colder than the winter of 1657/58 described by Van Aitzema. On the other hand, Winsemius was therefore correct in suggesting that the winter of 1620/21 was the coldest since that of 1607/08. The winter of 1607/08 observed by Velius was as cold as any that had affected the Low Countries since the beginning of the sixteenth century, except for the winter of 1664/65. The rough accuracy of references to past winter severity reflects the limitations of ice cover as a proxy for winter temperature. Ice cover, particularly along the coast, is affected not only by temperature but also by wind patterns, currents, and other environmental variables. More accurate ice cover proxies of winter intensity were provided by accounts that measured the cessation of trekvaart services owing to freezing. Trekvaart canals were shielded from many of the environmental influences that mediated the relationship between temperature and ice cover on larger waterways. However, no qualitative sources survive that interpret these statistics to contextualize cold or mild winters, let alone to trace long-term changes in the severity and frequency of winters.⁵⁷

High or low water levels, like severe winters, were not always more important for Dutch citizens than other sites of interaction between weather and the broader environment. However, in surviving documentary records of meteorological conditions, observers usually only described extreme winters and unusual water levels in the context of dated weather events in their past.

⁵⁶ Although it may be that, for some locations, the reconstructions themselves are actually less precise than contemporary references.

⁵⁷ "Dynamics." National Snow & Ice Data Center. Accessed 14 December 2013: <http://nsidc.org/cryosphere/seaice/processes/dynamics.html#wind>. Van Engelen, Buisman and IJnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112. De Vries, *Barges and Capitalism*, 287.

Most of these documents were written on land, perhaps because sailors had little interest in detailed weather history as they struggled with day to day concerns. It may be that winters and water levels were particularly important manifestations of weather in the terrestrial Low Countries, directly affecting life and death on a scale that could not be matched by, for example, summer heat. Consequently they were more easily recalled and more readily recorded in monuments and other media. Water levels and winter temperatures were also associated with many different weather variables. Accounts of freezing in fall, winter, and spring were often accompanied by observations of easterly winds, while references to storms, wind direction, temperature, or precipitation usually supplemented descriptions of high water levels. The dates of unusual meteorological conditions, like abnormally persistent westerly winds, were therefore often remembered in descriptions of past water levels or winter severity. The detailed weather history recorded in surviving qualitative sources is therefore more comprehensive than it initially appears.

Still, the focus of sources that accurately contextualize experienced weather was overwhelmingly winter severity and water levels. Additional clues for the attention both winter severity and high water levels received may be found in the ways human activity exacerbated, or mitigated, their effects with particular force. Flooding could be influenced as much by a storm surge as a faulty dam or land subsidence in the wake of peat harvesting, while survival during winter was directly tied to the availability of necessary supplies. Shifts in water levels, like severe winters, were therefore accompanied by a complex suite of meteorological conditions and a variety of mediating human influences. In strengthening or weakening the Republic's watery defenses, both could have military consequences, particularly during the lengthy sieges that characterized the Eighty Years' War. They were also preternatural events for many in the

sixteenth and seventeenth centuries, commonly tied either to the will of God or the machinations of Satan.⁵⁸

Shifts in water levels and severe winters were therefore events that forcefully tied together relationships between weather and society with particularly memorable clarity. Most importantly, both shifts in water levels and severe winters were easily measured using natural or artificial structures. Ice cover expanded or retreated and water rose or fell in ways that were more easily quantifiable and memorialized than, for example, shifts in prevailing wind direction that did not have additional environmental ramifications. These changes in ice cover and water levels had practical consequences for transportation, the lifeblood of the Dutch economy, which further increased the likelihood that they would be precisely recorded.

During the Golden Age of the Dutch Republic, interested observers accurately described past weather extremes to contextualize similar conditions in their present. These observers, usually educated men of moderate to high social standing, had access to weather histories that were stored in the archives of memories, landscapes, architecture, visual art, and literature. Consequently, they could accurately discern when, and to what extent, the extreme weather of the present differed from that of the past. Some observers sought patterns in these histories. In 1597, Francis Bacon wrote that:

They say it is observed in the Low Countries (I know not in what part) that every five and thirty years the same kind and suit of years and weathers comes about again; as great frosts, great wet, great droughts, warm winters, summers with little heat, and the like; and they call it the *Prime*. It is a thing I do the rather mention, because, computing backwards, I have found some concurrence.⁵⁹

⁵⁸ Duyck, *De slag bij Nieuwpoort*, 80. Bor, *Oorsprong, begin, en vervolgh der Nederlandsche oorlogen, Vol I.*, 454.

⁵⁹ Surviving Dutch sources do not mention this “Prime.” Francis Bacon, “Of Vicissitudes of Things.” In *Essays Civil and Moral*. The Harvard Classics, 1909-14. Accessed 14 December 2013: <http://www.bartleby.com/3/1/58.html>.

Bacon's suite of weather conditions is superficially contradictory, but the so-called "Prime" likely referred to a year of extremes, in which the seasons were disrupted by wild swings in temperature and precipitation. There is no scientific evidence for such a Prime, and indeed its effects would be felt at a finer temporal resolution than is provided by multi-proxy climate reconstructions. Still, Bacon's summary of a peculiar belief in the Low Countries reveals the contemporary existence of at least the progenitors for an understanding of climate change. However, only extreme weather events were contextualized with reference to the past by the authors of surviving documents. These observers therefore lacked the awareness of long-term statistical patterns in average weather that allows for a full conception of climate change.

On the other hand, policies followed in war and economic competition hint that climatic shifts may have been gleaned from ship logbooks in ways that allowed Dutch officials to respond strategically to changes in prevailing meteorological conditions. For example, De Ruyter's tactics for exploiting the advantage given to Dutch war fleets in easterly winds were developed in a decade when such winds occurred more frequently than they had in earlier conflicts (Chapter 6). More than seventy years later, recommendations for new ship designs and bounties for rapid passage to Batavia, presented by Gustaaf Willem van Imhoff to the VOC's Heren XVII in 1741, suggest some awareness that wind patterns had shifted (Chapter 2). Ship logbooks were generally not kept by mariners plying the Baltic trades, but innovations designed to minimize the financial risk of shipwrecks for merchants did correspond to periods of increased storminess during the Little Ice Age. Such policies and practices offer tantalizing hints that climate change was recognized by the economic or military leaders of a Republic whose citizens were often keenly aware of, and dependent on, meteorological conditions. Firm conclusions are, however, impossible in the absence of qualitative accounts that reveal whether such strategies were

consciously or, perhaps, unconsciously crafted in response to shifting weather patterns. Similar impediments complicate but do not prohibit attempts to discern Dutch cultural responses to the shifting climate of the Little Ice Age.⁶⁰

Cultural Responses to Climate Change in the Dutch Republic

Relationships between natural events and human consequences can be less tangible for cultural historians of climate than they are for climate historians studying economic trends or military confrontation. The latter must identify connections between material processes in human, natural, or hybrid worlds, and then develop long-term climate histories by exploring an abundance of reliable links between short-term weather and isolated human actions. It is not necessary that documents reflect a comprehensive understanding of the full scope of relevant material processes – a perception of climate change, in other words – because humans can be influenced by what they do not understand. On the other hand, cultural historians of climate change are explicitly concerned with relationships between material processes and ideas. They explore the understanding of weather and perhaps climate change, but they are also interested in the culturally significant notions such understandings inspired.

Cultural responses to climate change need not be accompanied by an awareness of climatic fluctuation. Moreover, it is difficult to identify the relationship between climatic shifts and cultural developments without the explicit articulation of climate change in surviving documentary evidence. For example, obsession with the preternatural in sixteenth-century Europe was encouraged by cultural developments including the influence of the popular press, the increasing challenge to Aristotelian cosmology, and the atmosphere of religious debate.

⁶⁰ Van Imhoff, “Consideratiën over den tegenwoordigen staat van de Nederlandsche O.I.C.”

These cultural changes intersected with the shifting political attitudes, new technologies, and evolving economic structures that made them possible and therefore also informed new conceptions of the preternatural. On the other hand, it is likely that in many parts of Europe more common, and more severe, extreme weather during the Grindelwald Fluctuation directly prompted widespread interest in the significance of unusual meteorological events. The fascination with the preternatural contributed to the secularization of natural philosophy, and in this sense the climate of the Grindelwald Fluctuation inspired cultural change in early modern Europe, even if climate change was not fully perceived or understood by contemporary scholars. Still, writing on the preternatural in sixteenth and seventeenth-century Europe explicitly reflects its cultural origins and its concern with weather, but only very rarely mentions long-term trends in weather. While it is possible to gain clearer understanding of how contemporary Europeans perceived weather and perhaps climate change using these sources, it is much harder to discern exactly how their culture was transformed by climate change. Educated guesswork must substitute for the kind of analysis with which climate historians are more comfortable.⁶¹

Such speculation is particularly problematic in the burgeoning climate historiography of art in the Dutch Golden Age. In 1970 meteorologist Hans Neuberger famously analyzed more than 12,000 paintings completed from 1400 to 1967 and held in American and European museums. He concluded that cloudiness and darkness peaked in paintings created between 1550 and 1849, which corresponds with the three minima of the Little Ice Age. His conclusions were repeated by Hubert Lamb, and in 1980 William Burroughs, also a meteorologist, published an article that expanded Neuberger's hypothesis. According to Burroughs, the winter landscapes most famously crafted by Dutch artists were almost exclusively painted between 1565 and 1665.

⁶¹ Behringer, *A Cultural History of Climate*, 125.

Their inspiration and popularity were therefore influenced by the severity of winters during the Little Ice Age.⁶²

Burroughs argued that the iconic winter landscapes painted by Pieter the Brueghel the Elder were directly inspired by the frigid winter of 1565. Burroughs decided that Pieter Brueghel the Younger's "slavish" copying of his father's winter landscapes could not be tied to contemporary weather. However, he emphasized how Hendrick Avercamp spearheaded a new series of such paintings in the years following the frigid winter of 1608 (Figure 7.5). Burroughs slightly nuanced Neuberger's conclusions, allowing that changes in artistic convention led to the decline of winter landscapes after 1665. His hypothesis, grounded in a particularly vivid source and ostensibly supported by rigorous quantitative analysis, has been repeated in many studies of the Little Ice Age. In recent years it has also inspired a new generation of interdisciplinary scholars to create their own art histories of the Little Ice Age, most of which are, again, concentrated on the painters of the Dutch Golden Age. Pieter the Brueghel the Elder's *Hunters in the Snow* (1565) is even featured on the cover of Behringer's *A Cultural History of Climate* (2010).⁶³

⁶² Hans Neuberger, "Climate in Art." *Weather* 25:2 (1970): 46. W. J. Burroughs, "Winter Landscapes and Climatic Change." *Weather* 36 (1981): 352. Lamb, *Climate, History and the Modern World*, 265.

⁶³ Metzger, *Plaisirs de Glace: Essai sur la peinture hollandaise hivernale due Siècle d'or*. Ingrid D. Sager, *The Little Ice Age and 17th Century Dutch Landscape Painting, a Study on the Impact of Climate on Art*. (Dominguez Hills: California State University, 2006), 6. Douglas Macdougall, *Frozen Earth: The Once and Future Story of Ice Ages*. (Berkeley: University of California Press, 2004), 225. W.J. Burroughs, "Winter Landscapes and Climatic Change." *Weather* 36 (1981): 352. Behringer, *A Cultural History of Climate*, 139. Fagan, *The Little Ice Age*, 202. See also: Emmanuel Le Roy Ladurie, *Histoire humaine et comparée du climat, Vol. I: Canicules et glaciers*. Paris: Fayard, 2004.



Fig. 7.5. One of many winter landscapes depicted by Hendrik Avercamp. This one was painted during the frigid winter of 1619/20. Hendrick Avercamp, “Ice Landscape,” painting, 1620, Staatliche Museen, Schwerin, <http://www.ibiblio.org/wm/paint/auth/avercamp/ice-landscape-schwerin.jpg>.

Nevertheless, newer art histories of the Little Ice Age are more cautious. Neuberger’s hypothesis was sharply criticized by art historians who pointed out that the golden backgrounds of medieval canvases discouraged depictions of clouds, landscape painting emerged as an established artistic genre in the early modern periods, and twentieth-century abstract art was hardly wedded to a faithful representation of reality. Consequently, there are more than sufficient cultural explanations to explain the rise of dark, cloudy vistas in the art of the Dutch Golden Age. Moreover, many of the names most associated with the remarkable artistry of the Dutch Republic, including Rembrandt van Rijn and Johannes Vermeer, actually painted very few winter landscapes.⁶⁴

The link between the popularity of winter landscapes and severe winters is also hardly straightforward. Icy landscapes certainly rose in popularity during the Grindelwald Fluctuation,

⁶⁴ David Huddart and Tim Stott, *Earth Environments Past, Present and Future*. (John Wiley & Sons, 2013), 863. Kelly and Ó Gráda, “The Waning of the Little Ice Age,” 314.

but not so during the Maunder Minimum, when Dutch consumers increasingly preferred bright, sunny landscapes. Many climate historians still conclude that the popularity of winter landscapes was influenced by the rising frequency and severity of Little Ice Age winters, yet most would acknowledge that contemporary climate change was one influence among many. In the new historiography, winter landscapes illustrate how contemporary Europeans perceived their cold climate, but they were not necessarily a cultural response to that climate. Anthropologist Brian Fagan provides an exception to this caution. In 2000 Fagan claimed that Neuberger was correct in his analysis of “6,500” paintings: changes in cloud cover in paintings created during the Little Ice Age were, “not mere artistic fashion but probably accurate depictions of increased cloud cover.”⁶⁵

In fact, the historiography of climate change and Dutch winter landscapes demonstrates both the limitations and possibilities of the cultural history of climate. Winter landscapes provide a window into the ways in which Dutch citizens understood and exploited cold weather, yet they were not directly encouraged by that weather, and they can do little more than hint at the relationship between climate change and cultural trends. In some respects, contemporary Dutch winter landscapes are a uniquely problematic source for cultural historians of climate change, despite their seemingly obvious connection to the Little Ice Age. To link such paintings to the influence of climate change with the rigour that should accompany historical climatology, the creation of each painting should be thoroughly contextualized. Upon confirming that the artist intended to paint in response to a particular weather event, climate historians must test how faithfully each painting represented a weather event by verifying where the artist painted, and for how long. Leaving aside the unfathomable influence of the subconscious, historians can then

⁶⁵ Sam White, “The Real Little Ice Age.” *The Journal of Interdisciplinary History* 44:3 (2014), 338. Adriaan M. J. de Kraker, “The Little Ice Age: Harsh Winters Between 1550 and 1650,” in *Hendrick Avercamp: Master of the Ice Scene*, ed. Pieter Roelofs. (Amsterdam, 2009), 23. Brian Fagan, *The Little Ice Age*, 202.

consider relationships between climate change and art, but only by applying their methodology to many paintings created across several decades. Such scholarship is, of course, impossible given the sources that survive to document the creation of paintings in the Golden Age. Indeed, unlike many seventeenth-century naval paintings and illustrations, most winter landscapes were imagined within an artist's studio. Climate historians must therefore acknowledge the limitations of examining early modern art, while expanding their focus to include depictions of weather events beyond severe winters.

Similar issues plague the nascent scholarly analysis of contemporary literary responses to the Little Ice Age. Like the most famous Dutch winter landscapes, modern English drama was developed during the Grindelwald Fluctuation. The plays of Shakespeare in particular abound with references to unusual weather events like severe winters and ferocious storms, which grew more common in the North Sea region during the minima of the Little Ice Age. Shakespeare's plays have been subjected to "ecocritical" readings that explore how his many references to weather responded to contemporary environmental change. Similar methodology can be applied when examining weather references in the theatrical productions of the Dutch Golden Age.⁶⁶

For example, in 1637 Joost van den Vondel, the Republic's answer to Shakespeare, premiered his most famous work, *Gijsbrecht van Aemstel*. Written to inaugurate Amsterdam's first city theatre, the play dramatized a siege of Amsterdam in 1304 that bore some similarity to the beleaguerment of Troy. Characters in the play occasionally refer to weather events that were more common during cold decades in Little Ice Age. Gijsbrecht van Aemstel is mayor of the

⁶⁶ Loretta Johnson, "Greening the Library: The Fundamentals and Future of Ecocriticism." *Choice* (December 2009): 10. Robert Markley, "Summer's Lease: Shakespeare in the Little Ice Age," in *Early Modern Ecostudies: From the Florentine Codex to Shakespeare*, ed. Thomas Hallock, Ivo Kamps, and Karen L. Raber. (Hampshire: Palgrave Macmillan, 2008), 132. Sam White, "Was a Sad Tale Best for Winter? Shakespearean Theater and the Culture of the Little Ice Age." (Paper presented at the World Congress of Environmental History, Guimarães, Portugal, 8-12 July 2014).

young town and the play's ill-fated protagonist, but in the play's third act his wife Badeloch gives the most lucid description of weather. Although the siege around Amsterdam appears to have failed, in a dream Badeloch's niece warns her to flee, for the enemy is not defeated. Later in the act her dream appears to be confirmed, and she jealously lauds the fortune of small, poor villages that elude the storms and winds that threaten larger towns. Nevertheless, she remembers that "Since my marriage, since my engagement: / What storms have not blown over my head? / What tower is high enough to let me see / The waves, the sea of all I have endured?"⁶⁷

Badeloch's reflections are the product of a maritime culture in which storms threatened life at sea and near the coast. Storms mattered to the worldviews of Van den Vondel's characters, and served as apt metaphors for their violent lives. Certainly such storms grew more common during the nadir of the Little Ice Age, and some connection might exist between climate change and the expression of adversity in Golden Age literature. However, an analysis of Van den Vondel's beautiful poetry also demonstrates the limitations of this ecocritical approach. Neither 1637 nor the years that directly preceded and followed it were particularly cold, and indeed all were typical of the milder interval between Little Ice Age minima in the Low Countries. While a mild storm surge did flood some streets in Amsterdam in 1637, no significant inundations affected Holland in either 1636 or 1635. In fact, the meteorological context in which *Gijsbrecht van Aemstel* was written and initially performed appears to have been unusually mild and tranquil in the broader context of the seventeenth century. It is, of course, possible that Van den Vondel laid the intellectual groundwork for his play in years that were accompanied by weather

⁶⁷ Joost van den Vondel, *Gijsbrecht van Aemstel*, ed. Mieke B. Smits-Veldt. (Amsterdam: Amsterdam University Press, 1994), 70.

typical of the Little Ice Age. However, such mental fermentation is as opaque to climate historians as the intentions with which winter landscapes were crafted.⁶⁸

More importantly, descriptions of weather in literature rarely reflect attempts by authors accurately to depict reality. Weather can serve the interests of plot, or, when used metaphorically, highlight a character's internal struggle. Meteorological descriptions in literature can therefore suggest contemporary attitudes towards weather, but they can, at best, merely hint at relationships between climate change and culture. In Shakespeare's *The Tempest*, for example, the sorcerer Prospero raises a storm that advances the plot while providing a metaphor for upheaval and confusion. The preternatural agency behind the storm would have resonated for contemporary audiences (Figure 7.6), although Shakespeare was careful to distinguish Prospero's scholarly knowledge of magic from its more occult variants. Descriptions of storms in Van den Vondel's *Gijsbrecht van Aemstel* are almost entirely metaphorical, but they contribute to a theme of beleaguerment that is a product of a prosperous, urbanized Republic that was literally walled off from water, weather, and opposing armies. However, neither the narrative decisions taken by Van den Vondel or Shakespeare, nor their significance for contemporary audiences, can be convincingly tied to the climatic fluctuations of the Little Ice Age.⁶⁹

⁶⁸ Gottschalk, *Stormvloed en rivieroverstromingen Vol. III*, 128. Van Engelen, Buisman and Ijnsen, "A Millennium of Weather, Winds and Water in the Low Countries," 112.

