

The Weather Gage:

An examination of Seventeenth Century Dutch Ship Logs to understand links between
Weather and Trade, Climate and Economy.

Dagomar Degroot
Richard Hoffmann
History 5350.06
May 1, 2009

Current research indicates that by the eleventh century temperatures were typically 1 degree Celsius warmer than twentieth century averages.¹ However, this “Medieval Warm Period” faltered beginning in the fourteenth century, as swaths of the Northern Atlantic were increasingly troubled by rapid fluctuations in temperature from year to year, frequent storminess, and seasons of intensified precipitation. Many historical climatologists have labelled this the beginning of a “Little Ice Age” that would linger with warmer respites until roughly 1850. The exact origins and early extent of the phenomenon remain a source of controversy, yet its first great nadir, beginning as early as 1565 and lasting until roughly 1630, was almost certainly global in scope.² Termed the “Grindelwald Fluctuation” by historical climatologist Christian Pfister after the contemporaneous expansion of the Alpine Grindelwald glacier, the period was marked by decades in which yearly temperatures plummeted to a sustained 1-2 degrees Celsius below twentieth century averages. Although spring and fall were especially cold, summers were also generally cooler and extreme winters grew more common.³ The Grindelwald Fluctuation

¹ In this context “Twentieth Century Averages” refers to global temperatures between 1900-1960. During this period global temperatures slowly rose until 1950 before experiencing a brief, twenty-year reduction; the current regime of accelerating global warming had not yet emerged in full. Hubert Lamb, *Climate, History and the Modern World*. (London: Methuen, 1982), 260.

² Wolfgang Behringer, "Climatic Change and Witch-Hunting: The Impact of the Little Ice Age on Mentalities," *Climatic Change* 43:1 (1999), 340. The global nature of both the Medieval Warm Period and Little Ice Age has long been a source of controversy. However, following recent and ongoing research the worldwide impact of these climatic shifts has grown increasingly apparent, although it appears there were significant regional variations. An exception remains the Maunder Minimum; its global nature remains a source of controversy. D. Camuffo, “Freezing of the Venetian lagoon since the 9th century A.D. in comparison to the climate of western Europe and England,” *Climatic Change*, 10 (1987), 46. That significantly more detailed evidence exists regarding the history of European climate counts as perhaps the major reason for the controversy surrounding the global impact of these climatic shifts. Reasons include significant government funding for pan-European database 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 sophisticated societies. John F. Richards, *The Unending Frontier*. (Berkeley: University of California Press, 2003), 69.

³ Rüdiger Glaser, *Klimageschichte Mitteleuropas. 1000 Jahre Wetter, Klima, Katastrophen*. (Darmstadt: Wissenschaftliche Buchgesellschaft, 2001), 58. During the warmer decades of the Little Ice Age summers were, in fact, often warmer than average. Behringer, Wolfgang. "Climatic Change and Witch-Hunting," 345.

was also marked by significantly wetter weather, particularly during summer and autumn, together with significantly enhanced storminess.⁴

In Europe temperatures generally rose in the aftermath of a “year without summer” in 1628, while precipitation patterns and the frequency of storms both stabilized to twentieth century averages. Owing either to reduced solar activity or volcanic forcing, however, by 1660 European and likely global climatic conditions deteriorated again. This “Maunder Minimum,” was named after astronomer Edward Maunder, who exposed the distinct absence of sunspots during the period. Like the Grindelwald Fluctuation, in the North-eastern Atlantic it coincided with renewed glacial expansion, increased storminess from March to October in particular, greater cloudiness, enhanced precipitation especially but not limited to fall and spring, and depressed temperatures that reached their lowest point around 1700.⁵ The middle of the eighteenth century was warmer and drier, but climatic conditions deteriorated again after roughly 1760. This global “Dalton Minimum” was especially marked by variability but endured in some form until around 1850, accompanied by now-familiar cold, wet and stormy conditions. With the exception of slight cooling between 1950 and 1970, temperatures have been on the rise ever since.⁶

⁴ It is important to remember that these are generalizations of tremendously complex climatic and meteorological conditions, masking paradoxes and fluctuation that existed even at very local levels. For example, analysis of the accounts of Flemish dikes by Adriaan M.J. 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.

⁵ 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, Jurg Luterbacher expanded this period, suggesting that the decades from 1645 to 1715 were the coldest of the Little Ice Age. For this paper the Maunder Minimum is understood to begin in 1660, owing to the higher number of storms and increased precipitation of that decade over the Northeastern Atlantic. Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*. (Cambridge: Cambridge University Press, 1991), 22.