⁶⁹ It is possible that the well-documented presentation and reception of Shakespeare's plays in particular could provide deeper insight into these relationships, particularly since his plays were viewed in the exposed Globe theatre. Climate historian Sam White of Ohio State University has recently taken up this avenue of scholarly inquiry. Joost van den Vondel, *Gijsbrecht van Aemstel*, 70. William Shakespeare, *The Tempest*. (New York: Dover Publications, 1998). Note that the conclusion provided here is not that there was no connection between the climatic fluctuations of the Little Ice Age and artistic references to, or depictions of, weather rendered more common during the period's minima. Instead, this chapter argues that historical climatologists should be more careful in establishing connections between climate, art, and culture.



Fig. 7.6. Frontispiece in a 1709 edition of Shakespeare's *The Tempest*. The preternatural origin of the tempest is abundantly demonstrated. William Shakespeare, *The Works of Mr. William Shakespear: Adorn'd with cuts. Revis'd and Corrected, with an account of the Life and Writings of the author, Vol. I.*, ed. Nicholas Rowe. London: Jacob Tonson, 1709.

Short poems crafted by amateurs or professionals in response to contemporary events could include far more direct references to weather than plays. For example, on 23 February 1602 a Northwesterly gale stimulated catastrophic storm flooding in Edam that, in turn, ignited a major fire. The disaster inspired the town's chronicler to write: "Oh frightful night: that has swallowed the sweat / Of so many days, who would not take pity on the city? / That just yesterday stood so proudly, now has Fallen, / One storm, one flood, one fire destroyed it all." Many short poems followed a similar template, and lamented the devastation, or simple

discomfort, caused by extreme weather. During the unusually wet summer of 1648, the poet Reyer Anslo wondered, “How could it be, / That raindrop after raindrop, / Crashes to the ground, / Day and night?”⁷⁰ A particularly lengthy poem was placed on the door of the office of the director of the herring fleet’s guild of pilots after the frigid winter of 1666/67. The poem reads:

In January sixteen hundred sixty seven,
 It froze and snowed severely,
 For six weeks shipping ceased,
 For three weeks people sailed as they pleased,
 [But] the most important thing commemorated here,
 Is how much ice accompanied March.
 On the 16th [of March] it started to freeze again,
 On the 17th fishermen abandoned their trade,
 On the 18th many walked on the IJ⁷¹ at the Laeg,
 On the 19th people crossed the IJ on the ice,
 On the 20th the weather and wind offered little relief,
 On the 21st it seemed that weather and wind might shift,
 On the 22nd the wind again ushered in freezing,
 On the 23rd the sun began to melt the ice,
 On the 24th the freezing lost its power,
 On the 25th many crossed the IJ with deliveries,
 On the 26th three people still walked across the IJ,
 After noon the boats sailed past the city,
 On the 27th the easterly wind piled the ice high on Pampus,⁷²
 On the 29th [sic] shipping was therefore still delayed,
 On the 30th some managed to managed to sail and walk across the ice,
 On 1 April some people still walked on the Zuider Zee,
 On the 2nd a ship was trapped in ice at Urk,⁷³
 This is recorded by M.T. the pilot’s man,
 To keep God’s wondrous power,
 In [everyone’s] thoughts.⁷⁴

Extreme weather events could stimulate cultural responses that were tied to the memory of weather and the interpretation of its significance. Such cultural responses were certainly

⁷⁰ Anton van Duinkerken, *Het goud der gouden eeuw, bloemlezing uit de poëzie der zeventiende eeuw*. (Utrecht: Het Spectrum, 1955), 118. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 212.

⁷¹ The waterway before the IJ, that led into the Zuider Zee.

⁷² The sandbank before Amsterdam’s harbour.

⁷³ An island, now part of the IJsselmeerpolders.

⁷⁴ Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 613.

mediated by cultural structures that encouraged poetry, for example, or economic frameworks that tied the Republic to waterborne commerce. Nevertheless, as extreme winters, severe storms, and catastrophic floods grew more common during the minima of the Little Ice Age, poetic responses also became more abundant. An unusually clear connection therefore exists between the climatic fluctuations of the Little Ice Age and these expressions of culture during the Dutch Golden Age. On the other hand, only a thin line separated poetry that responded directly to weather from poetry that employed descriptions of weather for narrative or metaphorical purpose. In poems about the “wind prince,” for example, Van den Vondel may have responded to storms and shifting wind patterns yet clearly employed his weather descriptions to serve patriotic Dutch narratives.⁷⁵

Discerning connections between climate change and art in the Dutch Republic is therefore a complex and inevitably speculative endeavour. However, some forms of art pointed towards more concrete connections between culture, weather, and the Little Ice Age. Many Dutch winter landscapes portrayed the vibrant social spaces that emerged when frozen waterways allowed skating, sledding, and sport (Figure 7.5). Particularly severe winters were never routine, even during the minima of the Little Ice Age, and among Dutch citizens they encouraged a feeling of shared experience. Participation in icy new social spaces across all of the Republic’s social strata was therefore enthusiastic and widespread. On 25 January during the frigid winter of 1668/69, for example, Van der Goes informed his brother that “an unbelievable number of people are on the ice every day.” Other observers described how thousands of sleds took to the ice when large portions of the Zuider Zee froze. The “ice culture” that emerged from

⁷⁵ Joost van den Vondel, “Aen den Leeuw van Holland,” 1642. *Universiteit van Amsterdam*. Accessed 17 December 2013: <http://cf.hum.uva.nl/dsp/ljc/vondel/1642/haarlemm.html>. Joost van den Vondel, *Volledige dichtwerken en oorspronkelijk proza*, ed. Albert Verwey. (Amsterdam, 1937): 981.

subsequent social interaction could take the form of a carnival in which merchants sold their wares and social norms collapsed.⁷⁶

For example, on 22 February 1608 in the bitterly cold winter of that year, army commander Frederich van Vervou reported that merchants had erected tents near the Ems in the Northeastern Republic, where everyone could drink beer and wine. New social and commercial spaces were not limited to the Republic, and in the same winter thousands of people drank their beverages on the frozen Scheldt off Antwerp. Meanwhile, Hugo de Groot in The Hague described the egalitarian character of mass culture on the ice. In a poem that may have also dated from the winter of 1607/08, De Groot relished how “here [on the ice] people are honest and free, / Here the farmer pushes aside the nobleman.” De Groot concluded with a couplet that declared: “if anyone should ask from their heart who is really wise, / I say from my heart: only the ice.” In a Republic in which social stratification was already less engrained than elsewhere in continental Europe, the ice culture that emerged in severe winters further levelled existing class distinctions, if only temporarily. This ice culture arose only in severe winters when the ice was thick enough, and extensive enough, to support large social gatherings. Consequently it would have been impossible or, at least, far less likely outside the minima of the Little Ice Age.⁷⁷

The ice culture of the Low Countries in cold winters was not limited to socialization on frozen waterways. In a Republic that depended on the manipulation and exploitation of different environments, it is no surprise that icy new landscapes encouraged innovation. On 17 January 1600 Adriaan Terrier received a patent for the construction of *ijsschuiten* or “ice boats” to

⁷⁶ Albeit without the religious and agricultural imagery, and politically charged atmosphere, that frequently accompanied medieval and early modern carnivals. Van der Goes, “Hage, den 25 January 1669.” *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II*, 22. Janszoon, *Het aantekeningenboek van Dirck Jansz*, 120. Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 192. Peter Burke, *Popular Culture in Early Modern Europe*. (Farnham: Ashgate Publishing, 2009), 256. Muir, *Mad Blood Stirring*, 114. Edward Muir, *Ritual in Early Modern Europe*. (Cambridge: Cambridge University Press, 1997), 92.

⁷⁷ Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 252. Frederich van Vervou, *Enige gedenckvveerdige geschiedenissen, tot narichtinge der nakomelingen*. (G.T.N. Suringar, 1841): 338.

navigate across frozen water. A decade later, Pieter Janszoon Twisck described seeing an “ice-wagon” that resembled a sailboat on skates. Stadhouder Maurice of Nassau permitted the construction of two such craft, which amazed onlookers by reaching the then-extraordinary velocity of 80 kilometres/hour. Linking the development and representation of such vehicles to cool winters during Little Ice Age minima is not as straightforward as it at first appears, for Dutch rivers can freeze even during warmer climatic regimes. Moreover, the ice wagon was soon adapted to function on land (Figure 7.7). On the other hand, it is significant that references to ice wagons appear in Dutch sources after two of the coldest winters of the Grindelwald Fluctuation. Any technology dependant on ice was naturally more practical when there was more ice, for longer, and so it is likely that ice wagons would not have been designed if milder winters had prevailed.⁷⁸



Fig. 7.7. The ice wagon, adapted to function on land. Willem Isaacsz van Swanenburgh, “The Land Yachts of Prince Maurits,” print, 1603, Rijksmuseum Amsterdam, <http://goo.gl/qc75EF>.

⁷⁸ Buisman and Van Engelen, *Duizend Jaar Vol. IV*, 192. Swan, *Art, Science, and Witchcraft in Early Modern Holland*, 3.

Conclusion: Cultural Vulnerability and Resilience during the Little Ice Age

Weather and climate change interacted with the Republic's culture in ways that reveal the complexity not only of contemporary Dutch society, but also its cultural history. Encouraged by the tolerance and observational emphasis of the Republic's intellectual culture, Dutch scholars developed an increasingly but not entirely secular understanding of weather. While some educated elites followed this scholarly trend, many others continued to interpret meteorological events as expressions of divine or demonic agency. Many among the less privileged may have adhered to a medley of magical and religious weather beliefs, although a pragmatic focus on the consequences of weather prevailed in their correspondence. Witchcraft persecution was muted in the Republic, perhaps owing to the distinct interactions between the climatic fluctuations of the Little Ice Age and Dutch socioeconomic, cultural, and environmental structures. Overall, the Dutch understanding of weather was complex and divided, however imperfectly, between social groups separated by their level of engagement in the Republic's intellectual culture.

Many literate Dutch observers employed their memories, memories of the elderly, and written sources to roughly discern the instability of patterns of severe weather. Extremes in winter severity and water levels, both of which were influenced but not determined by meteorological conditions, were recorded with remarkable accuracy using natural and artificial landmarks. However, there is little evidence suggesting that the detailed and continuous statistics of average weather listed in archived ship logbooks and toll accounts were interpreted using emerging techniques for quantitative analysis. Still, Dutch observers identified shifts in prevailing weather that represented a step towards perceiving, but certainly not understanding, contemporary climate change.

The visual art and literature of the Golden Age reflects the weather that was rendered more likely by the climatic minima of the Little Ice Age. However, these representations were mediated by the human circumstances in which they were created, and so do not clearly demonstrate the influence of contemporary climatic fluctuations. On the other hand, some popular poetry was written by observers in direct response to weather events that were common during Little Ice Age minima. Illustrations and paintings also depicted cultural spaces and technologies that were likely encouraged by severe winters during the coldest decades of the Little Ice Age. On the other hand, these were also shaped by cultural and social trends that were overlaid by personal agency in ways that obscure the precise influence of climatic stimuli. There were few straightforward cultural responses to the Little Ice Age, but the importance of weather in contemporary art hints at the influence of climatic fluctuations in the Republic.

Overall, Dutch sources express remarkably diverse attitudes towards meteorological conditions that, in turn, reflect the social heterogeneity of the Republic in its Golden Age. However, most Dutch accounts of weather during the Little Ice Age share a universal appreciation for the agency and power of weather. Many sources also demonstrate an understanding that the consequences of weather could be changed. Dikes could be rebuilt, ice could be used, water could impede or improve military defenses, and wind patterns could aid or hinder shipping. Dutch art both literary and visual could express loss or bewilderment in the face of extreme meteorological events. However, more often weather was endured or even exploited by voices and characters in Dutch art. Even particularly religious accounts of meteorological events possessed a pragmatic element, as prayer was intended to mitigate the adverse impacts of weather.

According to environmental historian Georgina Endfield, “the lived world of experience . . . informs people’s understandings and perceptions of their own relative vulnerability or resilience [to climate change].”⁷⁹ However, surviving Dutch sources suggest that cultural perceptions of weather and climate change did not just influence other cultural conceptions of adaptability. During the Little Ice Age, notions of environmental adaptability emerged within a Republic that was economically and militarily adaptable to shifting patterns of prevailing weather. This correlation indicates that the understanding of weather and climate change among a society’s citizens shapes their capacity to successfully adapt to climatic fluctuations in the physical world. Ultimately, the distinctively Dutch approach to weather may have contributed to the overall resilience of the Republic during the climatic fluctuations of the Little Ice Age.

⁷⁹ Endfield, “Exploring Particularity,” 305.

Conclusion: Conceptualizing the Influence of Climate Change in the Dutch Republic

Between approximately 1565 and 1720, the Little Ice Age reached its frigid nadir. In Northwestern Europe, temperatures declined, storminess increased, wind dynamics were altered, and precipitation patterns shifted during the Grindelwald Fluctuation (1565-1628) and the Maunder Minimum (1662-1720). Historical climatologists have demonstrated that the agricultural societies that dominated contemporary Europe generally suffered in the coldest phases of the Little Ice Age. By exploring both these minima and the warmer interval that separated them, the case studies in this dissertation have revealed that the influence of the Little Ice Age was more ambiguous across the Dutch commercial empire. The prosperity and security of the Republic were threatened by some meteorological conditions rendered more likely during Little Ice Age minima, but overall Dutch citizens resisted, and often successfully exploited, the weather that accompanied a cooler climate.

The first part of this dissertation introduced case studies that investigated how early modern climate change affected mobility, commerce, and ultimately the acquisition of wealth in the Dutch trading empire. The first chapter in that case study examined the three expeditions for a Northeast Passage in the 1590s, which pushed back the periphery of the world known to the Dutch. New multidisciplinary reconstructions of the contemporary Arctic atmosphere, hydrosphere, and cryosphere reveal that the voyages were shaped by complex interactions between a cooler climate and regional environmental conditions. Journals written by the explorers demonstrate that environmental influences were, in turn, mediated not only by the agency of the adventurers but also by the culture, technology, and economy of the Republic. All of these entanglements contributed to the failure to find a Northeast Passage, but they also

enabled both the expansion of contemporary scholarly knowledge, and the discovery of islands that would later feature prominently in the history of the Dutch Golden Age.

The second chapter examined how the manifestations of Little Ice Age climatic fluctuations in the North Sea region affected VOC ship journeys. Company day registers and correspondence reveal that shipwrecks and mortality rates both increased as the frequency of regional gales rose during the Maunder Minimum. Nevertheless, East Indiamen were less affected by storms than smaller ships, and some of their journeys could actually be shortened by several days of very high winds. Ship logbooks record that, in the North Sea region, a rise in the frequency of easterly and perhaps northerly winds during the Maunder Minimum increased the velocity of outbound VOC ships, although inbound vessels were more ambiguously affected. Overall, day registers suggest that changes in prevailing meteorological conditions in the North Sea region, which may also have affected much of the northeastern Atlantic, influenced a substantial reduction in the overall duration of outbound voyages that was not balanced by a rise in the length of returning journeys. This decline benefitted the Company's operations in Asia. More frequent easterlies likely also accelerated outbound voyages by rival East India Companies, but for most of the seventeenth century the VOC dominated Asian commerce. An advantage for the VOC was therefore more important to the Republic than advantages to other East India Companies were for the economies they helped support. Consequently, by accelerating outbound VOC journeys, weather conditions typical of the Maunder Minimum may have benefitted the Republic in the context of contemporary Europe.

The third chapter investigated mobility at the heart of the Dutch commercial empire. It began with an analysis of Dutch trade with the Baltic, which was more negatively affected by the meteorological conditions that accompanied Little Ice Age minima than the voyages of the VOC,

or even the expeditions of Arctic explorers. Dues paid by ships passing through the Danish Sound reveal that the rate of shipping in winter, spring, and autumn was strongly affected by prevailing temperatures and, in turn, the extent of local sea ice. Moreover, correspondence sent between Dutch government officials reflect the ways in which the complex manifestations of the Maunder Minimum in the Baltic could complicate Dutch diplomacy, encourage costly legal disputes, and hinder the supply of victuals to allied armies. More frequent storms could also devastate the ships that plied the Baltic trades, which often sailed close to lee shores. On the other hand, Dutch merchants creatively responded to the risks that accompanied more common gales by parcelling their commodities and investing in marine insurance. Cold winters may also have contributed to increases in grain prices, which could benefit Dutch merchants, and ultimately the Dutch economy.

The third chapter continued by exploring mobility within the borders of the Republic, where most travellers in the coastal provinces still journeyed by water. In the seventeenth century, the sailboats that serviced the beurtvaart network were gradually supplemented by the horse-drawn barges of the trekvaart, which were less susceptible to changes in wind direction but were still hampered by storms and winter freezing. However, even when the beurtvaart or trekvaart systems could not function, small-scale travel through the Republic persisted by road, on skates, or by a mixture of small boats and sleds. Certainly, some weather events more often experienced during Little Ice Age minima threatened all forms of mobility within the borders of the Republic. Overall, however, diverse transportation networks in the Republic, when exploited by Dutch citizens, fostered a remarkable resilience to movement through the northern Low Countries.

The second part of this dissertation examined the Anglo-Dutch Wars, to unravel connections between early modern climatic fluctuations and the Republic's defence of its prosperity. The fourth chapter began by introducing environmental, social, and cultural structures in the North Sea region on the eve of the First Anglo-Dutch War, which coincided with the warmer interval between the Grindelwald Fluctuation and the Maunder Minimum. The chapter employed ship logbooks, correspondence, intelligence reports, and diary entries to demonstrate that, in the first war, frequent westerly winds associated with a warmer climate often allowed Commonwealth fleets to claim the weather gage. With it, English commanders repeatedly seized the tactical initiative necessary to arrange ships of great size according to newly refined line of battle tactics. Dutch fleets usually lost in the face of these disadvantages. Moreover, English privateers, likely exploiting westerlies that allowed them easily to leave port and ambush merchant shipping, seized far more prizes than their Dutch counterparts. While the outcome of the war did little to alter the unequal commercial relationship between the Commonwealth and the Republic, it was very costly for Dutch merchants.

The fifth and sixth chapters of the dissertation analyzed the Second and Third Anglo-Dutch Wars, which were fought after the onset of the colder, wetter, stormier Maunder Minimum. In these wars, more common easterly winds frequently granted the weather gage to Dutch fleets that had adopted many of the most effective aspects of the English naval system. Easterly winds likely also contributed to the far greater success of Dutch privateers in the Second and especially the Third Anglo-Dutch Wars. High winds common during the Maunder Minimum forced English vessels to close their lower tier of guns, while thwarting attempts to blockade the Dutch coast. When France, Cologne, and Münster allied with England at the beginning of the third war, a complex suite of weather conditions that partially reflected the influence of a cooler

climate prohibited invasion from the sea but undermined the Republic's perimeter defences on land. Overall, in the Second and Third Anglo-Dutch Wars victory for the Republic was, in part, a consequence of meteorological conditions rendered more common by the coming of the Maunder Minimum.

The third part of the dissertation explored how what is now called the Little Ice Age was understood in the culture of the Dutch Republic, and how historical climatologists can conceptualize its influence in early modern Europe. The distinct culture of the Republic shaped, and was shaped by, the commercial acquisition and military defence of wealth during the Golden Age. Accordingly, the seventh and final chapter began by employing correspondence, diaries, newspaper articles, and other documentary sources to investigate the ways in which weather was understood across a diverse spectrum of Dutch society. As the Republic's seventeenth-century scholars contributed to the emergence of a more secular natural philosophy, many literate Dutch citizens continued to favour supernatural explanations for the kinds of weather phenomena that grew more common during the minima of the Little Ice Age. Nevertheless, the ambiguous and mediated material influence of the Little Ice Age in the Republic may have dampened some of the impetus behind Dutch witchcraft persecution. Moreover, letters dictated by the poor reflect pragmatic attitudes to even extreme weather events that demonstrate a concern for the consequences, rather than the causes, of meteorological conditions.

Among literate Dutch citizens, interest in the meaning of unusual weather likely contributed to the understanding that weather was prone to long-term fluctuations. Some Dutch observers employed their memories, documentary evidence, and natural or artificial landmarks to discern the weather history of severe winters and extreme water levels in particular with remarkable accuracy. However, there is no evidence that this rudimentary awareness of climate

change was accompanied by a perception of shifts in average weather conditions. Understanding of weather and perhaps climate change may also have stimulated cultural responses, but the influence of the Little Ice Age was, at best, indirect even in most of the art that represented weather rendered more likely in the period's minima. Still, contemporary depictions of weather common in the Grindelwald Fluctuation and Maunder Minimum, like the development of new practices and technologies, signified the conviction that adverse meteorological conditions could be tolerated and even exploited. In this, the Republic's culture may have contributed to its resilience in the face of the weather typical of Little Ice Age minima.

Contextualizing and Conceptualizing the Dutch Experience of the Little Ice Age

Dutch resilience was not shared by most inhabitants of contemporary Europe. In 1996, historical climatologist Jean Grove explained that "the impact of climatic changes on human society depends upon their scale on the one hand and the characteristics and sensitivity of the society concerned on the other."¹ Environmental historians have demonstrated that societal sensitivity was high, and climatic fluctuations were substantial, across much of early modern Europe. The cold, stormy, and often wet weather that accompanied the minima of the Little Ice Age contributed to famine, price increases, social unrest, and ultimately violence in France, England, Scotland, Scandinavia, the Holy Roman Empire, and elsewhere. On the other hand, in some parts of Europe, like the Swiss canton of Bern, social structures insulated populations from the worst demographic impacts of the Little Ice Age. Moreover, some agricultural societies prospered even in very cold decades, although these times of relative plenty rarely enter the largely declensionist historiography of the Little Ice Age. For example, by the waning of the

¹ Grove, "The Century Time-scale." 80.

Maunder Minimum, England and France were certainly wealthier and more influential than they had been at the beginning of the Grindelwald Fluctuation. Sweden, like the Dutch Republic, reached the height of its power within Europe during the nadir of the Little Ice Age. Indeed, the much-studied shift in European economic primacy from the Mediterranean to the Northwest was only partially a reflection of Dutch economic expansion. While these examples can provide helpful corrections to climate determinism, in much of northern Europe economic vitality and demographic growth were slowed, and in some cases sharply reversed, by socioeconomic influences that cascaded from the weather common in Little Ice Age minima. Moreover, between the beginning of the Grindelwald Fluctuation and the conclusion of the Maunder Minimum, no European society experienced the seemingly miraculous economic growth, demographic expansion, and cultural dynamism of the Republic in its Golden Age.²

These case studies have explored some of the most important technologies, attitudes, and socioeconomic structures that helped the Republic prosper during the coldest decades of the Little Ice Age. They have demonstrated that the Republic succeeded not only in spite of, but often partially because of, the cooler, wetter, stormier climate of the Grindelwald Fluctuation and the Maunder Minimum. In the context of contemporary Europe, the Republic's commercial economy provided networks of trade that responded very differently to changes in prevailing

² Although the Republic's population stagnated after 1660, and ultimately fell by 5% in subsequent decades. Even this decline was, however, moderate in the context of seventeenth-century Europe. For a provocative discussion of the social structures that render agricultural societies especially vulnerable to climate change, see: Behringer, *A Cultural History of Climate*, 146. Bell, "The Little Ice Age and the Jews," 12. Behringer, *A Cultural History of Climate*, 105, 146. Brown, *History and Climate Change*, 251. Karen J. Cullen, *Famine in Scotland: The 'Ill Years' of the 1690s*. (Edinburgh: Edinburgh University Press Ltd., 2010), 2. Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 50. Christian Pfister and Rudolf Brazdil, "Social vulnerability to climate in the 'Little Ice Age': an example from Central Europe in the early 1770s." *Climate of the Past Discussions* 2.2 (2006): 123. Lamb, *Climate, History, and the Modern World. 2nd Ed.*, 199. Erich Landsteiner, "Wenig Brot und saurer wein: Kontinuität und Wandel in der zentraleuropäischen Ernährungskultur im letzten Drittel des 16. Jahrhunderts." In *Kulturelle Konsequenzen der "Kleinen Eiszeit,"* ed. Wolfgang Behringer, Hartmut Lehmann, and Christian Pfister. (Göttingen: Vandenhoeck & Ruprecht, 2005), 109. See also: Karl Gunnar Persson, *Grain Markets in Europe, 1500-1900*. Cambridge: Cambridge University Press, 1999. Brazdil et al., "Historical Climatology in Europe - the State of the Art," 404. De Vries, "The Economic Crisis of the Seventeenth Century," 160. Parker, *Global Crisis*, xix.

weather than did agricultural production. The Dutch commercial system maintained the supply of essential commodities within the Republic, even in years accompanied by extremes in temperature or precipitation. Indeed, Dutch merchants could benefit from increases in the price of commodities such as wheat when meteorological conditions interacted with social forces to induce famine elsewhere in Europe. Moreover, changes in prevailing weather that accompanied contemporary climatic fluctuations could directly benefit movement of ships and, in turn, commodities, people, and information through the Dutch trading empire. Even when weather during Little Ice Age minima did impede some forms of travel, the Dutch transportation network was usually flexible enough to adapt.

The military capacity of the Dutch Republic was largely a consequence of its commercial pre-eminence. Dutch fleets were essential to the expansion and vigorous defence of the Republic's trading empire, and so the war ship was as much an economic asset as the merchant vessel. The Republic was not the only European naval power, although for more than a century it was arguably the most effective. Its naval success was a product of interactions between distinct environmental, social, economic, and cultural structures, which were leveraged with relative success by experienced mariners and their political masters. However, in European waters the weather that accompanied Little Ice Age minima also provided critical advantages that contributed to the defence of the Republic's commercial dominance. Moreover, by impeding the progress of armies, frigid winters and heavy precipitation rendered more common during the Grindelwald Fluctuation and Maunder Minimum could each hamper invasion of the heavily fortified Republic.³

³ Although freezing in cold winters could also undermine the effectiveness of defensive inundations, when these were necessary.

Nevertheless, storms, frigid winters, and floods could still devastate the Republic's commercial economy, its military operations, and ultimately the people who, by occupation or habitation, were vulnerable to extreme weather. Moreover, warmer decades during the Little Ice Age were accompanied by meteorological conditions that could reverse both the impediments and advantages of climatic minima for the Dutch. Accordingly, the influence of the Little Ice Age was profoundly ambiguous for the Dutch Republic. That ambiguity is reflected in aspects of contemporary Dutch culture. Surviving documents reveal a widespread fascination not only with the potentially devastating consequences of severe weather, but also with the possibility of explaining, and even exploiting it. This attitude towards the weather that frequently accompanied Little Ice Age minima may have been encouraged by a culture accustomed to both the prospect of environmental disaster, and the profitability of environmental manipulation.

Overall, the ambiguous influence of the weather that accompanied the coldest decades of the Little Ice Age in the Republic contrasted with its largely detrimental effects elsewhere in Europe. Consequently, early modern climatic fluctuations contributed to the economic, military, and cultural influence of the Dutch state within seventeenth-century Europe. Comprehensive historical narratives of the Dutch Republic at its height must therefore incorporate an analysis of the Little Ice Age. Indeed, weather and climate should become as important within modern histories of the Dutch Republic as they were to its citizens. Moreover, surveys of the Little Ice Age in Europe must include the Republic to nuance otherwise declensionist, and therefore partially misleading, accounts of early modern climate change.

The findings of this dissertation can also inform the creation of heuristic models that can help conceptualize relationships between climate change and human history. Such models need not necessarily accompany climate history, but their development and revision can provide

structured means for understanding the broader ramifications of otherwise isolated historical narratives. Many historians have a justified skepticism of explanatory models. Those detailed enough to reflect the nuances of history are often vulnerable to a host of historical exceptions, while those broad enough to avoid such exceptions usually reflect obvious and therefore banal relationships. However, conceptual or metaphorical models can, in climate history, provide ways of interpreting complex and sometimes counterintuitive relationships. They can also illustrate the synthesis of different interdisciplinary methodologies and results that necessarily inform historical climatology.

In recent decades, environmental historians have introduced or adapted interpretive models and theoretical approaches, many of which were originally devised in other disciplines or historical fields. In particular, Viennese researchers associated with the Institute for Interdisciplinary Studies of Austrian Universities are continuing to create and refine some of the most sophisticated models in environmental history. Perhaps the most enduringly influential has been the concept of “societal metabolism,” which employs the metaphor of cellular metabolism to trace the flow and transformation of energy and material within a socioecological system.⁴

This model can be readily applied to the Dutch Republic, a society that, in the context of early

⁴ The concept of “societal metabolism” has roots that stretch back to Karl Marx. It was revived by economists in the 1970s, when it was also employed in UNESCO’s “Man and the Biosphere” program. In the 1980s it was also termed “industrial metabolism,” and applied to industrial systems. Accordingly it was not developed by the Viennese researchers, but was instead adopted and refined by them for use in environmental history. The newer concept of “metabolic transition,” recently employed to conceptualize the industrial revolution, could also be applied to test the modernity of the Dutch economy in its early modern Golden Age, but it has little value for this study. Also influential within environmental history was the notion of the “environmental footprint,” coined in 1992 by William Rees, which was increasingly applied metaphorically by John McNeil and others. Richard C. Hoffmann, “Footprint Metaphor and Metabolic Realities: Environmental Impacts of Medieval European Cities,” in *Natures Past: The Environment and Human History*, ed. Paolo Squatriti. (Ann Arbor: University of Michigan Press, 2007), 291. Marina Fischer-Kowalski and Helmut Haberl, “Sustainable Development: Socio-economic metabolism and colonization of nature.” *International Social Science Journal* 50:4 (1998): 574. Marina Fischer-Kowalski and Walter Hüttler, “Society’s metabolism: The Intellectual History of Materials Flow Analysis, Part II, 1970-1998” *Journal of Industrial Ecology* 2:4 (1998): 108. Marina Fischer-Kowalski, “Society’s Metabolism: The Intellectual History of Materials Flow Analysis, Part I, 1860-1970” *Journal of Industrial Ecology* 2:1 (1998): 62. Fridolin Krausmann, Simone Gingrich, and Reza Nourbakhch-Sabet, “The Metabolic Transition in Japan: A Material Flow Account for the Period from 1878-2005.” *Journal of Industrial Ecology*, 15:6 (November 2011): 878.

modern Europe, was unusually reliant on the exploitation of energy and the manipulation of the environment for the large-scale movement of material. Moreover, the influence of Little Ice Age climatic fluctuations affected the ways in which the Dutch harnessed energy for transportation. However, the societal metabolism model does not provide an explicit illustration of relationships between the environmental structures involved in climate change.⁵ Moreover, the model cannot easily accommodate the study of, for example, Dutch military operations, journeys of exploration, or shifting cultural attitudes, all of which interacted with early modern climate change. It therefore has limited applicability for interpreting the influence of the Little Ice Age across the Dutch trading empire.⁶

In 2000, Marina Fischer-Kowalski, Helmut Haberl, and other Austrian researchers introduced the conceptual framework of Material and Energy Flow Accounting (MEFA) to better understand societal metabolism. Contributing to that framework were heuristic models that identify the intersection of culture and nature in the flow of material and energy through society's "biophysical structures," including human bodies. In a 2013 study that explores the environmental history of the Danube, Verena Winiwarter introduced the concept of the "socio-natural site," which avoids ontological dichotomies between nature and culture by connecting them through so-called "practices" and "arrangements." The MEFA framework, like the social metabolism model, incorporates the colonization of nature, but Winiwarter went further in

⁵ It places greater emphasis on "colonization" – the alteration of natural systems by human beings – than the internal workings of natural systems in ways that then influence human beings. Fischer-Kowalski and Haberl, "Society's metabolism," 575.

⁶ Fridolin Krausmann, "A City and its Hinterland: Vienna's Energy Metabolism, 1800-2006" in *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, ed. S.J. Singh, H. Haberl, M. Chertow, M. Mirtl, M. Schmid. (New York: Springer, 2013), 248. See also: Marina Fischer-Kowalski, *Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use*. (Cheltenham, U.K.: Edward Elgar, 2007). Sylvia Gierlinger and Fridolin Krausmann, "The Physical Economy of the United States of America: Extraction, Trade and Consumption of Materials from 1870 to 2005." *Journal of Industrial Ecology* 13:3 (2012): 365-377. Fridolin Krausmann and Helmut Haberl, "The Process of Industrialization from the Perspective of Energetic Metabolism: Socioeconomic Energy Flows in Austria, 1830-1995." *Ecological Economics*, 41:2 (2002), 177-201.

identifying how exactly nature can be colonized. These models and theoretical approaches have general applicability across the discipline of environmental history. Moreover, they distinguish between more or less colonized environmental systems in ways that are useful for climate history. However, they do not unravel the intricate relationships between natural phenomena that complicate the task of isolating the influence of climate in history.⁷

Consequently, some climate historians have developed their own models for interpreting relationships between human history and environmental change. Climate historians are forced carefully to consider relationships between distinct environmental processes that can be entirely devoid of human influence. Seasonal changes in the cryosphere near Novaya Zemlya, for example, were linked to climatic shifts and, in turn, to volcanic eruptions, yet during the Little Ice Age these entanglements were probably not influenced by human colonization. Historians cannot identify precisely how these relationships operated, but they can conceptualize them in ways that have relevance for the narratives they construct. For connecting human and climate histories, it matters that, for example, a generally colder climate did not always increase sea ice north of Russia, or indeed that warm seasons and even warm decades could occur during the nadir of the Little Ice Age. Moreover, many climate historians believe that there is a distinct pattern to the social consequences of climate change, even if the societal influence of climatic fluctuations is not necessarily different from that of other environmental transformations.

⁷ Verena Winiwarter, Martin Schmid, and Gert Dressel, "Looking at half a millennium of co-existence: the Danube in Vienna as a socio-natural site." *Water History* 5 (2013): 110. Helmut Haberl et al., "Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer." *Land Use Policy* 21:3 (2004): 201. Fridolin Krausmann et al., "Resource Flows and Land Use in Austria, 1950-2000: Using the MEFA Framework to Monitor Society-Nature Interaction for Sustainability." *Land Use Policy*, 21:2 (2004): 218. Carolyn Hendriks, et al. "Material flow analysis: a tool to support environmental policy decision making. Case-studies on the city of Vienna and the Swiss lowlands." *Local Environment* 5:3 (2000): 312. See also: S. Pritchard. "An envirotechnical disaster: nature, technology, and politics at Fukushima." *Environmental History* 17 (2012): 219–243. T. P. Hughes, *Human built world: how to think about technology and culture*. Chicago: Chicago University Press, 2005.

For example, one of the most recently published models in climate history was created by Christian Pfister to conceptualize the social impact of extreme weather. In Pfister's model, climatic variability influences water availability, food production and demand, and the "state of health." These variables then interact with one another and the properties of impacted societies, which include culturally-determined adaptive and adjustive mechanisms. However, the model does not conceptualize differences between climate, weather, and other natural influences. Moreover, it does not reveal the mechanism by which environmental change influences human history, and it omits meteorological conditions like wind, which were crucial to the early modern Dutch.⁸

In 2013, a team of interdisciplinary scholars from Europe and the United States introduced a much more comprehensive model for illustrating connections between climate change and human activity. In the model, a combination of climatic, natural, or human stimulus together creates drivers such as the emission of carbon dioxide, which can cause direct impacts, including warming, and indirect impacts, such as changes in crop yields or shifts in species phenology. Accordingly, the model differentiated climate change from other natural changes, distinguished direct from indirect impacts, and identified the kinds of influences that enable the co-evolution of climate, the broader environment, and society. It is probably the best conceptual model available to climate historians, but it still has some shortcomings. For example, it is heavily focused on explaining the consequences of anthropogenic global warming. It also does not identify the fundamental principle behind its drivers of change.⁹

The case studies in this dissertation have informed the development of a new heuristic model for conceptualizing, if not explaining, relationships between climate, environment, and

⁸ Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 40.

⁹ Dáithí Stone et al. "The challenge to detect and attribute effects of climate change on human and natural systems." *Climatic Change* 121 (2013): 385.

human history (Figure C.1). This model incorporates some of the insights of new models in environmental and climate history, but it adds important details. For example, gradual climate change and short-term, local environmental change (which includes weather) are distinguished from other environmental events that, like the movement of tectonic plates, can have climate impacts but are not inherently part of the climate system. Moreover, the model argues that human responses to climate change are a function of regional, short-term environmental changes, which are influenced in complex ways by broader environmental trends, like climatic fluctuations. Consequently, the model is helpful for visualizing the reality that relationships between natural phenomena are as complex, and as integral to climate history, as interactions between different aspects of society.

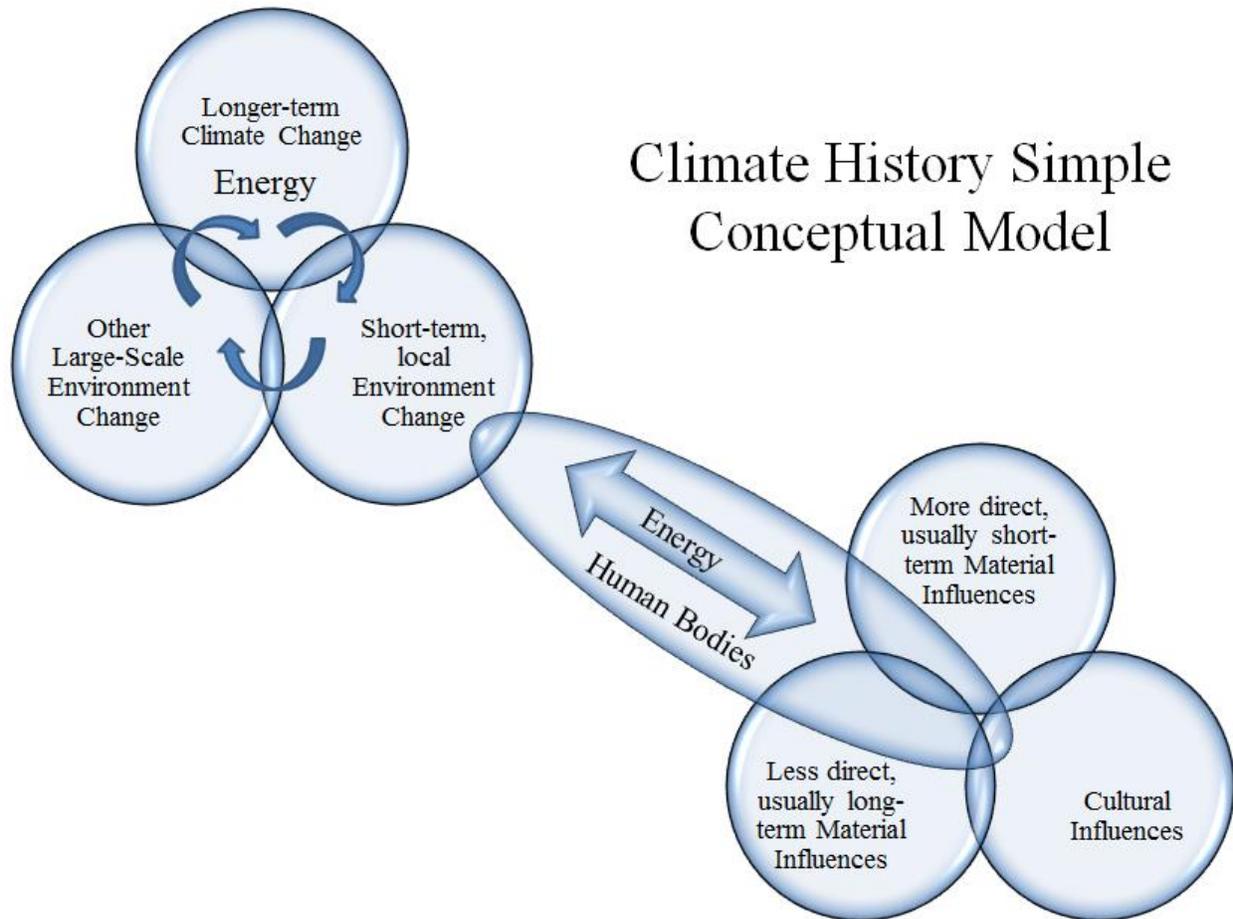


Fig. C.1. A simple model for conceptualizing broad interactions between climate change and human history.