⁶ Hubert Lamb, *Climate, History and the Modern World*, 260.

This history of violent, virtually unceasing climatic fluctuation obviously overlaps with an equally tumultuous human history. The Grindelwald Fluctuation, for example, coincided roughly with the Dutch revolt against Spain in 1568 and, in subsequent decades, the explosive emergence of the proto-capitalist Dutch trading empire. The transformation of a poor, water-logged sliver of land populated by a mere one million inhabitants in 1500 into Europe's economic and naval hegemon a century later remains a site of historiographical controversy. Nevertheless, reasons include ongoing ecological transformations stretching deep into the medieval period, agricultural "revolutions" that fundamentally altered the countryside, and developing economic processes shaping urbanization and trade.⁷ The personal agency of individuals like William of Orange or Philip II triggered political events in the Republic and abroad while intensifying exploration and technological development in fields like shipbuilding or finance. By 1600 the United Provinces of the Netherlands, with Holland and Zeeland at the fore,⁸ was blossoming into a cultural and economic golden age. With urbanization exceeding 40% and a market-based agricultural economy the Dutch Republic was uniquely dependent on its role as global trade entrepôt. The Dutch had dominated the Baltic "bulk" trades for decades, but now increasingly controlled the intra-European trades, including those in the Mediterranean and Levantine. Attempts to supplant the Portuguese as masters of the "rich" trades from the East had suffered from competition among various Dutch trading interests; as a result on 20 March 1602 the *Vereenigde Oost-Indische Compagnie* or "United East India Company" was formed on

⁷ Broadly speaking the Dutch ecological transformation involved the draining of peat bogs and marshes, the harvesting of peat, the subsequent lowering of the land relative to the water level and the measures designed to cope with those changes. The agricultural "revolution" refers to the (arguably resulting) undermining of traditional agriculture, and the subsequent rise of market economies emphasizing cash crops and animal husbandry in the countryside. Fernand Braudel, *The Perspective of the World*. (London: Collins, 1979), 179.

⁸ The United Provinces incorporated eight provinces: Holland, Zeeland, Utrecht, Overijssel, Gelre, Friesland, Groningen and Drenthe, in addition to the Generaliteitslanden (swaths of the southern Low Countries). However, only seven were represented in the States-General because Drenthe was so poor it was exempt from paying taxes. Of these provinces heavily populated Holland was dominant, and Zeeland first among the rest. Wil van de Pas, *Tussen centraal en lokaal gezag: Bestuurlijke organisatie en financieel beheer in Gelre en Holland tijdens de Habsburgse periode*. (Hilversum: Verloren, 2004), 16.

the initiative of the States-General, the confederal government.⁹ Using the material, human and technological resources gained from their domination of the Baltic trades, by the middle of the seventeenth century the Dutch were firmly in the control of the Eastern rich trades. Meanwhile, following the formation of the *Geoctroyeerde Westindische Compagnie* or “Chartered West India Company” the Dutch reach extended far into the New World, although the majority of Dutch conquests there were relatively short-lived.

The naval and commercial hegemon of Seventeenth Century Europe, by 1650 the Dutch Republic included two million inhabitants, and the population of Amsterdam, its central metropolis, would reach 200,000 by 1700. However, if the Peace of Westphalia in 1648 signalled a cessation of hostilities with Spain, the Anglo-Dutch War of 1652 initiated a period of ferocious struggle with England and, later, France. In these years the Dutch Republic generally maintained its trading empire; reasons include international support, global naval pressure, and the resources accrued from trade.¹⁰ However, already by the late seventeenth century Dutch domination of the Baltic trades was fading, while by 1700 Dutch primacy in the West African trade had effectively ended. The Dutch Republic’s economic decline is as historiographically contentious as its rise, but most historians agree that wars abroad, environmental degradation at home, and ossification of urban public authorities were vital contributing factors. Meanwhile, competition from England and France in shipbuilding and trade eventually proved too great a strain on the United Provinces

⁹ 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), 384. The Baltic trades or *moeder negocie* (“mother trade”) was a bulk trade in which Baltic imports of grain were paid for by shipments of salt, wine, and herring, primarily from south-western Europe. The Dutch rich trades were dominated by pepper, spices, drugs, pearls, silk and precious metals, either from the New World, Africa, and increasingly Asia. Fernand Braudel, *The Perspective of the World*, 211.

¹⁰ Jonathan Israel perceptively explained the persistent European support for the United Provinces during its wars with England, France, or both. While Dutch trade hegemony was resented, ultimately most European governments definitely preferred it to the only feasible alternatives: English or French hegemony. To Israel, “in the Dutch Republic Europe had a dominant entrepôt which lacked the manpower and military resources ever to translate that economic primacy into political domination.” Jonathan Irvine Israel, *Dutch primacy in world trade, 1585-1740*. (New York: Oxford University Press, 1989), 275.

as the eighteenth century matured.¹¹ These factors were compounded by the mercantilist policies of other European powers which, while at first stimulating domestic Dutch industry, ultimately proved disastrous for an economy sustained by free trade. By the end of the eighteenth century the Dutch Republic's hegemony over world trade was a thing of the past.¹²

This paper represents a preliminary attempt at understanding the possible relationships between these two histories: one of a fluctuating, often deteriorating climate, the other of a society's explosive rise and gradual decline. The paper focuses primarily on the last forty years of the seventeenth century, a period marked by both the onset of the Maunder Minimum and the maturity of the Dutch trading empire, when the rich trades increased in importance and wars abounded. Three ship logbooks from the recently compiled Climatological Database for the World's Oceans (CLIWOC) form the foundation for this paper: those of the VOC vessels *Maarseveen* in 1662, *Africa* in 1677, and *Wesel* in 1699. The *Maarseveen* and *Africa* are examined only as long as they remained roughly within the North-eastern Atlantic because of the extent of existing climatic data, lingering uncertainty over the global nature of the Maunder Minimum, and the need to constrain the proportions of this study. The disastrous journey of the *Wesel* occurred in very different waters but reveals the different sorts of influence various meteorological conditions exerted on oceanic trade while suggesting very unusual, unsettled weather existed outside of Europe during the coldest phase of the Maunder Minimum. Of course, it is impossible to know how the voyages of these three ships were influenced by unique meteorological conditions without some reference to trade under a warmer climate. Hence, to establish a control this paper introduces results from 32 ship logbooks available through the

¹¹ Richard W. Unger, *Dutch Shipbuilding Before 1800*. (Assen/Amsterdam: Van Gorcum, 1978), 116.

¹² Jonathan Irvine Israel, *Dutch primacy in world trade*, 383. The primary historiographical debate concerns two issues: at what point the Dutch decline stopped being relative to the rise of other European powers and became absolute, and whether a decline in bulk trades signified a general economic deterioration, considering the long-term strength of the rich trades. It is worth noting that contemporaries already perceived a decline in Dutch economic dynamism in the early Eighteenth Century. *Ibid*, 380.

CLIWOC database, written between 1750 and 1775 on vessels travelling through similar waters as those navigated by the *Maarseveen*, *Africa* and *Wesel*. These 25 years were marked by the beginnings of the Dalton Minimum, enabling comparisons to both a warmer and similarly cool climatic regime. The CLIWOC database represents the culmination of a project funded by the European Union and consists of 287,114 ship logs from the Dutch, English, French and Spanish navies. The vast majority of ship logs date from between 1750 and 1850, yet four ship logbooks were incorporated that predate 1750. Of these only the three examined for this study predate 1748; all three are written in Dutch and originate from ships belonging to the VOC.¹³

Examining these logbooks leads to two dominant conclusions. The first is that the journeys of these vessels were significantly influenced by the types of weather conditions encountered. These conditions have not yet been comprehensively examined using ship logs – certainly not Dutch ship logs, and certainly not outside the North Sea – but they played a crucial role in determining the speed and course of the *Maarseveen*, *Africa* and *Wesel*. The second is that these weather conditions were typical of those caused and enabled by the colder, wetter decades of the Little Ice Age. The meteorological conditions experienced by the ships could have occurred outside of the Maunder Minimum, but they were certainly rendered far more likely by the climatic shifts occurring in the second half of the seventeenth century. Fluctuations in climate over oceans and seas have not been established with any great precision on a larger scale, in part because ship logs remain a chronically under-examined resource.¹⁴ However, using a combination of different sources climatic conditions for the late seventeenth century can be

¹³ To my knowledge these logbooks have escaped all attention, perhaps because they are written in Dutch, perhaps because of their unusual nature within the CLIWOC database, the relatively recent completion of the CLIWOC project, or the novelty of looking at ship logs to begin with.