In the model, natural changes co-evolve with society through transfers of energy, which are most directly expressed in the shared space of human bodies. Energy also influences physical changes, which can be expressed both in different local environmental conditions, and in more or less direct, and shorter or longer-term, material responses by human beings. Matter does not move without energy, and therefore energy that ultimately derives from the sun and flows through the climate system is the essential mediator between different kinds of material change. Short-term material influences of climatic fluctuations typically respond more directly than long-term material influences to local, short-lived environmental changes, because short-term natural

and social developments function on similar temporal and geographic scales. More direct, usually short-term, material influences on societies might include, for example, destruction caused by a storm, while less direct, usually longer-term influences could involve changes in transportation networks. Overall, the stimulus of energy in social change is always mediated by social structures and personal agency.

Energy flowing between environment and society also affects culture, partially but not entirely through its influence on society's material structures. Moreover, energy affects interactions between natural and social categories depicted in the model. These relationships are only visualized to link natural phenomena, because establishing such connections between social and cultural developments can as often complicate as clarify causality in human history. Ultimately, this is not a comprehensive model; it does not display all possible interactions between the environmental and social elements essential for climate history. However, it is detailed enough to help conceptualize the way in which climate change influences society, yet broad enough to be applicable across climate history.

While this heuristic model is not presented here as an analytical tool, it does provide a method for visualizing some of the major findings and ideas of this dissertation. For example, it illustrates why climate historians should first identify relationships between climate and local, short-term environmental change, as well as between human activity and local, short-term environmental change, before they can discern broader connections between climate and human history. It also visualizes the potential social importance of weather that does not conform to the climatic trend, such as the relatively warm summer of 1594, which encouraged the Republic's polar explorers. The model moreover includes the influence of changes in weather that accompany climatic fluctuations but are not usually examined by climate historians, like the

prevailing direction of regional winds. The model also accounts for differences between the direct and indirect material influences of local environmental change that are, in turn, affected by climatic shifts. This helps illuminate the distinct experience of the Little Ice Age in the Republic. For instance, the influence of weather on agriculture was often (if not inevitably) more direct than its influence in the transportation networks that supported the Republic's economy, and that probably benefitted the Dutch in early modern Europe.

Finally, the model illustrates that the ways in which energy is harnessed by a society can shape its social vulnerability to climate change. Survival for humans depends on energy derived from nutrients that are, in turn, created by photosynthesis and ultimately solar radiation. The production of these nutrients was central to the economic performance of the agricultural societies that dominated early modern Europe. However, the Dutch economy was largely sustained by commerce, and therefore energy was generally exploited differently in the coastal Republic than it was elsewhere in Europe. Weather conditions that reduced the amount of useable energy in agricultural societies did not necessarily reduce the energy available to the Dutch commercial economy. Visualized in the model, a consideration of energy provides a useful way of conceptualizing, if not explaining, the distinct experience of the Dutch during the Little Ice Age.¹⁰

The continued development and refinement of heuristic models in climate history is important for an area of study in which new work too often trends towards determinism. Indeed, by introducing the significance of early modern climate change within the Dutch Republic, this dissertation has raised many questions that promise to inform future climate histories of premodern Europe. Its case studies on mobility suggest the potential of research into the interactions between the maintenance of transportation infrastructure – like roads or docks – and

¹⁰ Sieferle, *The Subterranean Forest*, ix. Wrigley, *Poverty, Progress and Population*, 33.

climatic fluctuations. Its analysis of the Anglo-Dutch Wars raises the possibility of climate histories that holistically examine tactical operations, strategic planning, and resource flows in their analysis of premodern war. Even more pressing in a Dutch context is the need for studies that connect shifts in different kinds of agricultural and industrial production to the weather that accompanied Little Ice Age minima. Such research could incorporate relationships between domestic animals, weather, and climate change, which have scarcely been examined by climate historians.¹¹

More broadly, this dissertation has demonstrated the pressing need for further research that explores not only vulnerability but also resilience in past societal interactions with climate change. Sometimes the environmental manifestations of climatic fluctuations did worsen life for most people in, for example, parts of early modern Europe. However, declensionist assumptions too often simplify climate history. How did past societies and social groups adapt to, or even exploit, times of climatic transition? Are there any common characteristics shared by these peoples? This study has revealed that the continued high-resolution reconstruction of meteorological conditions beyond seasonal temperature and precipitation will be essential to answering these questions. In no way can historians contribute more to climate reconstruction than in the interpretation of past meteorological observations relevant to, for example, patterns of prevailing wind and daily changes in weather.

Precisely identifying the full spectrum of weather at a particular time, and in a particular place, will also allow climate historians to examine relationships between individual decisions and societal vulnerability to climate change. This dissertation has demonstrated that occasionally counterintuitive decisions made by individuals mitigated, or exacerbated, the socioeconomic and military influence of weather that was, in turn, shaped by climate change. Acknowledging the

¹¹ Sam White, "Animals, Climate Change, and History." *Environmental History* 19 (2014): 322.

importance of human agency and accidents can lead climate historians towards a more explicit treatment of chance in their narratives, and towards more complex descriptions of historical change. Historical climatology has evolved tremendously in the past decade, yet there is great potential for research that will render it even more relevant for historians and climatologists alike.

Ultimately, climate history can inform modern attempts to predict, and respond to, the consequences of anthropogenic global warming. The primary contribution of this dissertation to that crucial endeavour lies in the troublesome questions and complexities that it has unearthed, which are not always addressed by scientists. While interdisciplinary reports by the IPCC and the World Meteorological Organization explicitly identify uncertainty in their projections, many scientists have published deterministic assessments of life on a warmer planet. Such determinism has subsequently been propagated by journalists, non-governmental organizations, and policymakers. For example, in 2009 the prestigious but now-defunct Global Humanitarian Forum, an NGO based in Geneva, published a report documenting the current global impact of anthropogenic climate change. According to the report, “every year climate change leaves over 300,000 people dead, 325 million people seriously affected, and [causes] economic losses of US \$125 billion.”¹² Such determinism is usually tempered in the most high-profile scientific studies, many of which are more explicit in their treatment of possible uncertainties. Nevertheless, even most of the more sophisticated, nuanced studies of current and future relationships between humanity and climate change lack historical context and depth.¹³

¹² Global Humanitarian Forum, *The Anatomy of a Silent Crisis*. Geneva: Global Humanitarian Forum, 2009: 1.

¹³ Including IPCC predictions of future relationships between societies and projected climate change. Mike Hulme, “Reducing the Future to Climate: A Story of Climate Determinism and Reductionism.” *Osiris* 26:1 (2011): 245. Chris D. Thomas et al., “Extinction Risk from Climate Change,” *Nature* 427 (2004): 145. Joeri Rogelj et al. “Probabilistic cost estimates for climate change mitigation.” *Nature* 493: 7430(2013): 79. Mark Carey, “Science, Models, and Historians: Toward a Critical Climate History.” *Environmental History* 19 (2014): 354.

Determinism is not the same as alarmism, and indeed there might be value in both given the glacial pace of climate change mitigation today. Still, projections of relationships between climate change and future societies, when developed for policymakers, should be as accurate as possible. To this end, the insights of climate history, and the findings of this dissertation, can play an important role. An analysis of the Dutch Republic in the Little Ice Age reveals above all that climate change influences society in complex, often counter-intuitive ways that, in considerations of the future, resist confident prediction. For example, weather rendered less likely in a particular climate can have the greatest social consequences; climatic fluctuations can be expressed very differently in different regions; environmental crisis for some can provide opportunities for others; and possibilities precluded by climatic stimuli can prompt decisions that would have been better all along. Global warming is perhaps the greatest crisis of the coming century, yet the future, like the past, is sure to be non-linear.

Bibliography

Archival Sources:

Claes Arisz. *Caescoper*, Dagboek van Claes Arisz. *Caescoper*. PA-143. Gemeente Archief Zaanstad (Zaanstad, Netherlands).

Documents from reference number: 5501. Archief van het Ambacht Nierwer-Amstel, met het Archief van de Ambachten Rietwijk, Rietwijkeroord en Rietwijkeroorderpolder.

Documents from Deutz Family 1613-1878. Reference code: 234. Gemeente Amsterdam Stadsarchief (Amsterdam, Netherlands).

Maps from the Kaartcollectie Ministerie van Oorlog, Situatiekaarten. Reference code: 4. Nationaal Archief (The Haag, Netherlands).

Ordinance and correspondence from Ambachts en dorpsbestuur Zoeterwoude, Reference code: 0500A. Regionaal Archief Leiden (Leiden, Netherlands).

Ship logbooks and correspondence in the Verenigde Oost-Indische Compagnie Collectie, Reference code: 1.04.02. Nationaal Archief (The Hague, Netherlands).

Ship logbooks in Aanwinsten Eerste Afdeling, Reference code: 1.11.01.01, Nationaal Archief (The Hague, Netherlands).

Ship logbooks and correspondence in Collectie de Ruyter, Reference code: 1.10.72.01, Nationaal Archief (The Hague, Netherlands).

Online Resources:

Aristotle. *Physics I.1*, Translated by Webster. Available online:
<http://classics.mit.edu/Aristotle/meteorology.mb.txt>.

Avercamp, Hendrick. "Ice Landscape." Painting. 1620. Staatliche Museen, Schwerin.
<http://www.ibiblio.org/wm/paint/auth/avercamp/ice-landscape-schwerin.jpg>.

----- "Winter Scene on a Canal." Painting. C. 1605. Toledo Museum of Art.
<http://goo.gl/HndX5w>

Bacon, Francis. "Of Vicissitudes of Things." In *Essays Civil and Moral*. The Harvard Classics, 1909-14. Accessed 14 December 2013: <http://www.bartleby.com/3/1/58.html>.

Beersraten, Jan Abrahamsz. "IJsvermaak bij de Hoofdtoren te Hoorn." Painting. C. 1651-1666.
http://www.colf-kolf.nl/1450-1700/3/details/Jan_Beerstraten_na_1651.htm.

- Beerstraten, Jan Abrahamszoon. "Slag bij Ter Heijde." Painting. 1653-1666. Rijksmuseum Amsterdam. <https://www.rijksmuseum.nl/en/collection/SK-A-22>.
- Bruegel, Pieter the Elder. "Hunters in the Snow." Painting. 1565. Kunsthistorisches Museum Vienna. <http://www.google.com/culturalinstitute/asset-viewer/hunters-in-the-snow-winter/WgFmzFNNN74nUg?hl=en>
- , "The Census at Bethlehem." Painting. 1566. Musées royaux des Beaux-Arts de Belgique. <http://www.wikipaintings.org/en/pieter-bruegel-the-elder/census-at-bethlehem-1566>.
- , "Winter Landscape with a Bird Trap." Painting. 1565. Musées Royaux des Beaux-Arts. http://www.wga.hu/frames-e.html?html/b/bruegel/pieter_e/01/13winter.html.
- Brueghel, Pieter the Younger. "Winter Scene with Ice Skaters and Birds." Painting. 1638. <http://goo.gl/8rbqLX>.
- Clark, Liat. "Arctic Northeast Passage will melt even earlier this summer." Wired UK, 14 June 2012. <http://www.wired.co.uk/news/archive/2012-06/14/northeast-passage-melts>.
- "CLIWOC Data Position Plots: Maarseveen (CLIWOC Meta Data)." Accessed June 24 2013, http://www.knmi.nl/cliwoc/cliwocmeta_maarseveen.htm.
- "CLIWOC Data Position Plots: Afrika (CLIWOC Meta Data)." Accessed June 24 2013, http://www.knmi.nl/cliwoc/cliwocmeta_afrika.htm.
- "CLIWOC Ship Logbook Database." Accessed June 24 2013, <http://www.knmi.nl/cliwoc>
- Cuyp, Aelbert. "River Scene with a Ferry Boat." Painting. C. 1652. Auckland Art Gallery Toi o Tāmaki. <http://www.aucklandartgallery.com/the-collection/browse-artwork/121/river-scene-with-a-ferry-boat>.
- "Database VOC Schepen." De VOC Site. Accessed June 24 2013, <http://www.vocsite.nl/schepen/lijt.html>.
- "De briefwisseling van Anthonie Heinsius 1702-1720." Accessed March 8 2014, <http://resources.huygens.knaw.nl/heinsiusrepublicpoliticswarfinance>.
- De Hooghe, Romeyn and Govard Bibloo. "Franse wreedheden in Bodegraven en Zwammerdam." Print. 1673. Rijksmuseum Amsterdam. <http://goo.gl/5XjR8k>.
- Du Val, Pierre D'Abbeville. "Carte des Isles Britanniques, 1677," map, 1677, <http://goo.gl/I8zIX1>.
- "Dynamics." National Snow & Ice Data Center. Accessed January 4 2013, <http://nsidc.org/cryosphere/seaice/processes/dynamics.html#wind>.

- “Eastern England: Climate,” Met Office. Accessed February 2, 2013, <http://www.metoffice.gov.uk/climate/uk/ee>.
- Hollar, Wenceslaus. “Plan of London before the fire.” Map. 1665. Thomas Fisher Rare Book Library. University of Toronto. <http://goo.gl/cqvf2U>.
- Hondius, Abraham. “A Frost Fair on the Thames at Temple Stairs.” Painting. 1684. Museum of London. <http://www.museumoflondon.org.uk/london-wall/whats-on/exhibitions-displays/frost-fairs>.
- Kreamer, Andrew E. “Warming Revives Dream of Sea Route in Russian Arctic.” *New York Times*, 17 October 2011, <http://www.nytimes.com/2011/10/18/business/global/warming-revives-old-dream-of-sea-route-in-russian-arctic.html>.
- Letters in *Corpus Brieven als Buit*. Instituut voor Nederlandse Lexicologie. Accessed December 20 2013, <http://brievenalsbuit.inl.nl/zeebrieven/page/search>.
- Liss, Artyom. “Arctic trail blazers make history.” *BBC News*, 19 September 2009. <http://news.bbc.co.uk/2/hi/8264345.stm>.
- “Northeast England: Climate,” Met Office. Accessed February 2, 2013, <http://www.metoffice.gov.uk/climate/uk/ne>.
- Pepys, Samuel. “Monday 23 January 1664/65,” *Diary of Samuel Pepys*, accessed 10 January 2011, <http://www.pepysdiary.com/archive/1665/01>.
- Schellinks, Willem. “The Dutch in the Medway.” Painting. 1667. Rijksmuseum, Amsterdam.
- Smallegange, Mattheus, and Jan Luyken. “Panorama op Reimerswaal.” Print. 1696. Amsterdam Museum. <http://goo.gl/w0rt7d>.
- Storck, Abraham. “The ‘Royal Prince’ and other Vessels at the Four Days Battle, 1-4 June 1666.” Painting. 1667. National Maritime Museum. <http://collections.rmg.co.uk/collections/objects/11778.html>.
- “The Sound Toll Database,” Sound Toll Registers Online. Accessed July 3 2013, <http://www.soundtoll.nl/index.php/en/over-het-project/sonttol-registers>.
- Van Dam, Petra J. E. M. “De amfibische cultuur: Een visie op watersnoodrampen.” Accessed February 1 2014, <http://goo.gl/ICV1ZD>.
- Van de Velde, Willem the Younger. “A Dutch Ship Scudding Before a Storm.” Painting. C. 1690. National Maritime Museum. <http://collections.rmg.co.uk/collections/objects/12397.html>.

- , "The Capture of the Royal Prince." Painting. 1666. Rijksmuseum Amsterdam.
<http://goo.gl/xeYBrS>.
- Van den Vondel, Joost. "Aen den Leeuw van Holland," 1642. *Universiteit van Amsterdam*.
 Accessed 17 December 2013, <http://cf.hum.uva.nl/dsp/ljc/vondel/1642/haarlemm.html>.
- Van der Meulen, Adam Frans. "Louix XIV passing the Rhine." Painting. 1672. Deutsches
 Historisches Museum. <http://goo.gl/JLrCXL>.
- Van Eeertveld, Andries. "The Return to Amsterdam of the Second Expedition to the East Indies
 on 19 July 1599." Painting. C. 1610-1620. National Maritime Museum.
<http://collections.rmg.co.uk/collections/objects/12240.html>.
- Van Swanenburgh, Willem Isaacsz. "The Land Yachts of Prince Maurits." Print. 1603.
 Rijksmuseum Amsterdam. <http://goo.gl/qc75EF>.
- Veluwenkamp, J. W. "Sound Toll Registers: Concise source criticism." Accessed August 10
 2013, <http://www.soundtoll.nl/images/files/STRpdf.pdf>.
- Verschuier, Lieven. "The Great Comet of 1680." Painting. 1680. <http://goo.gl/7F5piV>.
 "Wat is het NAP?" Stichting Normaal Amsterdams Peil. Accessed March 13 2014,
<http://www.normaalamsterdamspeil.nl>.
- Wilson, Robert M. "Volcanism, Cold Temperature and Paucity of Sunspot Observing Days
 (1818-1858): A Connection?" The Smithsonian/NASA Astrophysics Data System, 1998.
 Accessed July 7, 2012,
<http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19980233233.pdf>.
- "Wrecks in Documents." *Maritiem programma Nederland, Rijksdienst voor het Cultureel
 Erfgoed*. Accessed June 24 2013, http://www.maritiemprogramma.nl/WID_00.htm.
- "Zoeken in the Collectie." Rijksmuseum Amsterdam. Accessed 20 March 2014,
<https://www.rijksmuseum.nl/nl/zoeken>

Published Sources and Studies:

- "A Perfect relation of the great fight between the English and Dutch fleets on Fryday and
 Satturday [sic] last." London: Printed for George Horton, 1653.
- Alexander, Lisa V., Simon K. Allen, Nathaniel L. Bindoff, François-Marie Bréon, John A.
 Church, Ulrich Cubasch, Seita Emori, et al. *Climate Change 2013: The Physical Science
 Basis*, edited by Thomas F. Stocker, Dahe Win, Gian-Kasper Plattner, Melinda M. B.
 Tignor, Simon K. Allen, Judith Boschung, Alexander Nauels, et al. IPCC WGI AR5,
 2013.