¹⁴ As Christian Pfister and Rudolf Brazdil related, “a great abundance of naval logbooks are known to exist in the marine archives of the ancient great Powers, but only a tiny fraction of these sources have been investigated so far.” For oceans and seas only ship logs can provide reliable climatic data from human observers. Rudolf Brazdil, Christian Pfister, et al. "Historical Climatology in Europe - the State of the Art" in *Climatic Change* 70 (2005): 386.

reconstructed in sufficient detail for the North-eastern Atlantic. Hence, the voyages of the VOC ships and the experiences of their crews can be linked to the influence of climatic fluctuations during the Maunder Minimum.

Establishing this relationship suggests but does not confirm that the oceanic rich trades as a whole were significantly influenced by climatic conditions, pointing to a climatic effect on an area of the contemporary European economy that has generally escaped the attention of historical climatologists.¹⁵ In examining this broader relationship the paper will introduce sources, ideas, and possibilities for future research, yet must refrain from presenting conclusions that cannot yet be adequately supported. These ruminations will take place after the core of the paper, which for each ship will inspect first the influence of weather on the course of the voyage, and second link these meteorological conditions with climatic fluctuations. Third, the seventeenth century vessel's journey will be compared to a "control" of multiple ship voyages dating from a warmer climatic regime in the mid-eighteenth century, then again with journeys originating from a shifting climate roughly 10 years later. First, however, the conceptual and historiographical framework of this study deserves some mention.

The historiographies of ships, ship design, shipping and seaborne voyages are vast in the study of medieval and early modern Europe. However, works analysing the impact of weather on ships and shipping are sparse, and the influence of climate on seaborne trade has received virtually no attention. Hubert Lamb, Dennis Wheeler of the CLIWOC project and others have used ship logs to reconstruct climatic trends, but the ship logs themselves have not been employed as a social or cultural source revealing the influence of climate on human affairs. Granted, significant work has been undertaken on the opening and closing of shipping in the

¹⁵ Hubert Lamb identified both "trade" and "travel and communications" as being affected by climatic fluctuations but, strangely did not include the impact of climate on the actual voyages of ships themselves. Hubert Lamb *Climate, history and the modern world*, 275.

Northern Atlantic and Arctic Ocean as a result of Medieval Warm Period and the Little Ice Age.¹⁶ Meanwhile many studies at least briefly acknowledge the role of weather in naval affairs, including the defeat of the Spanish armada, and some understanding exists that, for example, Asian trade was profoundly affected by the rhythms of the monsoons.¹⁷ There are also tantalizing suggestions of something more; one is presented by Richard Unger, who insightfully claimed that “it was, after all, the regional differences in climate and history which served in part to create the spectrum of trading opportunities and the context in which shippers and shipbuilders had to function.”¹⁸ However, the concepts of climatic fluctuation and weather’s impact on maritime travel have not been linked or examined in any detail, let alone using ship logbooks. This paper does fit into the broadest definition of historical climatology given by Pfister and Brazdil, in that it seeks to reconstruct “temporal and spatial patterns of weather and climate,” investigate “the vulnerability of past societies and economies to climate variations” while exploring “past discourses and the social representations of the climate.”¹⁹

The ship logs examined in this study are cultural artefacts originating from a period defined by increasing control of global trade by Northern European nations employing the most sophisticated technological devices of their time: great, ocean-going sailing ships. The *Vereenigde Oost-Indische Compagnie* (VOC) was the largest corporation of the Seventeenth and Eighteenth Centuries. Governed by the *Heren XVII* (“Seventeen Lords”) The Company was the

¹⁶ This has often been employed to explain the rise and fall of Norse power and Viking civilizations in Greenland, a favourite (and perhaps overused) example of the influence of climatic fluctuations on human societies. More determinist explanations include those of Robert Claiborne (1973) and Brian Fagan (2000); more nuanced examinations are given by Hubert Lamb (1982), Fred Pearce (1989), Jean Grove (1996), P.C. Buckland, et al (1996) and Neville Brown (2001).

¹⁷ Femme S. Gaastra, *The Dutch East India Company: expansion and decline*. (Zutphen: Uitgeversmaatschappij Walburg Pers, 2003), 119.

¹⁸ Richard W. Unger, *The Ship in the Medieval Economy, 600-1600*. (London: Croom Helm Limited, 1980), 29. Unger probably referred to the influence of climate in enabling the availability of different products (like wine) in different places (France versus Norway, for example), which in turn facilitates trade; still, the mention of a climatic influence on (seaborne) trade is noteworthy.

¹⁹ Rudolf Brazdil, Christian Pfister, et al. "Historical Climatology in Europe - the State of the Art," 365.

world's first firm based on permanent share capital, had been granted a monopoly over Dutch trade from the Red Sea to Japan, and employed over 30,000 men. Grand Pensionary Johan van Oldenbarnevelt explained the primary reasons for the creation of the Company: "to damage the enemy and to secure the homeland." The VOC, then, not only emerged as a driving force behind Dutch prosperity but through its expansion also forcefully usurped Iberian control over the rich trades, rendering it a vital tool in the ongoing war against Spain.²⁰ Establishing bases, factories and trading ports throughout Asia, the VOC ultimately dominated not only the rich trades from the East but also intra-Asian trade, where its continental reach granted it a competitive advantage.²¹ The VOC's trade in Asia was organized and governed from Batavia (modern day Jakarta) which emerged as the primary *rendezvous* for vessels arriving from the Netherlands. Ultimately, although the VOC's control over the intra-Asian trade peaked around 1670 its overall profits continued to expand deep into the eighteenth century, driven by increased demand from Europe.

The celebrated early voyages of the VOC fleets were often dangerous, fraught with uncertainty and, for the most part, ultimately lucrative. Eventually, however, routes were standardized and the increasing numbers of ships were gathered into a series of fleets. That process began in 1610, when Commander Hendrik Brouwer decided not to take the normal course to Indonesia via Madagascar and Mauritius, instead taking a route that began around latitude 40° S from the Cape of Good Hope in southern Africa, and continued past the west coast of Australia. This course employed the year-round Westerlies of those latitudes while avoiding the winds and storms of the ostensibly shorter route and in 1616 was approved by the Heren

²⁰ Harm Stevens, *Dutch Enterprise and the VOC: 1602-1799*. (Zutphen: Walburg Pers, 1998), 16.

²¹ Goods carried on VOC ships around 1670 included cloves, nutmeg, cinnamon, mace, pepper, textiles, silk, cotton, saltpetre, sugar, indigo and copper. By 1740 a quarter of all cargo consisted of tea and coffee. See Appendix I for a cargo list of the first shipment of the return fleet of 1679-1680. Femme S. Gaastra, *The Dutch East India Company*, 134.

XVII as mandatory for all VOC vessels.²² After some experimentation the course of ships from Europe to Asia was formally laid down in the “sailing orders.” VOC vessels were to sail through the English Channel or through “the back way” around Scotland and Ireland in time of war. From there ships sail South, passing West of the Bay of Biscay. On 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. Ships were then required to anchor at the Cape of Good Hope to resupply; from there they would follow Brouwer’s route to Indonesia, hoping to avoid the coast of Australia.²³

The VOC’s ships were at first organized into two fleets: the Christmas Fleet departing in December, and the Easter Fleet which left around April. After 1636 the Heren XVII judged that some ships should be launched in September or October, allowing them to arrive in Batavia in time to send correspondence or goods to factories in Japan, India or China. This third fleet was eventually termed the Fairs Fleet after the Amsterdam fair in September. By the Eighteenth Century so many VOC ships travelled between Asia and the Netherlands that the idea of separate fleets was obsolete. On board VOC ships themselves ultimate authority lay with the senior merchant until the rules were changed in 1742, although in practice when business was not being conducted the captain was in command. Various petty officers were in charge of stowage of goods and maintenance of the ship; their ranks also included the junior merchant, the *hoogbootsman*, who supervised the crew, and most importantly for this study the *opperstuurman*, who supervised the navigation of the ship.²⁴

²² Harm Stevens, *Dutch Enterprise and the VOC*, 9.

²³ Femme S. Gaastra, *The Dutch East India Company*, 114. The risk of being shipwrecked on Australia’s western coast was real, but in the VOC’s history only six vessels were lost there. See Appendix 2 for a map of the standardized courses of VOC ships.

²⁴ Herman Ketting, *Leven, werk en rebellie aan boord van Oost-Indiëvaarders (1595-±1650)*. (Amsterdam: Het Spinhuis, 2005), 57. Routines on board VOC ships were rigidly enforced, and discipline was maintained through remarkably brutal punishments. Harm Stevens, *Dutch Enterprise and the VOC*, 28.