- Allin, Thomas. *The Journal of Sir Thomas Allin, Vol. I, 1660-1666*. Edited by R. C. Anderson. London: Navy Records Society, 1939.
- Alpers, Svetlana. *The Art of Describing: Dutch Art in the Seventeenth Century*. Chicago: University of Chicago Press, 1983.
- Alting, Egbert. *Diarium van Egbert Alting, 1553-1594*. Edited by W.J. Formsma and R. van Roijen. The Hague: Nijhoff, 1964.
- Anderson, R. C. "Introduction," in *The Journal of Sir Thomas Allin, Vol. II, 1667-1678*, ed. R. C. Anderson. London: Navy Records Society, 1939.
- Andrade, Tonio. "The Company's Chinese Pirates: How the Dutch East India Company Tried to Lead a Coalition of Pirates to War against China, 1621-1662." *Journal of World History* 15:4 (2004): 415-444.
- Andreae, S. J. Fockema. "De trekvaart Haarlem-Leiden driehonderd jaar," In *Haerlem jaarboek*, 1959.
- Anonymous. "The Dutch bloody almanack, conteyning the exact astrologicall predictions, for the yeare of our Lord 1653." London: printed by John Clowes, 1653.
- Apian, Peter. *Cosmographia*. Landshut, 1524.
- Aram, Bethany. "Chapter 12: Distance and Misinformation in the Conquest of America" in *The Limits of Empire: European Imperial Formations in Early Modern World History: Essays in Honor of Geoffrey Parker*, ed. William Reger. Farnham: Ashgate Publishing, 2013.
- Bacon, Francis. *Historia Ventorum, Vol. 12*. Oxford: Oxford University Press, 2007.
- Ball, Clara Sue. "The Early History of the Compound Microscope." 51. *Bios* 37:2 (1966): 51-60.
- Bamber, Jonathan L. and Antony J. Payne (eds). *Mass Balance of the Cryosphere: Observations and Modelling of Contemporary and Future Changes*. Cambridge: Cambridge University Press, 2004.
- Bang, Nina Ellinger. *Tabeller over Skibsfart og Varetransport gennen Øresund 1497-1660, Vol. I-III*. Copenhagen: Gyldendalske Boghandel, 1906-1933.
- Bankoff, Greg. "The 'English Lowlands' and the North Sea Basin: A History of Shared Risk," *Environment and History* 19:1 (2013): 3-37.
- Barbour, Violet. *Capitalism in Amsterdam in the 17th Century*. Ann Arbor: University of Michigan Press, 1963.

- Barents, Willem. *Deliniatio cartæ trium navigationum etc.* The Hague: Cornelis Claeszoon, 1599.
- Bartels, Michiel H. "Zeven keer door de Zuiderdijk." *Jaarboek* 78 (2011): 69-77.
- Baten, Joerg and Jan Luiten van Zanden. "Book production and the onset of modern economic growth." *Journal of Economic Growth* 13 (2008): 217-235.
- Bauernfeind, W. and U. Woitek, "The Influence of Climatic Change on Price Fluctuations in Germany during the 16th Century Price Revolution," *Climatic Change* 43:1 (1999): 303-321.
- Bawlf, Samuel. *The Secret Voyage of Sir Francis Drake, 1577-1580.* Vancouver: Douglas & McIntyre, 2003.
- Becht, Harold Edward. *Statistische gegevens Betreffende den Handelsomzet van de Republiek der Vereenigde Nederlanden Gedurende de 17e Eeuw (1579-1715).* The Hague: Firma I. J. C. Boucher, 1908.
- Beenakker, J. J. J. M. "De Trekvaart tussen Leiden en Haarlem." *Dever Bulletin* (1994): 18-21.
- Behringer, Wolfgang. "Climatic Change and Witch-Hunting: The Impact of the Little Ice Age on Mentalities." *Climatic Change* 43:1 (1999), 335-351.
- *A Cultural History of Climate.* Cambridge: Polity Press, 2010.
- Bell, Dean Phillip. "The Little Ice Age and the Jews: Environmental History and the Mercurial Nature of Jewish-Christian Relations in Early Modern Germany." *AJS Review* 32:1 (2008): 1-27.
- Benedict, Barbara M. *Curiosity: A Cultural History of Early Modern Inquiry.* Chicago: University of Chicago Press, 2001.
- Berlioz, Jacques. *Catastrophes naturelles et calamités au Moyen Âge.* Florence : Edizioni del Galluzzo, 1998.
- Bernstein, Lenny, Peter Bosch, Osvaldo Canziani, Zhenlin Chen, Renate Christ, Ogunlade Davidson, William Hare, et al. *Climate Change 2007: Synthesis Report, An Assessment of the Intergovernmental Panel on Climate Change*, edited by Abdelkader Allali, Roxana Bojariu, Sandra Diaz, Ismail Elgizouli, Dave Griggs, David Hawkins, Olav Hohmeyer, et al. Valencia: IPCC, 2007.
- Birks, Hilary. "Holocene vegetational history and climatic change in west Spitsbergen – plant macrofossils from Skardtjørna, an Arctic lake." *The Holocene* 1:3 (1991): 209-218.

- Black, J. "Was There a Military Revolution in Early Modern Europe?" *History Today* 58:7 (July 2008): 34-41.
- "Bloudy newes from Holland: being a true relation of the present proceedings of the Dutch-men against the English." London: Printed for E. Cotton, 1652.
- Blussé, Leonard. "No Boats to China. The Dutch East India Company and the Changing Pattern of the China Sea Trade, 1635-1690." *Modern Asian Studies* 30:1 (1996): 51-76.
- Bogucka, Maria. "Amsterdam and the Baltic in the First Half of the Seventeenth Century." *The Economic History Review* 26:3 (1973): 433-447.
- Bor, Pieter Christiaanszoon. *Oorsprongk, begin, en vervolgh der Nederlandsche oorlogen*, Vol I. Amsterdam: Joannes van Someren, Abraham Wolfgangh, Hendrick en Dirck Boom, 1679-1684.
- Borodachev, V. Ye. and V. Yu. Alexandrov, "History of the Northern Sea Route." In *Remote Sensing of Sea Ice in the Northern Sea Route: Studies and Applications*, ed. Ola M. Johannessen. New York: Springer Praxis Books, 2007.
- Braat, J. "Dutch activities in the North and the Arctic during the sixteenth and seventeenth centuries." *Arctic* 37:4 (1984): 473-480.
- , *Behouden uit het Behouden Huys. Catalogus van voorwerpen van de Barentsexpeditie (1596), gevonden op Nova Zembla. De Rijksmuseumcollectie, aangevuld met Russische en Noorse vondsten*. Amsterdam: De Bataaf sehe leeuw, 1998.
- Bradley, Raymond S. and Philip D. Jones. "'Little Ice Age' summer temperature variations: their nature and relevance to recent global trends." *The Holocene* 3 (1993): 367-376.
- Brady, Lisa M. "The Wilderness of War: Nature and Strategy in the American Civil War." *Environmental History*, 10:3 (2005): 421-447.
- Brandt, Gerard. *Uit het Leven en Bedrijf van den here Michiel de Ruiter*. Amsterdam: G. Schreuders, 1687.
- Braun, Georg and Franz Hogenberg, *Civitates Orbis Terrarum Vol. IV*. Cologne, 1588.
- Braudel, Fernand. *The Mediterranean and the Mediterranean World in the Age of Philip II, Vol. I*. California: University of California Press, 1995.
- Brázdil, Rudolf, Christian Pfister, Heinz Wanner, Hans Von Storch, and Jürg Luterbacher. "Historical Climatology in Europe - the State of the Art." *Climatic Change* 70 (2005): 363-430.

- Briffa, K. R., P. D. Jones, R. B. Vogel, F. H. Schweingruber, M. G. L. Baillie, S. G. Shiyatov, and E. A. Vaganov. "European Tree Rings and Climate in the 16th Century." *Climatic Change* 43:1 (1999): 151-168.
- Briffa, K. R., T. J. Osborn and F. H. Schweingruber. "Large-scale temperature inferences from tree rings: a review." *Global and Planetary Change* 40:1-2 (2004): 11-26.
- Brown, Christopher. *Dutch Paintings*. London: National Gallery Publications, 1983.
- Brown, Neville. *History and Climate Change: A Eurocentric perspective*. London: Routledge, 2001.
- Bruijn, Jaap R. "Between Batavia and the Cape: Shipping Patterns of the Dutch East India Company." *Journal of Southeast Asian Studies*, 11:2 (1980): 251-265.
- "Dutch Fisheries: An Historiographical and Thematic Overview." In *The North Atlantic Fisheries, 1100-1976: National Perspectives on a Common Resource*, ed. Poul Holm, David J. Starkey and Jón Th. Thór, 105-120. Esbjerg: Fiskerimuseet, 1996.
- "Dutch Privateering during the Second and Third Anglo-Dutch Wars." In *The Low Countries History Yearbook 1978*, edited by I. Schöffler, 67-83. Dordrecht: Springer, 1979.
- "The Dutch East India Company as Shipowner, 1602-1796." *American Neptune* 47:4 (September 1987): 240-248.
- Bruijn, J. R., F. S. Gaastra, and I. Schöffler, with assistance from A.C.J. Vermeulen. *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Introductory Volume*. The Hague: Martinus Nijhoff, 1987.
- Bruijn, J. R., F. S. Gaastra, and I. Schöffler, with assistance from E. S. van Eyck. *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Volume II, Outward-bound voyages from the Netherlands to Asia and the Cape (1595-1794)*. The Hague: Martinus Nijhoff, 1979.
- Bruijn, J. R., F. S. Gaastra, and I. Schöffler, with assistance from E. S. van Eyck. *Dutch-Asiatic Shipping in the 17th and 18th Centuries, Volume III: Homeward-bound voyages from the Asia and the Cape to the Netherlands (1597-1795)*. The Hague: Martinus Nijhoff, 1979.
- Buisman J. and A. F. V. van Engelen, ed. *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575-1675*. Franeker: Uitgeverij Van Wijnen, 2000.
- *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675-1750*. Franeker: Uitgeverij Van Wijnen, 2006.
- Burke, Peter. "Viewpoint: The Invention of Leisure in Early Modern Europe." *Past & Present* 146 (1999): 136-150.

- . *Popular Culture in Early Modern Europe*. Farnham: Ashgate Publishing, 2009.
- . *What is Cultural History?* Cambridge: Polity Press, 2008.
- Burkett, Virginia, Avelino G. Suarez, Marco Bindi, Cecilia Conde, Rupa Mukerji, Michael Prather, Asuncion Lera St. Clair, et al. *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. IPCC WG II AR5, 2014.
- Burroughs, W. J. "Winter Landscapes and Climatic Change." *Weather* 36 (1981): 352-357.
- Burstyn, Harold L. "Early Explanations of the Role of the Earth's Rotation in the Circulation of the Atmosphere and the Ocean." *Isis* 57:2 (1966): 167-187
- Camuffo, Dario and Chiara Bertolin, "Recovery of the early period of long instrumental time series of air temperature in Padua, Italy (1716-2007)." *Physics and Chemistry of the Earth*, 40-41 (2012): 23-31.
- Camuffo, Dario, Claudio Cocheo, and Giovanni Sturaro. "Corrections of Systematic Errors, Data Homogenisation and Climatic Analysis of the Padova Pressure Series (1725-1999)," *Climatic Change* 79 (2006): 493-514.
- Carey, Mark and Philip Garone, "Forum Introduction." *Environmental History* 19 (2014): 282-293.
- Carey, Mark. "Science, Models, and Historians: Toward a Critical Climate History." *Environmental History* 19 (2014): 354-364.
- Carleton, Sir Dudley. *Letters from and to Sir Dudley Carleton*. London: C. Herring, 1757.
- Christensen, Aksel E. *Dutch Trade to the Baltic about 1600: Studies in the Sound Toll Register and Dutch Shipping Records*. Copenhagen: Einar Munksgarrd, 1941.
- Citino, R. M. "Military Histories Old and New: A Reintroduction." *American Historical Review* 112 (2007): 1070-1090.
- Claiborne, Robert. *Climate, Man and History*. London: Angus and Robertson, 1973.
- Clark, Stuart. *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe*. Oxford: Oxford University Press, 1999.
- Colenbrander, H. T., ed. *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. I: 1652-1667*. The Hague: Martinus Nijhoff, 1919.
- Colenbrander, H. T., ed. *Bescheiden uit Vreemde Archieven omtrent de Groote Nederlandsche Zeeoorlogen, Vol. II: 1667-1676*. The Hague: Martinus Nijhoff, 1919.

- Cook, Harold J. *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age*. New Haven: Yale University Press, 2007.
- Coolhaas, W. P. H. ed. *Generale missiven van gouverneurs-generaal en raden aan heren XVII der Verenigde Oostindische Compagnie, Vol. 1-9*. The Hague: Martinus Nijhoff, 1980.
- Cornelisz. the Younger, Cornelis. *Utrechtsch kronijkjen, Vol. VI*. Archief voor Kerkelijke en Wereldsche Geschiedenissen. Utrecht, 1846.
- Crespin, Elisabeth, Hugues Goosse, Thierry Fichefet, Aurélien Mairesse, and Yoann Sallaz-Damaz. "Arctic climate over the past millennium: Annual and seasonal responses to external forcings." *The Holocene* 23 (2013): 321-329.
- Crespin, Elisabeth, Hugues Goosse, Thierry Fichefet, and M. E. Mann. "The 15th century Arctic warming in coupled model simulations with data assimilation." *Climate of the Past* (2009): 389-401.
- Crone, G. C. E. *Nederlandsche binnenschepen*. Amsterdam: Alert de Lange, 1944.
- Cullen, Karen J. *Famine in Scotland: The 'Ill Years' of the 1690s*. Edinburgh: Edinburgh University Press Ltd., 2010.
- Culver, Lawrence. "Seeing Climate through Culture." *Environmental History* 19 (2014): 311-318.
- D'Andrea, William J., Yongsong Huang, Sherilyn C. Fritz, and N. John Anderson. "Abrupt Holocene climate change as an important factor for human migration in West Greenland." *Proceedings of the National Academy of Sciences* 108:24 (2011): 9765-9769.
- D'Andrea, William J., David A. Vaillencourt, Nicholas L. Balascio, Al Werner, Steven R. Roof, Michael Retelle, and Raymond S. Bradley. "Mild Little Ice Age and unprecedented recent warmth in an 1800 year lake sediment record from Svalbard." *Geology* 10.1130 (2012): 1007-1010.
- Daston, Lorraine. *Classical Probability in the Enlightenment*. Princeton: Princeton University Press, 1988.
- "Marvelous Facts and Miraculous Evidence in Early Modern Europe." *Critical Inquiry* 18:1 (1991): 93-124.
- Davids, C. A. "De technische ontwikkeling in Nederland in de vroeg-moderne tijd. Literatuur, problemen en hypothesen." *Jaarboek voor de Geschiedenis van Bedrijf en Techniek* 8 (1991): 9-37.

- Davids, Karel. "Technological Change and the Economic Expansion of the Dutch Republic, 1580-1680," in *The Dutch Economy in the Golden Age: Nine Studies*, edited by K. Davids and L. Noordegraaf 79-104. Amsterdam: Nederlandsch Economisch-Historisch Archief, 1993.
- . *The Rise and Decline of Dutch Technological Leadership: Technology, Economy and Culture in the Netherlands, 1350-1800, Vol. I*. Leiden: Brill, 2008.
- Davis, N. Z. "The Rites of Violence: Religious Riot in Sixteenth-Century France," *Past and Present* 59 (1973), 51-91.
- De Groot, Hugo. *Batavi, Mirabilium Anni MDC*. Den Haag: 1600, 137.
- De Hollantsche Mercurius*. Haarlem: Pieter Casteleun, 1666.
- De Jonge, J. C. *Het Nederlandsche Zeewezen, Vol I, 2nd Ed*. Haarlem: A.C. Kruseman, 1858.
- De Kraker, Adriaan M. J. "A method to assess the impact of high tides, storms and storm surges as vital elements in climatic history. The case of stormy weather and dikes in the Northern part of Flanders, 1488-1609," *Climatic Change* (1999): 287-302.
- . "Reconstruction of Storm Frequency in the North Sea Area of the Preindustrial Period, 1400-1625 and the Connection with Reconstructed Time Series of Temperatures," *History of Meteorology* 2 (2005), 66.
- . "The Little Ice Age: Harsh Winters Between 1550 and 1650," in *Hendrick Avercamp: Master of the Ice Scene*, ed. Pieter Roelofs. Amsterdam, 2009.
- De Pottre, Jan. *Dagboek van Jan de Pottre, 1549-1602*. Edited by B. de St. Genois. Ghent: C. Annoot-Braeckman, 1861.
- De Silva, R. Rajpal Kumar. *Illustrations and Views of Dutch Ceylon 1602-1796: A Comprehensive Work of Pictorial Reference with Selected Eye-Witness Accounts*. Brill Archive, 1988.
- De Veer, Gerrit. *Reizen van Willem Barents, Jacob van Heemskerck, Jan Cornelisz. Rijk en Anderen Naar het Noorden (1594-1597), Eerste Deel*. The Hague: Martinus Nijhoff, 1917.
- . *The True and Perfect Description of Three Voyages by the Ships of Holland and Zeeland*. London, 1609.
- . *Warhafftiige Relation der dreyen neuen, unerhörten seltzamen Schiffart*. Neurenberg: L. Hulsius, 1598.

- De Vries, Jan and Ad van der Woude. *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500-1815*. Cambridge: Cambridge University Press, 1997.
- De Vries, Jan. *Barges and Capitalism. Passenger Transportation in the Dutch Economy, 1632-1839*. Utrecht: HES Publishers, 1978.
- . "Measuring the Impact of Climate on History: The Search for Appropriate Methodologies." *Journal of Interdisciplinary History*, x:4 (Spring 1980): 599-630.
- . "The Economic Crisis of the Seventeenth Century after Fifty Years." *Journal of Interdisciplinary History* 40:2 (2009): 151-194.
- Deen, Femke, David Onnekink, and Michel Reinders. "Pamphlets and politics: introduction," in *Pamphlets and Politics in the Dutch Republic*, edited by Femake Deen, David Onnekink and Michel Reinders 3-30. Leiden: Brill, 2010.
- Delano-Smith, Catherine. "Milieus of Mobility: Itineraries, Route Maps and Road Maps." In *Cartographies of Travel and Navigation*, ed. James R. Akerman. Chicago: University of Chicago Press (2006): 16-68.
- De Witt, Johan. *Brieven, Geschreven ende gewisselt tusschen den Heer Johan de Witt, Raedt-Pensionaris, ende de Gevolmghtigden van den Staedt der Vereenighde Nederlanden, so in Vranckryck, Engelandt, Sweden, Denemarcken, Poolen, enz: Beginnende met den jaere 1652 tot het jaer 1669 incluys, Volume II*. The Hague: Hendrick Scheurleer, 1723.
- De Witt, Johan. *Brieven van Johan de Witt, Derde Deel: 1665-1669*. Edited by Robert Fruin. Amsterdam: Johannes Müller, 1912.
- Dreiskämper, Petra. *Redeloos, radeloos, reddeloos: de geschiedenis van het rampjaar 1672*. Hilversum: Uitgeverij Verloren, 1998.
- Dres-Coenders, Lene. *Het verbond van heks en duivel. Een waandenkbeeld aan het begin van de moderne tijd als symptoom van een veranderende situatie van de vrouw en als middel tot hervorming der zeden*. Baarn: Ambo, 1983.
- Duyck, Anthonis. *De slag bij Nieuwpoort: Journaal van de tocht naar Vlaanderen in 1600*. Nijmegen: SUN, 2000.
- . *Journaal van Anthonis Duyck, advocaat-fiscaal van den raad van state: (1591 - 1602) Uitgegeven op last van het departement van oorlog, met inleiding en aantekeningen door Lodewijk Mulder, Vol. I*. The Hague: Martinus Nijhoff, 1862.
- Eamon, William. *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture*. Princeton, NJ: Princeton University Press, 1994.

- Edwards, Paul. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge: The MIT Press, 2010.
- Emmer, P. C. *The Dutch in the Atlantic economy, 1580-1880*. Aldershot: Ashgate, 1998.
- Endfield, Georgina H. "Exploring Particularity: Vulnerability, Resilience, and Memory in Climate Change Discourses." *Environmental History* 19 (2014): 303-310.
- Enthoven, Victor. "Early Dutch Expansion in the Atlantic Region, 1585-1621," in *Riches from Atlantic commerce: Dutch transatlantic trade and shipping, 1585-1817*, edited by Johannes Postma and Victor Enthoven 17-47. Leiden: Brill, 2003.
- Esper, Jan, David C. Frank, Mauri Timonen, Eduardo Zorita, Rob J. S. Wilson, Jürg Luterbacher, Steffen Holzkämper, Nils Fischer, Sebastian Wagner, Daniel Nievergelt, Anne Verstege, and Ulf Büntgen. "Orbital Forcing of tree-ring data." *Nature Climate Change* (2012): 862-866.
- Evans, D. C. B., J. F. Nye, and K. J. Cheeseman. "The Kinetic Friction of Ice." *Proceedings of the Royal Society* 347:1651 (1976): 493-512.
- Fagan, Brian M. *The Great Warming: Climate Change and the Rise and Fall of Civilizations*. New York: Bloomsbury Press, 2009.
- , *The Little Ice Age: how climate made history, 1300-1850*. Boulder: Basic Books, 2000.
- Fischer-Kowalski, Marina. *Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use*. Cheltenham, U.K.: Edward Elgar, 2007.
- Fischer-Kowalski, Marina and Helmut Haberl, "Sustainable Development: Socio-economic metabolism and colonization of nature." *International Social Science Journal* 50:4 (1998): 573-587.
- Fix, Andrew C. *Prophecy and Reason: The Dutch Collegiants in the Early Enlightenment*. Princeton: Princeton University Press, 1991.
- Flinn, Michael. *The European Demographic System, 1500-1820*. Baltimore: Johns Hopkins University Press, 1981.
- Fock, Willemijn C. "Funst en rariteiten in het Hollandse interieur." In *De wereld binnen handbereik: Nederlandse kunst- en rariteitenverzamelingen, 1585-1735*, ed. Ellinoor Bergevelt and Renee Kistemaker, 70-91. Zwolle: Waanders Uitgevers/Amsterdam Historisch Museum, 1992.
- Frank, F. C. "Descartes' Observations on the Amsterdam Snowfalls of 4, 5, 6 and 9 February 1635," *Journal of Glaciology* 13:69 (1974), 535-539.

- Frisinger, H. Howard. "René Descartes: The Last of the Old, and the First of the New Meteorologists." *Weather* 21:12 (1966): 443-446.
- Fritschy, Wantje, Marjolein 'T Hart, and Edwin Horlings. "Long term trends in the fiscal history of the Netherlands, 1515-1914." In *The Rise of Fiscal States: A Global History, 1500-1914*, edited by B. Yun-Casalilla & P.K. O'Brien 39-66. Cambridge: Cambridge UP, 2012.
- Fritschy, Wantje. "Schulden als leerschool? De Unie der Zeven Verenigde Provinciën en de Europese Unie." *Tijdschrift voor Sociale en Economische Geschiedenis*, 9:2 (2012): 3-28.
- Fruin, Robert. *De oorlog van 1672*. Groningen: Wolters-Noordhoff 1972.
- Furnivall, J. S. *Netherlands India: A Study of Plural Economy*. Cambridge: Cambridge University Press, 2010.
- Gales, Ben, Astrid Kander, Paolo Malanima, and Mar Rubio. "North versus South: Energy transition and energy intensity in Europe over 200 years." *European Review of Economic History* 11 (2007): 219-253.
- Gaastra, Femme S. *Bewind en beleid bij de VOC: de financiële en commerciële politiek bij de bewindhebbers, 1672-1702*. Zutphen, 1989.
- , *The Dutch East India Company: expansion and decline*. Zutphen: Uitgeversmaatschappij Walburg Pers, 2003.
- García-Herrera, Ricardo, Gunther P. Können, D. A. Wheeler, Maria R. Prieto, Philip D. Jones, and Frits B. Koek. "CLIWOC: A climatological database for the world's oceans 1750-1854," *Climatic Change* 73 (2005): 1-12.
- García-Herrera, Ricardo, Luis Prieto, David Gallego, Emiliano Hernández, Luis Gimeno, Gunther Können, Frits Koek, Dennis Wheeler, Clive Wilkinson, Maria Del Rosario Prieto, Carlos Báez, and Scott Woodruff. *CLIWOC Multilingual Meteorological Dictionary: An English-Spanish-Dutch-French dictionary of wind force terms used by mariners from 1750 to 1850*. Den Haag: Koninklijke Nederlands Meteorologisch Instituut.
- Gelderblom, Oscar and Joost Jonker. "Completing a Financial Revolution: The Finance of the Dutch East India Trade and the Rise of the Amsterdam Capital Market, 1595-1612." *The Journal of Economic History* 64:3 (2004): 644.
- Gelderblom, Oscar. *Zuid-Nederlandse kooplieden en de opkomst van de Amsterdamse stapelmarkt (1578-1630)*. Hilversum: Uitgeverij Verloren, 2000.

- Gergis, Joëlle et al., "The Influence of Climate on the First European Settlement of Australia: A Comparison of Weather Journals, Documentary Data and Palaeoclimate Records, 1788–1793." *Environmental History* (2010) 15(3): 485-507.
- Gierlinger, Sylvia and Fridolin Krausmann, "The Physical Economy of the United States of America: Extraction, Trade and Consumption of Materials from 1870 to 2005." *Journal of Industrial Ecology* 13:3 (2012): 365-377.
- Gijswijt-Hofstra, Marijke. "The European witchcraft debate and the Dutch variant." *Social History* 15:8 (2008): 181-194.
- Glacken, Clarence. *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century*. Berkeley: University of California Press, 1967.
- Glaser, Rüdiger and Gerhard Koslowski. "Variations in reconstructed ice winter severity in the western Baltic from 1501 to 1995, and their implications for the North Atlantic Oscillation." *Climatic Change* 41 (1999): 175-191.
- Glaser, Rüdiger. *Klimageschichte Mitteleuropas. 1000 Jahre Wetter, Klima, Katastrophen*. Darmstadt: Buchgesellschaft, 2001.
- Glete, Jan. *Warfare at Sea, 1500-1650*. New York: Routledge, 2000.
- Global Humanitarian Forum, *The Anatomy of a Silent Crisis*. Geneva: Global Humanitarian Forum, 2009.
- Go, Sabine. *Marine Insurance in the Netherlands, 1600-1870: a comparative institutional approach*. Amsterdam: Askant, 2009.
- Goldgar, Anne. *Impolite Learning: Conduct and Community in the Republic of Letters, 1680-1750*. New Haven: Yale University Press, 1995.
- , *Tulipmania: Money, Honor, and Knowledge in the Dutch Golden Age*. Chicago: University of Chicago Press, 2008.
- Golinski, Jan. "Time, Talk and the Weather in Eighteenth-Century Britain," in *Weather, Climate, Culture*, edited by Sarah Strauss and Benjamin S. Oorlove, 17-38. London: Bloomsbury Academic, 2003.
- Gonnet, C. J. "Inleiding," in *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I.*, edited by C. J. Gonnet, i-xxxix. Amsterdam: Johannes Müller, 1899.
- "Good newes from General Blakes fleet." London: Printed for Robert Ibbitson dwelling in Smithfield near Hosier Lane, 1652.

- Goodman, Dena. *The Republic of Letters: A Cultural History of the French Enlightenment*. Ithaca: Cornell University Press, 1996.
- Gottschalk, Elisabeth M. K. *Stormvloeden en rivieroverstromingen in Nederland, Vol II: de periode 1400-1600*. Assen: Van Gorcum, 1975.
- *Stormvloeden en rivieroverstromingen in Nederland, Vol III: de periode 1600-1700*. Assen: Van Gorcum, 1977.
- Grant, Edward. "Celestial Orbs in the Latin Middle Ages," *Isis* 78:2. (1987): 153-173.
- Grove, Jean M. *Little Ice Ages: Ancient and Modern*. London: Routledge, 2004.
- "The Century Time-scale." In *Time-scales and Environmental Change*, edited by Thackwray S. Driver and Graham P. Chapman, 39-87. Oxford: Routledge, 1996.
- Grove, Richard. "Indigenous Knowledge and the Significance of South-West India for Portuguese and Dutch Constructions of Tropical Nature." *Modern Asian Studies* 30:1 (1996): 122.
- Gunn, J. D. "A.D. 536 and its 300-year Aftermath." In *The Years Without Summer: Tracing AD 536 and its Aftermath*, edited by J. D. Gunn, 5-20. Oxford: Archaeopress, 2000.
- Gupta, Anil K., David M. Anderson, and Jonathan T. Overpeck. "Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean." *Nature* 421 (2003): 354-357.
- Haberl, Helmut, Marina Fischer-Kowalski, Fridolin Krausmann, Helga Weisz, and Verena Winiwarter. "Progress towards sustainability? What the conceptual framework of material and energy flow accounting (MEFA) can offer." *Land Use Policy* 21:3 (2004): 199-213.
- Hacking, Ian. *The Emergence of Probability, Second Edition*. Cambridge: Cambridge University Press, 2006.
- *The Taming of Chance*. Cambridge: Cambridge University Press, 1990.
- Hacqueborn, Louwrens. "In Search of *Het Behouden Huys*: A Survey of the Remains of the House of Willem Barentsz on Novaya Zemlya." *Arctic* 48:3 (1995): 248-256.
- "The hunting of the Greenland right whale in Svalbard, its interaction with climate and its impact on the marine ecosystem." *Polar Research* 18:2 (1999): 375-382.
- Hainsworth, Roger and Christine Churches. *The Anglo-Dutch Naval Wars*. Stroud: Sutton Publishing Limited, 1998.

- Hale, J. R. *War and Society in Renaissance Europe*. London: Fontana, 1985.
- Haley, K. H. D. *The Dutch in the Seventeenth Century*. London: Thames and Hudson Ltd., 1972.
- Harding, Richard. *Seapower and Naval Warfare, 1650-1830*. London: UCL Press, 1999.
- Heckscher, Eli. *Mercantilism*. Oxford: Routledge, 2013; orig. 1931.
- Hendriks, Carolyn, Richard Obernosterer, Daniel Müller, Susanne Kytzia, Peter Baccini, and Paul H. Brunner. "Material flow analysis: a tool to support environmental policy decision making. Case-studies on the city of Vienna and the Swiss lowlands." *Local Environment* 5:3 (2000): 311-328.
- Hellinga, Gerben Graddeesz. *Pioniers van de Gouden Eeuw*. Zutphen: Walburg Pers, 2007.
- *Zeehelden van de Gouden Eeuw*. Zutphen: Walburg Pers, 2008.
- Hill, Charles E. *The Danish Sound Dues and the Command of the Baltic*. Durham: Duke University Press, 1926.
- Hodge, Adam R. "‘In Want of Nourishment for to Keep Them Alive:’ Climatic Fluctuations, Bison Scarcity, and the Smallpox Epidemic of 1780-82 on the Northern Great Plains." *Environmental History* (2012) 17(2): 365-403.
- Hoffmann, Richard C. *An Environmental History of Medieval Europe*. Cambridge: Cambridge University Press, 2014.
- "Footprint Metaphor and Metabolic Realities: Environmental Impacts of Medieval European Cities." In *Natures Past: The Environment and Human History*, edited by Paolo Squatriti 288-325. Ann Arbor: University of Michigan Press, 2007.
- Hooke, Robert. *Micrographia: or some physiological descriptions of minute bodies made by magnifying glasses with observations and inquiries thereupon*. London: Martyn and Allestry, 1665.
- Horensma, P. T. G. "Olivier Brunel and the Dutch involvement in the discovery of the Northeast Passage." *Fram* 2:1 (1985): 121-128.
- Horsten, Frits H. *Doorgaande wegen in Nederland, 16e tot 19e eeuw: Een historische wegenatlas*. Amsterdam: Uitgeverij Aksant, 2005.
- Hoving, A. J. and Cor Emke. *Het schip van Willem Barents: een hypothetische reconstructie van een laat-zestiende-eeuws jacht*. Hilversum: Uitgeverij Verloren, 2004.
- Huddart, David and Tim Stott. *Earth Environments Past, Present and Future*. John Wiley & Sons, 2013.

- Hughes, T. P. *Human built world: how to think about technology and culture*. Chicago: Chicago University Press, 2005.
- Hulme, Mike. "Reducing the Future to Climate: A Story of Climate Determinism and Reductionism." *Osiris* 26:1 (2011): 245-266.
- Ingram, M. J., G. Farmer and T. M. L. Wigley. "Past Climates and their Impact on Man: a Review." In *Climate and History: Studies on Past Climates and their Impact on Man*, edited by M.J. Ingram, G. Farmer and T. M. L. Wigley 3-50. Cambridge: Cambridge University Press, 1981.
- Israel, Jonathan Irvine. *Dutch primacy in world trade, 1585-1740*. New York: Oxford University Press, 1989.
- . *Radical Enlightenment: Philosophy and the Making of Modernity, 1650-1750*. Oxford: Oxford University Press, 2001.
- . *The Dutch Republic: Its Rise, Greatness, and Fall, 1477-1806*. Oxford: Clarendon Press, 1998.
- Instititoris, Heinrich and Jacobus Sprenger. *Malleus Maleficarum Vol. II: The English Translation*, ed. Christopher Mackay. Cambridge: Cambridge University Press, 2006.
- Jacobs, E. M. *In Pursuit of Pepper and Tea: The Story of the Dutch East India Company*. Walburg: Walburg Pers, 2009.
- James, John. *In Search of the Unknown in Medieval Architecture*. London: The Pindar Press, 2007.
- Jansen, Captain. "Notes on the Ice between Greenland and Nova Zembla; Being the Results of Investigations into the Records of Early Dutch Voyages in the Spitzbergen Seas." *Proceedings of the Royal Geographical Society of London* 9:4 (1864 - 1865): 163-181.
- Jansson, Jan. "Nova Europae Descriptio." In *Atlantis maioris appendix*. Amsterdam: Ioannis Ianzonii, 1630.
- Janssonius, Johannes. *Novus Atlas Sive Theatrum Orbis Terrarum*. Amsterdam, 1658.
- Janszoon, Dirck. *Het aantekeningenboek van Dirck Jansz. (1578-1636)*. Edited by Pieter Gerbenzon. 120. Hilversum: Uitgeverij Verloren, 1993.
- Jardine, Lisa. *Going Dutch: How England Plundered Holland's Glory*. New York: Harper Collins Publishers, 2008.

- Johnson, Loretta. "Greening the Library: The Fundamentals and Future of Ecocriticism." *Choice* (December 2009): 7-13.
- Jones, E. "Climate, Archaeology, History, and the Arthurian Tradition: A Multiple-Source Study of Two Dark-Age Puzzles," in *The Years Without Summer: Tracing AD 536 and its Aftermath*, edited by J. D. Gunn 25-34. Oxford: Archaeopress, 2000.
- Jones, J. R. *The Anglo-Dutch Wars of the Seventeenth Century*. London: Longman, 1996.
- Jorink, Eric. *Reading the Book of Nature in the Dutch Golden Age*. Leiden: Brill, 2010.
- . *Wetenschap en wereldbeeld in de Gouden Eeuw*. Hilversum: Uitgeverij Verloren, 1999.
- Jorink, Henricus Gerardus Maria. *Het boeck der natuere: Nederlandse geleerden en de wonderen van Gods schepping, 1575-1715*. PhD Diss, University of Groningen, 2004.
- Josselin, Ralph. *The Diary of Ralph Josselin, 1616-1683*. Oxford: Oxford University Press, 1991.
- Kaak, Maurice. *Vlaamse en Brabantse Binnenschepen uit de 18de en 19de eeuw: vergeten vaktaal en oude constructies*. Ghent: Provinciebestuur Oost-Vlaanderen, 2010.
- Kaplan, Benjamin J. "Possessed by the Devil? A Very Public Dispute in Utrecht." *Renaissance Quarterly* 49 (1996): 738-759.
- Keblusek, Marika. *Boeken in de Hofstad: Haagse boekcultuur in de Gouden Eeuw*. Hilversum: Uitgeverij Verloren, 1997.
- Kelly, Morgan and Cormac Ó Gráda. "The Waning of the Little Ice Age: Climate Change in Early Modern Europe." *Journal of Interdisciplinary History* 44:3 (2014), 301-325.
- Ketting, Herman. *Leven, werk en rebellie aan boord van Oost-Indiëvaarders (1595-±1650)*. Amsterdam: Het Spinhuis, 2005.
- Klein, P. W. and Jan Willem Veluwenkamp, "The Role of the Entrepreneur in the Economic Expansion of the Dutch Republic." *Economic and Social History in the Netherlands* 4 (1992): 27-53
- Klinkert, Wim. "Water in oorlog. De rol van het water in de militaire geschiedenis van Holland na 1550." In *Hollanders en het water. Twintig eeuwen strijd en profijt, Vol. II*, edited by Eelco Beukers 451-504. Hilversum: Uitgeverij Verloren, 2007.
- Knaap, Gerrit and Ger Teitle, ed. *De Verenigde Oost-Indische Compagnie: Tussen Oorlog en Diplomatie*. Leiden: KITLV Uitgeverij, 2002.
- Koene, Bert. *De Caeskopers: Een Zaanse koopmansfamilie in de Gouden Eeuw*. Hilversum: Uitgeverij Verloren, 2011.

- Korevaar, C. G. *North Sea Climate, based on observations from ships and lightvessels*. Dordrecht: Kluwer Academic Publishers, 1990.
- Kors, Alan Charles and Edward Peters ed. "The Trail of Marie Cornu (1611)," in *Witchcraft in Europe, 400-1700: A Documentary History*. Philadelphia: University of Pennsylvania Press, 2001.
- Krausmann, Fridolin. "A City and its Hinterland: Vienna's Energy Metabolism, 1800-2006." In *Long Term Socio-Ecological Research: Studies in Society-Nature Interactions Across Spatial and Temporal Scales*, ed. S.J. Singh, H. Haberl, M. Chertow, M. Mirtl, M. Schmid, 247-268. New York: Springer, 2013.
- Krausmann, Fridolin and Helmut Haberl. "The Process of Industrialization from the Perspective of Energetic Metabolism: Socioeconomic Energy Flows in Austria, 1830-1995." *Ecological Economics*, 41:2 (2002), 177-201;
- Krausmann, Fridolin, Helmut Haberl, Karl-Heinz Erb, and Mathis Wackernagel. "Resource Flows and Land Use in Austria, 1950-2000: Using the MEFA Framework to Monitor Society-Nature Interaction for Sustainability." *Land Use Policy*, 21:2 (2004): 215-230
- Krausmann, Fridolin, Simone Gingrich, and Reza Nourbakhch-Sabet, "The Metabolic Transition in Japan: A Material Flow Account for the Period from 1878-2005." *Journal of Industrial Ecology*, 15:6 (November 2011): 877-892.
- Krokar, James P. "New Means to an Old End: Early Modern Maps in the Service of an Anti-Ottoman Crusade." *Imago Mundi* 60 (February 2008): 23-38.
- Kuijpers, Erika. "Poor, Illiterate and Superstitious? Social and Cultural Characteristics of the 'Noordse Natie' in the Amsterdam Lutheran Church in the Seventeenth Century." In *Dutch Light in the Norwegian Night: Maritime Relations and Migration across the North Sea in Early Modern Times*, edited by Louis Sicking, Harry de Bles and Erlend des Bouvrie 57-68. Hilversum: Uitgeverij Verloren, 2004.
- Lamb, Hubert H. *Climate, History and the Modern World, 2nd Ed*. Routledge: New York, 1995.
- . *Historic Storms of the North Sea, British Isles, and Northwest Europe*. Cambridge: Cambridge University Press, 1991.
- . *The English Climate*. London: English Universities Press, 1964.
- Lambert, Audrey M. *The Making of the Dutch Landscape: An Historical Geography of the Netherlands*. London: Academic Press, 1985.
- Landblad, J. Thomas. "Foreign trade of the Dutch Republic in the Seventeenth Century." *Economic and Social History in the Netherlands* 4 (1992): 219-249.