Harm Stevens accurately described how “the ships were the engine that kept the Company moving;” as such decisions regarding the construction and design of new vessels were taken by the Heren XVII themselves. Over 1,500 ships were built during the life of the VOC, and the Company’s directors forever sought standardization of ship design to achieve maximum efficiency in cargo haulage. These ships represented the culmination of a centuries-long process of experimentation and development by European shipbuilders. The crises of the fourteenth century disrupted European economies and established ways of doing things; as a result techniques originating from Northern ship traditions born from the Vikings were gradually merged with southern practices stemming from the Greeks and Romans.²⁵ New forms of ships like the carrack were far larger than their predecessors, employing stern rudders, altered hulls and square sails. Most important, however, was their three-masted design and use of artillery at sea.²⁶ Although by 1550 there was still no real distinction between warships and cargo ships, by the seventeenth century vessels were increasingly divided between those dedicated to freight – dominated by Dutch-designed *fluyts* – and massive galleons intended for battle.

The ships employed by the VOC for the conquest of the oceanic rich trades were interesting exceptions to this trend.²⁷ The East Indiamen employed on the long voyages to Asia were both merchantmen and battleships, often incorporated into the Dutch fleet during the frequent wars of the seventeenth century, not only in distant theatres but typically in the home

²⁵ Richard W. Unger, “Introduction,” ed. Robert Gardiner and Richard W Unger, *Cogs, Caravels and Galleons: The Sailing Ship 1000-1650*. (London: Conway Maritime Press, 1994), 8. Changes in European ship design were, of course, also influenced by extra-European sources.

²⁶ Christiane Villain-Gandossi, “Introduction: Medieval Ships and the Birth of Technological Societies.” In *Medieval Ships and the Birth of Technological Societies: Volume 1: Northern Europe*. Ed. Christiane Villain-Gandossi, Salvino Busuttill and Paul Adam. (Malta: European Coordination Centre for Research and Documentation in Social Sciences, 1989), 9.

²⁷ Richard W. Unger, *The Ship in the Medieval Economy*, 252. This is ironic considering how Dutch shipbuilders developed some of the most extreme versions of specialized ships early in the Seventeenth Century. Ibid, 253.

waters of the North Sea.²⁸ Naturally the VOC continued to seek the perfect compromise ship design that merged the roles of efficient cargo carrier and sufficiently powerful gun platform; this was complicated in times of war, when VOC vessels carried additional cannons. Dutch vessels were also uniquely limited by the natural environments of harbours within the United Provinces. While the presence of water throughout the Dutch Republic made transport easy harbours themselves were shallow, problematic as ship sizes continued to grow into the seventeenth and eighteenth Centuries. By necessity East Indiamen approached ports like Rotterdam or Amsterdam by a circuitous route, off-loading cargo at foreports to lessen draught. Dutch ships – particularly warships - were constructed with nearly flat bottoms and helped into the especially shallow Amsterdam harbour by using a floating dry-dock termed the “camel.” These environmental factors placed severe limits on Dutch ship design, and, as a result, the ability of the Dutch to keep pace with their naval rivals.²⁹ These problems became especially acute into the eighteenth century, but for most of the seventeenth century VOC ships remained models of versatility, functioning as the key elements in the projection of Dutch power abroad.

²⁸ Gerrit Knaap and Ger Teitler, “Inleiding.” *De Verenigde Oost-Indische Compagnie: Tussen Oorlog en Diplomatie*, ed. Gerrit Knaap and Ger Teitler. Leiden: KITLV Uitgeverij, 2002), 4.

²⁹ Unger, Richard W. *Ships and Shipping in the North Sea and Atlantic, 1400-1800*. (Aldershot: Ashgate Publishing Limited, 1997), 28. It is possible that climatic conditions lowering sea levels exacerbated this problem. Noteworthy attributes of typical Dutch ships in comparison with those employed by other navies included: greater beam, which led to violent rolling action in heavy seas but yielded a more stable gun platform in calm waters, smaller draught which kept the lowest guns out of water in good weather and allowed Dutch ships to carry less canvas, lighter ships using lower-quality wood (never iron), greater capacity for cargo or stores, increased amount of cannons given the length of the vessel, flat sterns and the lingering presence of upperworks past 1700. Into the Eighteenth Century Dutch vessels could also still be constructed far more quickly than those built by other nations. Ibid. Changes in ship design during the Little Ice Age warrant additional research, because shifts in the physical properties of ships could well have had as much of an impact on the nature of voyages as conditions at sea. How exactly different meteorological conditions affected different types of ships also requires further study. Richard Unger in particular has undertaken extensive work in this field; potential sources for primary source research on Dutch ships during the period examined for this paper include contemporary technical manuals like Witsen’s *Aeloude en hedendaefse Scheeps-bouw* (1671), *Hollandsche Scheepsbouw* (1678), Allard’s *Nieuwe Hollandsche Scheepsbouw* (1695) and van IJk’s *De Nederlandsche Scheeps-bouw-konst open Gestelt* (1697). Blaise Ollivier, *18th Century Shipbuilding: Remarks on the Navies of the English & the Dutch from Observations made at their Dockyards in 1737, by Blaise Ollivier, Master Shipwright of the King of France*. Translated/Edited by David H. Roberts. (East Sussex: Jean Boudriot Publications, 1992), 10.

The VOC East Indiaman *Maarseveen* was a particularly massive example of such flexible, adaptable ship design. Built in Amsterdam in 1660, the ship was 170 feet long, 39 feet wide, and just over 18 feet high.³⁰ It was very heavily armed for an East Indiaman; its 78 cannons rendered it on par with heavy warships and established it as perhaps the best-armed VOC vessel. The ship's deadweight tonnage, referring to how much mass or weight of cargo a vessel can safely carry, was listed at an impressive 1,210 tons. On 9 October 1662 the ship was launched from Rotterdam to begin its long voyage to Batavia, where it arrived on 27 April 1663.³¹ The principal observer of the data recorded in the ship's log was Gerritsz Boos, the ship's *opperstuurman*. He could not have known that the *Maarseveen* would meet a violent end at the disastrous battle of Lowestoft just three years later, in the Second Anglo-Dutch War.³²

The ship logs meticulously compiled by the crew of the *Maarseveen* and other VOC vessels were similar – if not identical – to those kept by officers on other European ships, which were compiled for the purpose of navigation. The invention of the octant and sextant meant that latitude could be judged with reasonable accuracy from the mid-Seventeenth Century on, yet longitude was another matter. Neville Maskelyne's *Nautical Almanac*, containing tables that enabled the lunar distance method of finding longitude, would not be published until 1767, while John Harrison's H4 chronometer was not ready for use until the 1770s.³³ Until then ship

³⁰ One Amsterdam foot measured 283.1 mm, and was divided into 11 inches of 25.73 mm. Blaise Ollivier, *18th Century Shipbuilding*, 208.

³¹ A note on dates: in the study the dates are given as they were recorded by observers at the time. These dates were recorded on the Julian Calendar (Old Style), and were therefore eleven days behind the Gregorian Calendar (New Style). Data on storms taken from sources other than the ship logs is given in the Old Style (OS) dates to give a better indication of their relation to the events described within the logs. Precision to the day regarding oceanic weather conditions is either not available or not applicable outside of these logs and data on storms, and so monthly patterns of precipitation are, for example, not given in Old Style dates. Dennis Wheeler, "Understanding Seventeenth-Century Ships' Logbooks: An Exercise in Historical Climatology." *Journal for Maritime Research* (2004), 5.

³² See Appendix 3 for a depiction of the *Prins Willem*. The ship was built in 1649 and sank in 1662; it was among the largest Dutch East Indiamen of its period and resembled the *Maarseveen*. It is important to know what is actually being physically affected by the meteorological conditions described in this paper.

³³ Dennis Wheeler, "Understanding Seventeenth-Century Ships' Logbooks," 3.

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 factors would have been enough to determine a vessel’s position, but a further correction was necessary to account for “leeway” in the ship’s course. A Northerly wind caused leeway to the South, for example, while a Westerly breeze might push a ship to the East. Determining the impact of these meteorological conditions was a mathematically sophisticated but inexact science; nevertheless, the safety of the ship, its crew and its cargo depended on it. Hence, ship logs abound with reliable meteorological detail taken several times on virtually every day of the vessel’s journey.³⁴

Although the ship departed Rotterdam on 9 October, the first logs recorded for the *Maarseveen*’s voyage date from 15 October, 1662.³⁵ By this point the vessel had already cleared the English Channel and was positioned at 49.6 °N 6.2 °W, just southwest of the southern fringes of England. For the day the *Maarseveen* travelled 7 *Duitse mijlen* – “German miles” – each of which equalled 7532.5 meters; the distance covered was therefore roughly 35 miles as that unit of measurement is understood today, or exactly 52.7 km. During the day a calm breeze blew from the South-southeast, and the log recorded conditions of “*mou koelte*.” Meteorological conditions qualitatively described in Early Modern ship logs are difficult to decipher in part because the usage of the words has often changed with time; in British ship logs, for example, the term “gale” was used to describe anything from a pleasant breeze to an intense storm.³⁶ While further research is required to decipher the etymology and precise meanings of *mou, koelte* and