- Landers, John. "The Destructiveness of Pre-Industrial Warfare," *Journal of Peace Research* (July 2005), 455-470.
- . *The Field and the Forge: Population, Production and Power in the Pre-Industrial West*. New York: Oxford University Press, 2003.
- Landsteiner, Erich. "Wenig Brot und saurer wein: Kontinuität und Wandel in der zentraleuropäischen Ernährungskultur im letzten Drittel des 16. Jahrhunderts." In *Kulturelle Konsequenzen der "Kleinen Eiszeit,"* edited by Wolfgang Behringer, Hartmut Lehmann, and Christian Pfister 87-148. Göttingen: Vandenhoeck & Ruprecht, 2005.
- Lansberg, H. E. "Past Climates from Unexploited Written Sources," *Journal of Interdisciplinary History*, No. 10 (1980), 631-642.
- Lawson, Philip. *The East India Company: A History*. Oxford: Routledge, 2014.
- Le Roy Ladurie, Emmanuel. *Histoire humaine et comparée du climat, Vol. I: Canicules et glaciers*. Paris: Fayard, 2004.
- . *Times of Feast, Times of Famine: A History of Climate Since the Year 1000*. Garden City, NY: Doubleday & Company, Inc., 1971.
- Lefebvre, Henri. *Rhythmanalysis: Space, Time and Everyday Life*. London: Continuum, 2004.
- Lehner, Flavio, Andreas Born, Christoph C. Raible, and Thomas F. Stocker. "Amplified inception of European Little Ice Age by sea ice-ocean-atmosphere feedbacks." *Journal of Climate* 26:19 (2013): 7586-7602.
- Lemke, Peter, Markus Harder, and Michael Hilmer. "The Response of Arctic Sea Ice to Global Change." *Climatic Change*, 46 (2000): 277-287.
- Lesger, Clé. *Handel in Amsterdam ten tijde van de Opstand: kooplieden, commerciële expansie en verandering in de ruimtelijke economie van de Nederlanden ca. 1550 - ca. 1630*. Hilversum: Uitgeverij Verloren, 2001.
- . *The Rise of the Amsterdam Market and Information Exchange: Merchants, Commercial Expansion and Change in the Spatial Economy of the Low Countries, C. 1550-1630*. Farnham: Ashgate Publishing Ltd., 2006..
- Levy, Jack S. "The Rise and Decline of Anglo-Dutch Rivalry, 1609-1689." In *Great Power Rivalries*, edited by William R. Thomsson, 172-200. Columbia: University of South Carolina Press.
- Levy, Jack S. and Salvatore Ali. "From Commercial Competition to Strategic Rivalry to War: The Evolution of the Anglo-Dutch Rivalry, 1609-52." In *The Dynamics of Enduring*

- Rivalries*, edited by Paul Francis Diehl, 29-63. Champaign: University of Illinois Press, 1998.
- Li, Jinbao, Shang-Ping Xie, et al. "Interdecadal modulation of El Niño amplitude during the past millennium." *Nature Climate Change* 1 (2011): 114-118.
- Ligtendag, W. A. "Willem Barentsz en de kartografie van het hoge noorden." *Kartografisch tijdschrift* 23:1 (1997): 5-14.
- Lis, Catharina and Hugo Soly. "Different Paths of Development: Capitalism in the Northern and Southern Netherlands during the Late Middle Ages and the Early Modern Period." *Review (Fernand Braudel Center)* 20:2 (1997): 211-242.
- Lund, David C., Jean Lynch-Stieglitz, and William B. Curry. "Gulf Stream density structure and transport during the past millennium." *Nature* 444 (2006): 601-604.
- Luterbacher, Jürg. "The Late Maunder Minimum (1675-1715) – Climax of the 'Little Ice Age' in Europe." In *History and Climate: Memories of the Future?*, edited by P.D. Jones, A. E. J. Ogilvie, T. D. Davies, and K. R. Briffa, 101-120. New York: Kluwer Academic/Plenum Publishers, 2001.
- Lynn, John A. *Giant of the Grand Siècle: The French Army, 1610-1715*. Cambridge: Cambridge University Press, 2006.
- "The Embattled Future of Academic Military History," *Journal of Military History* 61 (1997): 777-789.
- *Women, Armies, and Warfare in Early Modern Europe*. Cambridge: Cambridge University Press, 2008.
- Macdougall, Douglas. *Frozen Earth: The Once and Future Story of Ice Ages*. Berkeley: University of California Press, 2004.
- Mackay, Christopher S. "General Introduction." In *Institoris, Henricus and Jacobus Sprenger, Malleus Maleficarum Vol. I: The Latin Text and Introduction*, ed. Christopher Mackay, 1-188. Cambridge: Cambridge University Press, 2006. 37.
- Magnusson, Lars. *Mercantilism: The Shaping of an Economic Language*. Oxford: Routledge, 2002.
- Mann, Michael E., Zhihua Zhang, Scott Rutherford, Raymond S. Bradley, Malcolm K. Hughes, Drew Shindell, Caspar Ammann, Greg Faluvegi, and Fenbiao Ni. "Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly." *Science* 326 (2009): 1256-1260.

- Marchenko, Nataliya. *Russian Arctic seas: navigational conditions and accidents*. New York: Springer, 2012.
- Marcott, Shaun A., Jeremy D. Shakun, Peter U. Clark, and Alan C. Mix. "A Reconstruction of Regional and Global Temperature for the Past 11,300 Years," *Science*, CCCIX (2013), 1198-1201.
- Markham, Clements R. "On Discoveries east of Spitzbergen, and Attempts to reach the Pole on the Spitzbergen Meridians." *Proceedings of the Royal Geographical Society of London* 17:2 (1872-73): 97-107.
- Markley, Robert. "Summer's Lease: Shakespeare in the Little Ice Age," in *Early Modern Ecostudies: From the Florentine Codex to Shakespeare*, edited by Thomas Hallock, Ivo Kamps, and Karen L. Raber, 131-142. Hampshire: Palgrave Macmillan, 2008.
- Martin, Craig. "Experience of the New World and Aristotelian Revisions of the Earth's Climates during the Renaissance." *History of Meteorology* 3 (2006): 1-15.
- McNeill, J. R. "Author's Response by J. R. McNeill, Georgetown University," *HEnvironment Roundtable Reviews*, Vol. 1, 1 (2011): 23-28.
- . *Mosquito Empires: Ecology and War in the Greater Caribbean, 1620-1914*. Cambridge: Cambridge University Press, 2011.
- Mercator, Gerard. *Septentrionalium Terrarum descriptio 1595*. Amsterdam, 1595.
- Metcalf, Michael F. "Conflict as catalyst: Parliamentary innovation in eighteenth-century Sweden." *Parliaments, Estates and Representation* 8:1 (1988): 63-75.
- Metzger, Alexis. "Le froid en Hollande au Siècle d'or. Essai de climatologie culturelle." PhD diss., University of Paris, expected 2016.
- . *Plaisirs de Glace: Essai sur la peinture hollandaise hivernale du Siècle d'or*. Editions Hermann, 2012.
- Miller, Gifford H., Áslaug Geirsdóttir, Yafang Zhong, Darren J. Larsen, Bette L. Otto-Bliesner, Marika M. Holland, David A. Bailey, Kurt A. Refsnider, Scott J. Lehman, John R. Southon, Chance Anderson, Helgi Björnsson, and Thorvaldur Thordarson. "Abrupt onset of the Little Ice Age triggered by volcanism and sustained by sea-ice/ocean feedbacks." *Geophysical Research Letters*, 39:2 (2012), 1-5. Accessed January 14 2013. doi: <http://dx.doi.org/10.1029/2011GL050168>
- Mills, William J. *Exploring Polar Frontiers: A Historical Encyclopedia, Vol. II*. Santa Barbara: ABC CLIO, 2003.

- Molitor, Ulrich. "Witches sacrificing cock and snake to raise hailstorm." In *De Ianjis et phitonicis mulieribus*, 1489.
- Monck, George. "Two letters from the fleet: the one written by Generall Monck to the Commissioners of the Admiralty sitting at Whitehall. The other by Capt Bourn, captain of the Resolution to his wife . . .". London: Printed by Tho. Newcomb, dwelling in Thamestreet, over against Baynards-Castle, 1653.
- Muir, Edward. *Mad Blood Stirring: Vendetta and Factions in Friuli during the Renaissance*. Baltimore and London: Johns Hopkins University Press, 1993.
- , *Ritual in Early Modern Europe*. Cambridge: Cambridge University Press, 1997.
- Murdmaa, Ivar, Leonid Polyak, Elena Ivanova, and Natalia Khromova. "Paleoenvironments in Russkaya Gavan' Fjord (NW Novaya Zemlya, Barents Sea) during the last millennium." *Palaeogeography, Palaeoclimatology, Palaeoecology* 209 (2004): 141-154.
- Narbrough, John. "Journal of John Narbrough, Captain of the *Fairfax*. September 18, 1672, to July 1, 1673. Pepysian MS. 2556." In *Journals and Narratives of the Third Dutch War*, edited by R. C. Anderson. London: Publications of the Navy Records Society, 1945-1947.
- National Maritime Museum, *The Second Dutch War: described in pictures & manuscripts of the time*. London: Her Majesty's Stationery Office, 1967.
- Neuberger, Hans. "Climate in Art." *Weather* 25:2 (1970): 46-56.
- Nicholas, David. *The Northern Lands: Germanic Europe, c. 1250-c. 1500*. Chichester: John Wiley & Sons Ltd., 2009.
- Ogilvie, Astrid and Graham Farmer. "Documenting the Medieval Climate." In *Climates of the British Isles*, edited by Mike Hulme and Elaine Barrow, 112-133. London: Routledge, 1997.
- Ormrod, David. *The Rise of Commercial Empires: England and the Netherlands in the Age of Mercantilism, 1650-1770*. Cambridge: Cambridge University Press, 2003.
- Oster, Emily. "Witchcraft, Weather and Economic Growth in Renaissance Europe." *The Journal of Economic Perspectives*, 18:1 (2004), 215-228.
- Outten, S. D. and I. Esau, "A link between Arctic sea ice and recent cooling trends over Eurasia." *Climatic Change* 110:3-4 (2011): 1069-1075.
- Overpeck, J., K. Hughen, D. Hardy, R. Bradley, R. Case, M. Douglas, B. Finney, K. Gajewski, G. Jacoby, A. Jennings, S. Lamoureux, A. Lasca, G. MacDonald, J. Moore, M. Retelle, S.

- Smith, A. Wolfe, and G. Zielinski. "Arctic Environmental Change of the Last Four Centuries." *Science* 278:1251, (1997): 1251-1256.
- Panhuysen, Luc. *Rampjaar 1672. Hoe de republiek aan de ondergang ontsnapte*. Amsterdam: Atlas, 2009.
- Parker, Geoffrey. *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century*. London: Yale University Press, 2013.
- . *The Army of Flanders and the Spanish Road, 1567-1659*. Cambridge: Cambridge University Press, 1971.
- . *The Dutch Revolt*. London: Penguin Books, 1985.
- . "Braudel's Mediterranean: The Making and Marketing of a Masterpiece." *The Journal of the Historical Association* 59: 195 (1974): 238-243.
- Parker, Geoffrey and Lesley M. Smith, ed. *The General Crisis of the Seventeenth Century*. Oxford: Routledge, 2005.
- Parthesius, Robert. *Dutch Ships in Tropical Waters: The Development of the Dutch East India Company (VOC) Shipping Network in Asia 1595-1660*. Amsterdam: Amsterdam University Press, 2010.
- Pearce, Fred. *Climate and Man: From the Ice Ages to the Global Greenhouse*. London: Vision Books, 1989.
- Persson, Karl Gunnar. *Grain Markets in Europe, 1500-1900*. Cambridge: Cambridge University Press, 1999.
- Petram, Lodewijk. "The world's first stock exchange: How the Amsterdam market for Dutch East India Company shares became a modern securities market, 1602-1700." PhD diss., University of Amsterdam, 2014.
- Pfister, Christian and Rudolf Brazdil. "Social vulnerability to climate in the 'Little Ice Age': an example from Central Europe in the early 1770s." *Climate of the Past Discussions* 2.2 (2006): 123-155.
- . "Climatic Variability in Sixteenth-Century Europe and its Social Dimension: A Synthesis." *Climatic Change* 43:1 (1999): 5-53.
- Pfister, Christian. "Climatic Extremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth and Early Seventeenth Centuries," *The Medieval History Journal* 10: 1&2 (2007): 33-73.

- Pilcher, J. R. and B. Gray. "The Relationships Between Oak Tree Growth and Climate in Britain." *Journal of Ecology* 70 (1982): 297-304.
- Polyak, Leonid, Ivar Murdmaa and Elena Ivanova, "A high-resolution, 800-year glaciomarine record from Russkaya Gavan', a Novaya Zemlya fjord, eastern Barents Sea." *The Holocene* 14:4 (2004): 628-634.
- Post, F. *Groninger Scheepvaart en Scheepsbouw vanaf 1600*. Bedum: Profiel uitgeverij, 1997.
- Postma, C. *Het hoogheemraadschap van Delfland in de middeleeuwen 1289-1589*. Hilversum: Uitgeverij Verloren, 1989.
- Poter, Ted. *The Rise of Statistical Thinking 1820-1900*. Princeton: Princeton University Press, 1986.
- Pots, R. and J. Knoester. *Blauwe ader van de Bollenstreek: 350 jaar Haarlemmertrekvaart-Leidsevaart, 1657-2007. Geschiedenis, betekenis en toekomst*. Leiden: Primavera Pers, 2010.
- Poulsen, Bo. *Dutch Herring: An Environmental History, C. 1600-1860*. Amsterdam: Amsterdam University Press, 2009.
- Prak, Maarten. *Gouden Eeuw: Het raadsel van de Republiek*. Nijmegen: Uitgeverij SUN, 2002.
- Price, J. L. *Dutch society, 1588-1713*. New York: Longman, 2000.
- Pritchard, S. "An envirotechnical disaster: nature, technology, and politics at Fukushima." *Environmental History* 17 (2012): 219–243.
- Rackham, Oliver. *Ancient Woodland: Its History, Vegetation and Uses in England*. London: Castlepoint Press, 1980.
- Raible, Christoph C. "Climate variability - observations, reconstructions, and model simulations for the Atlantic-European and Alpine region from 1500–2100 AD." *Climatic Change* 79 (2006): 9-29.
- Rawson Gardiner, Samuel, ed. *Letters and Papers Relating to the First Dutch War, 1652-1654, Vol I*. London: Publications of the Navy Records Society, 1899.
- Reinders, Michel. "Burghers, Orangists and 'good government': Popular Political Opposition during the 'Year of Disaster' 1672 in Dutch Pamphlets." *The Seventeenth Century*, 23:2 (2013): 315-346.
- , *Printed Pandemonium: the Power of the Public and the Market for Poplar Political Publications in the Early Modern Dutch Republic*. PhD Dissertation, Erasmus University Rotterdam, 2008.

- Richards, John F. *The Unending Frontier*. Berkeley: University of California Press, 2003.
- Rodger, N. A. M. *The Command of the Ocean: A Naval History of Britain 1649-1815*. London: Penguin Books, 2004.
- , *The Safeguard of the Sea: A Naval History of Britain, 660-1649*. New York: W. W. Norton & Company, 1997.
- Roeper, V. D. and G. J. D. Wildeman. *Ontdekkingsreizen van Nederlanders (1590-1650)*. Utrecht: Kosmos Uitgevers, 1993.
- Rogelj, Joeri, David L. McCollum, Andy Reisinger, Malte Meinshausen, and Keywan Riahi. "Probabilistic cost estimates for climate change mitigation." *Nature* 493: 7430(2013): 79-83.
- Rohr, Christian. *Extreme Naturereignisse im Ostalpenraum: Naturerfahrung im Spätmittelalter und am Beginn der Neuzeit*. Böhlau Verlag Köln Weimar, 2007.
- Rommelse, Gijs. *The Second Anglo-Dutch War: international raison d'état, mercantilism and maritime strife*. Hilversum: Uitgeverij Verloren, 2006.
- Rothrock, D. A. "The energetics of the plastic deformation of pack ice by ridging." *Journal of Geophysical Research* 80:33 (1975): 4514-4519.
- Rötzer, Thomas and Frank M. Chmielewski. "Phenological maps of Europe." *Climate Research* 18 (2001): 249-257.
- Ruangsilp, Bhawan. *Dutch East India Company Merchants at the Court of Ayutthaya: Dutch Perceptions of the Thai Kingdom, Ca. 1604-1765*. Leiden: Brill, 2007.
- Rueda, Gemma, Susanne Fietz, and Antoni Rosell-Melé. "Coupling of air and sea surface temperatures in the eastern Fram Strait during the last 2000 years." *The Holocene* 23:5 (2013): 692-698.
- Ruestow, Edward G. *The Microscope in the Dutch Republic: The Shaping of Discovery*. Cambridge: Cambridge University Press, 2004.
- Russell, Edmund. *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring*. Cambridge: CUP, 2001.
- Sager, Ingrid D. *The Little Ice Age and 17th Century Dutch Landscape Painting, a Study on the Impact of Climate on Art*. Dominguez Hills: California State University, 2006.

- Salvesen, Helge. "The Climate as a factor of historical causation." In *European climate reconstructed from documentary data: methods and results*, edited by Buckhard Frenzel, 219-255. Stuttgart: Gustav Fischer Verlag, 1992.
- Sarazin, Thilo. *Europa Braucht den Euro Nicht: Wie uns politisches Wunschdenken in die Krise geführt hat*. München: DVA Dt. Verlags-Anstalt, 2012.
- Scammell, G. V. *The First Imperial Age: European Overseas Expansion c. 1400~1715*. Abingdon: Routledge, 1989.
- Schama, Simon. *The Embarrassment of Riches: An Interpretation of Dutch Culture in the Golden Age*. Berkeley: University of California Press, 1988.
- Scheltjens, Werner F. Y. "The Changing Geography of Demand for Dutch Maritime Transport in the Eighteenth Century." *Histoire & mesure* 27:2 (2012): 3-48.
- Shabalova, M. V. and A. F. V. van Engelen. "Evaluation of a reconstruction of temperature in the Low Countries AD 764-1998." *Climatic Change* (March 2000), 219-242.
- Shakespeare, William. *The Tempest*. New York: Dover Publications, 1998.
- , *The Works of Mr. William Shakespear: Adorn'd with cuts. Revis'd and Corrected, with an account of the Life and Writings of the author, Vol. I.*, edited by Nicholas Rowe. London: Jacob Tonson, 1709.
- Shimada, Ryūto. *The Intra-Asian Trade in Japanese Copper by the Dutch East India Company During the Eighteenth Century*. Leiden: Brill, 2006.
- Sicking, Louis. *Neptune and the Netherlands: State, Economy, and War at Sea in the Renaissance*. Leiden: Brill, 2004.
- Sicre, Marie-Alexandrine, Jérémy Jacob, Ullah Ezat, Sonia Rousse, Catherine Kissel, Pascal Yiou, Jón Eiríksson, Karen Luise Knudsen, Eystein Jansen, and Jean-Louis Turon. "Decadal variability of sea surface temperatures off North Iceland over the last 2000 years." *Earth and Planetary Science Letters* 268: 1-2 (2008): 137-142.
- Sieferle, Rolf P. *The Subterranean Forest: Energy Systems and the Industrial Revolution*. Cambridge: White Horse Press, 2001.
- Siegismund, Frank and Corinna Schrum. "Decadal changes in the wind forcing over the North Sea." *Climate Research* 18:39-45 (2001): 39-45.
- Smil, Vaclav. *Energy in World History*. Boulder: Westview, 1994.
- Smith, Lacey Baldwin. *This Realm of England, 1399-1688, Eighth Edition*. Boston: Houghton Mifflin Company, 2001.

- Smith, Pamela H. "Art, Science and Visual Culture in Early Modern Europe." *Isis* 97:1 (2006), 83-100.
- Soens, Tim. "Explaining deficiencies of water management in the late medieval Flemish coastal plain, 13th-16th centuries." In *Water Management, Communities, and Environment: The Low Countries in Comparative Perspective, C. 1000 - C. 1800*, edited by Hilde Greefs, 35-62. Hilversum: Academia Press, 2006.
- "Floods and money: funding drainage and flood control in coastal Flanders from the thirteenth to the sixteenth centuries." *Continuity and Change* 26:3 (2011): 333-365.
- Sonnino, Paul. *Louix XIV and the Origins of the Dutch War*. Cambridge: Cambridge University Press, 2003.
- Sopers, P. J. V. M. and H. C. A. Kampen. *Schepen die verdwijnen*. Haarlem: Uitgeverij Hollandia, 2000.
- Spies, Marijke. *Arctic Routes to Fabled Lands: Olivier Brunel and the Passage to China and Cathay in the Sixteenth Century*. Amsterdam: Amsterdam University Press, 1997.
- *Bij noorden om. Olivier Brunel en de doorvaart naar China en Cathay in de zestiende eeuw*. Amsterdam, 1994.
- Staarman, A. "De VOC en der Staten-Generaal in de Engelse Oorlogen: een ongemakkelijk bondgenootschap," *Tijdschrift for Zeegechiedenis* 15 (1996): 3-24.
- Starkey, David J. "Voluntaries and Sea Robbers: A review of the academic literature on privateering, corsairing, buccaneering and piracy." *The Mariners Mirror* 97:1 (2001): 127-147.
- Stearns, Peter. "The Essence of Commodification: Caffeine Dependencies in the Early Modern World," *Journal of Social History* 35 (2001): 269-294.
- Stevens, Harm. *Dutch Enterprise and the VOC: 1602-1799*. Zutphen: Walburg Pers, 1998.
- Stigler, Steve. *The History of Statistics: The Measurement of Uncertainty before 1900*. Chicago: Chicago University Press, 1986.
- Stoaks, "A great victory obtained by the English against the Dutch." (London: Geo: Horton), 1652.
- Stone, Dáithí, Maximilian Auffhamme, Mark Carey, Gerrit Hansen, Christian Huggel, Wolfgang Cramer, David Lobell, Ulf Molau, Andrew Solow, Lourdes Tibig, and Gary Yohe. "The challenge to detect and attribute effects of climate change on human and natural systems." *Climatic Change* 121 (2013): 381-395.

- Struik, Dirk Jan. *The Land of Stevin and Huygens: A Sketch of Science and Technology in the Dutch Republic During the Golden Century*. Leiden: Springer, 1981.
- Sundberg, Adam. PhD diss., "Weathering the Little Ice Age - Wealth and Climate Adaptation during the Dutch Golden Age." University of Kansas, 2015.
- Swan, Claudia. *Art, Science, and Witchcraft in Early Modern Holland: Jacques de Gheyn II (1565-1629)*. Cambridge: Cambridge University Press, 2005.
- 'T Hart, Marjolein. "The Dutch Republic: the urban impact upon politics," in *A Miracle Mirrored, A Miracle Mirrored: The Dutch Republic in European Perspective*, ed. Karel Davids and Jan Lucassen. Cambridge: Cambridge University Press, 1996.
- TeBrake, William. "Hydraulic Engineering in the Netherlands during the Middle Ages." In *Working with Water in Medieval Europe: Technology and Resource Use*, ed. Squatriti, Paolo. Leiden: Brill, 2000.
- Thomas, Chris D. et al. "Extinction Risk from Climate Change," *Nature* 427 (2004): 145.
- Tilly, Charles. *Big Structures, Large Processes, Huge Comparisons*. New York: Russell Sage Foundation, 1984.
- Tol, Richard S.J. and Sebastian Wager, "Climate change and violent conflict in Europe over the last millennium." *Climatic Change* 99 (2010): 65-79.
- Tucker, Richard P. and Edmund Russell ed. *Natural Enemy, Natural Ally: Toward an Environmental History of War*. Corvallis: Oregon State University Press, 2004.
- Twisck, Pieter Janszoon. *Comeet Boecxken*. Hoorn: Jan Jansz. Deutel, 1665.
- Unger, Richard W. "Energy sources for the Dutch Golden Age; Peat, wind and coal." *Research in Economic History* 9 (1984): 221-53.
- "Grain, beer and shipping in the North and Baltic Seas." In *Medieval Ships and the Birth of Technological Societies: Volume 1: Northern Europe*, edited by Villain-Gandossi, Christiane; Salvino Busutil and Paul Adam, 121-135. Malta: European Coordination Centre for Research and Documentation in Social Sciences, 1989.
- *Ships and Shipping in the North Sea and Atlantic, 1400-1800*. Aldershot: Ashgate Publishing Limited, 1997.
- Unwin, Rayner. *A Winter Away from Home: Willem Barents and the North-east Passage*. Seafarer Books: London, 1995.

- Utterström, Gustaf. "Climatic fluctuations and population problems in early modern history," *Scandinavian History Review* 3:1 (1955): 3-47.
- Van Aitzema, Lieuwe. *Saken van staet en oorlogh van Lieuwe van Aitzema*. The Hague: Johan Veekym Johan Tongerlos and Jasper Doll, 1669.
- Van Bavel, Bas. "Manors and markets. Economy and society in the Low Countries (500-1600): a synopsis." *Tijdschrift voor Sociale en Economische Geschiedenis* 8:2 (2011): 62-65.
- Van Berkel, Klaas, Albert van Helden, and Lodewijk Palm, ed. *A History of Science in the Netherlands: Survey, Themes, and Reference*. Leiden: E.J. Brill, 1999.
- Van Dam, Petra J. E. M. "Fuzzy boundaries and three-legged tables. A comment on ecological and spatial dynamics in Bas van Bavel's Manors and markets." *Tijdschrift voor Sociale en Economische Geschiedenis* 8:2 (2011): 103-113.
- "Water, Steam, Ice. Environmental Perspectives on Historical Transitions of Water in Northwestern Europe. *Nova Acta Leopoldina* 98:360 (2009): 29-43.
- Van Dam, Pieter. *Beschryvinge van de Oostindische Compagnie Vol. 3*. Edited by F. W. Stapel. The Hague: Martinus Nijhoff, 1927; orig. 1701.
- Van de Ven, G. P. *Man-made lowlands: History of water management and land reclamation in the Netherlands*. Utrecht: Uitgeverij Matrijs, 1993.
- Van den Dool, H. M., H. J. Krijnen and C. J. E. Schuurmans. "Average winter temperatures at De Bilt (the Netherlands) 1634-1977," *Climatic Change* 1 (1978): 319-330.
- Van den Heuvel, Charles. "De verspreiding van de Italiaanse vestingbouwkunde in de Nederlanden in de tweede helft van de zestiende eeuw." In *Vesting: Vier eeuwen vestingbouw in Nederland*, edited by J. Sneep, H. A. Treu and M. Tydeman, 9-18. The Hague: Stichting Menno van Coehoorn, 1982.
- Van den Vondel, Joost. *Gijsbrecht van Aemstel*. Edited by Mieke B. Smits-Veldt. Amsterdam: Amsterdam University Press, 1994.
- *Volledige dichtwerken en oorspronkelijk proza*. Edited by Albert Verwey. Amsterdam, 1937.
- Van der Goes, Adriaen et al. *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol I*. Edited by C. J. Gonnet. Amsterdam: Johannes Müller, 1899.
- "Hage, den 27 February 1670." *Briefwisseling tusschen de gebroeders van der Goes (1659-1673) Vol II*. Edited by C. J. Gonnet. Amsterdam, 1899.

- Van der Krogt, Peter. "Introduction." In John Blaeu, *Atlas Major of 1665*. Cologne: Taschen, 2010.
- Van der Vleuten, Erik and Cornelis Disco. "Water Wizards: Reshaping Wet Nature and Society." *History and Technology* 20:3 (2004): 291-309.
- Van Duinkerken, Anton. *Het goud der gouden eeuw, bloemlezing uit de poëzie der zeventiende eeuw*. Utrecht: Het Spectrum, 1955.
- Van Engelen, A. F. V., J. Buisman, and F. IJnsen. "A Millennium of Weather, Winds and Water in the Low Countries," in *History and Climate: Memories of the Future?*, edited by P.D. Jones, A. E. J. Ogilvie, T. D. Davies, and K. R. Briffa, 101-124. New York: Kluwer Academic/Plenum Publishers, 2001.
- Van Heule, Andreas, ed. *Memorieboek det stad Ghent van 't jaar 1301 tot 1793, Vol. III*. Ghent: Annoot-Braeckman, 1854.
- Van Holk, André Frederik Lambertus. *Archeologie van de binnenvaart: wonen en werken aan boord van binnenvaartschepen (1600-1900)*. PhD Diss., University of Groningen, 1997.
- Van Hoof, J. P. C. M. "Met een vijand als bondgenoot. De rol van het water bij de verdediging van het Nederlandse grondgebied tegen een aanval over land." *BMGN* 103 (1985): 622-651.
- Van Linschoten, Jan Huyghen. "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten, van bijnoorden om lans Noorwegen, de Noordkaap, Lapland, Finland, Rusland, &c. Anno 1594 en 1595." Franeker: Gerard Ketel, 1601.
- Van Oldenbarnevelt, Johan. "Rapport van Oldenbarnevelt als Gecommitteerde der Staten van Holland, 12-22 Maart 1589." In *Bescheiden betreffende zijn staatkundig beleid en zijn familia, Eerste Deel: 1570-1601*, edited by S. P. Haak. The Hague: Martinus Nijhoff, 1934.
- Van Persyn, J. de Jonge, Dirk Botjager, Wouter de Jong, Broer Smit, J. Benninbroek, P. Straat, and Jacob Groes de Jonge. *Beschryvinge, van de schade en rasinge aan de zee-dyken van Noort-Hollanden West-Vriesland, door de worm in de palen, en de daar op gevolgde storm*. Hoorn: Jacob Duyn, 1732.
- Van Rossum, M. "De intra-Aziatische vaart: Schepen, 'de Aziatische zeeman' en ondergang van de VOC?", *Tijdschrift voor Sociale en Economische Geschiedenis* 8:3 (2011): 32-69.
- Van Spilbergen, Joris. "'T historiaal journael, van tgene ghpaseert is van whegen dry schepen, ghenamt den Ram, Schaep ende het Lam, ghevaren wt zeelandt vander stadt Camp-Vere naar d'Oost-Indiën, onder t'beleyt van Joris van Spilberghen, Generael anno 1601.'" In *De reis van Joris van Spilbergen naar Ceylon, Atjeh en Bantam 1601-1604*. The Hague: Martinus Nijhoff, 1933.

- Van Tielhof, Milja and Petra J. E. M. van Dam. *Waterstaat in Stedenland: het Hoogheemraadschap van Rijnland voor 1857*. Utrecht: Matrijs, 2006.
- Van Tielhof, Milja. *De Hollandse graanhandel, 1470-1570: koren op de Amsterdamse molen*. PhD Diss, Universiteit Leiden 1995.
- . *The Mother of All Trades: The Baltic Grain Trade in Amsterdam from the Late 16th to the Early 19th Century*. Leiden: Brill, 2012.
- Van Vervou, Fredrich. *Enige gedenckvveerdige geschiedenissen, tot narichtinge der nakomelingen*. G.T.N. Suringar, 1841.
- Van Wassenaer, Nicolaes. *Historisch Verhael aller gedenckwaerdiger geschiedenis Vol. 3, 4, 8, 12*. Amsterdam: Jan Janszoon, 1625.
- Van Zanden, Jan Luiten. *Arbeid tijdens het handelskapitalisme: Opkomst en neergang van de Hollandse economie 1350-1850*. Hilversum: Uitgeverij Verloren, 1991.
- . "Early modern economic growth: A survey of the European economy, 1500-1800." In *Early Modern Capitalism: Economic and Social Change in Europe 1400-1800*, edited by Maarten Praak, 67-84. Oxford: Routledge 2005.
- . "The Emergence of Modern Economic Growth in the North Sea Region." In *The Long Road to the Industrial Revolution: The European Economy in a Global Perspective, 1000-1800*, edited by J. L. van Zanden, 233-268. Leiden: Brill, 2009.
- . "The 'revolt of the early modernists' and the 'first modern economy': an assessment." *Economic History Review* 4 (2002): 619-641.
- Velius, Th. *Kroniek van Hoorn Band 2: 1560-1629*. Edited by Jan Plekker and Rob Resoort. Hoorn: Publicatiestichting Bas Baltus, 2007.
- Venendaal Jr., A. J., ed.. *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VI: 1707*. The Hague: Martinus Mijhoff, 1984.
- . *De Briefwisseling van Anthonie Heinsius, 1702-1720. Deel VXIX: 2 oktober 1718-22 juli 1720*. Den Haag: Instituut voor Nederlandse Geschiedenis, 2001.
- Vermij, Rienk. *The Calvinist Copernicans: The reception of the new astronomy in the Dutch Republic, 1575-1750*. Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2002.
- Vinje, Torgny. "Barents Sea ice edge variation over the past 400 years." In *Extended abstracts, Workshop on Sea-Ice Charts of the Arctic*. WMO/TD 949 (1999): 4-6.

- Vink, M. "'The World's Oldest Trade:' Dutch Slavery and Slave Trade in the Indian Ocean in the Seventeenth Century." *Journal of World History* 14:2 (2003): 131-177.
- Vonk, P. G. *De Victorieuze Zeeslag op Schoneveld: het hol van de Ruyter*. The Hague: Pieters, 1990.
- Wagner, Sebastian and Eduardo Zorita. "The influence of volcanic, solar and CO₂ forcing on the temperatures in the Dalton Minimum (1790-1830): a model study," *Climate Dynamics* 25 (2005): 205-218.
- Waite, Gary K. *Eradicating the Devil's Minions: Anabaptists and Witches in Reformation Europe, 1525-1600*. Toronto: University of Toronto Press, 2007.
- Wang, Tina, Donna Surge, and Karen Jo Walker, "Isotopic evidence for climate change during the Vandal Minimum from *Ariopsis felis* otoliths and *Mercenaria campechiensis* shells, southwest Florida, USA," *The Holocene* 21:7 (2011): 1081-1091.
- Ward, Kelly. *Networks of Empire: Forced Migration in the Dutch East India Company*. Cambridge: Cambridge University Press, 2009.
- Warde, Paul. *Energy Consumption in England & Wales*. Rome: Consiglio Nazionale delle Ricerche, Istituto di studi sulle società del Mediterraneo, 2007.
- Wegman, Anton. *De Waterlandse Melkschuit: varende boeren tussen Waterland en Amsterdam 1600-1900*. Amsterdam: Stichting de Waterlandse Melkschuit, 2011.
- Węśławski, J. M. et al. "Greenland whales and walruses in the Svalbard food web before and after exploitation." *Oceanologia* 42:1 (2000): 37-56.
- Westermann, Mariët. *A Worldly Art: The Dutch Republic, 1585-1718*. New Haven: Yale University Press, 1996.
- Wheeler, D., R. Garcia-Herrera, C. W. Wilkinson, and C. Ward. "Atmospheric circulation and storminess derived from Royal Navy logbooks: 1685 to 1750." *Climatic Change* 18 (2009): 257-280.
- Wheeler, Dennis. "British Naval Logbooks from the Late Seventeenth Century: New climatic information from old sources." *History of Meteorology* 2 (2005), 133-146.
- "Understanding Seventeenth-Century Ships' Logbooks: An Exercise in Historical Climatology." *Journal for Maritime Research* (2004), 21-36.
- White, Sam. "Animals, Climate Change, and History." *Environmental History* 19 (2014): 319-328.

- "The Real Little Ice Age." *The Journal of Interdisciplinary History* 44:3 (Winter, 2014): 327-352.
- "Was a Sad Tale Best for Winter? Shakespearean Theater and the Culture of the Little Ice Age." Paper to be presented at the World Congress of Environmental History, Guimarães, Portugal, 8-12 July 2014.
- White, Thomas. "An exact and perfect relation relation [sic] of the terrible, and bloody fight: between the English and Dutch fleets in the Downs, on Wednesday the 19 of May, 1652." London: Printed for Robert Wood, 1652.
- Wilson, Stephen. *The Magical Universe: Everyday Ritual and Magic in Pre-modern Europe*. London and New York: Hambledon, 2000.
- Winiwarter, Verena, Martin Schmid, and Gert Dressel. "Looking at half a millennium of co-existence: the Danube in Vienna as a socio-natural site." *Water History* 5 (2013): 101-119.
- Winsemius, Pier. *Chronique ofte historische geschiedenisse van Vrieslant, Vol. 20*. Franeker, 1622.
- World Meteorological Organization. *The Global Climate 2001-2010, A Decade of Climate Extremes – Summary Report*. Geneva: World Meteorological Organization, 2013.
- Worster, Donald. "Appendix: Doing Environmental History." In *The Ends of the Earth: Perspectives on Modern Environmental History*, edited by Donald Worster 289-308. Cambridge: Cambridge University Press, 1989.
- Wrigley, E. A. *Continuity, Chance and Change: The character of the industrial revolution in England*. Cambridge: Cambridge University Press, 1988.
- *Poverty, Progress and Population*. Cambridge: Cambridge University Press, 2004.
- Zeeberg, Jaap Jan. *Climate and Glacial History of the Novaya Zemlya Archipelago, Russian Arctic: With Notes on the Region's History of Exploration*. Amsterdam: Rozenberg Publishers, 2002.
- *Into the Ice Sea: Barents' winter on Novaya Zemlya – a Renaissance voyage of discovery*. Amsterdam: Rozenberg Publishers, 2005.
- *Terugkeer naar Nova Zembla: de laatste en tragische reis van Willem Barents*. Zutphen: Walburg Pers, 2007.
- Zhang, David D. et al., "Climate Change and War Frequency in Eastern China over the Last Millennium." *Human Ecology* 35 (2007): 403-414.

Zhong, Y., G. H. Miller, B. L. Otto-Bliesner, M. M. Holland, D. A. Bailey, D. P. Schneider, and A. Geirsdottir. "Centennial-scale climate change from decadal-paced explosive volcanism: a coupled sea ice-ocean mechanism." *Climate Dynamics* 37 (2011): 2373-2387.