³⁴ Dennis Wheeler, “British Naval Logbooks from the Late Seventeenth Century: New climatic information from old sources.” *History of Meteorology* 2 (2005), 136. See Appendix 4 for an image of an actual Seventeenth Century British ship log; see Appendix 5 for an screenshot of how data from ship logs is presented within the CLIWOC database, obtainable through Microsoft Access.

³⁵ See Appendix 6 for a map of the *Maarseveen*’s voyage, traced using the location of the ship given in every log.

³⁶ Dennis Wheeler, “Understanding Seventeenth-Century Ships’ Logbooks,” 7.

other archaic Dutch terms used to describe conditions at sea, it is likely that *koelte* referred to a cool wind, while *mou* suggested a calm breeze.³⁷

The first day of the *Maarseveen*'s trip was fairly typical of conditions experienced during the following two weeks. The prevailing winds were not only calm, but also generally contrary to the course desired by the ship's navigator and captain, blowing from the South. On 18 October it began to rain; it rained again on 19 October, and the log for 23 October recorded *harde regen* or "hard rain." By the 23rd the winds had shifted to the Southwest – directly contrary to the ship's intended course – and on 24 October the winds nearly ceased. That day the ship moved a mere 0.25 German miles – a remarkably low number – while on 25 October the intense rain returned, with winds continuing to blow from the Southwest. It rained continually for four days; by 27 October the log recorded *mottig weer* or "damp weather," but the rain persisted until 28 October. For the 14 days from the start of the voyage until 29 October the *Maarseveen* travelled a total of only 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; as visible in the first highlighted area in Appendix 6 the *Maarseveen* dithered near the Celtic Sea for much of this period. This leeway was likely caused by contrary winds, which were problematic in part because they were calm and therefore could not be easily harnessed.³⁸ It is possible that the *Maarseveen*'s captain was coping with adverse wind conditions by sailing back and forth seeking a trade wind to take the ship

³⁷ *Koelte* currently means "cool" or "brisk" in Dutch; it is employed within the wind force measurements of the ship logs and often used as a synonym for wind, implying it was used to describe a cool breeze. *Mou* is similar to the Dutch word for tired and was also used within the wind force measurements of the ship logs, especially on days when the ship did not move very far and the wind was often recorded as calm with other words. It seems reasonable to conclude, therefore, that *mou* refers to calm – if not dead – winds. These are preliminary conclusions and this paper avoids placing too much stock in qualitative data that cannot be defined with reasonable certainty.

³⁸ European vessels had the capacity to sail "close enough to a contrary wind to gain against it." Alfred W. Crosby, *Ecological Imperialism: the Biological Expansion of Europe, 900-1900*. 113.

towards the southeast, a strategy reflected in other logs contained within the CLIWOC database. After all, in this part of the Atlantic persistently calm winds are rare. Ultimately the first two weeks of the vessel's voyage indicate that weak, contrary winds were often coupled with increased precipitation, and that these conditions were a serious impediment to the progress of a Dutch East Indiaman like the *Maarseveen*.³⁹

Fortunately for the ship's crew the weather shifted on 29 October. With stiffer winds the ship travelled 19 German miles over the course of the day; sadly, however, one Abraham Pieter van Masterlandt fell overboard and could not be recovered. On 30 October three soldiers engaged in a drunken brawl and were disciplined, but with strong winds the *Maarseveen* travelled 21 German miles. The ship was able to steer towards the East and back onto the course outlined in the VOC's Sailing Orders; before long it was again headed for the Canary Islands. On 2 November the ship reached 39.1 °N 13.6 °W – roughly West of Lisbon – and now, for the first time, winds 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. The stretch highlights the impact favourable weather – in this case consisting of strong winds from advantageous directions and generally dry conditions - could have on a seventeenth century sailing ship.⁴⁰

As it closed on the Canary Islands on 7 November 1662 the *Maarseveen* entered another stretch of troublesome weather. For the 7th and 8th winds remained favourable from the North but

³⁹ Gerritsz Boos, *Maarseveen* logs, records 69229 – 69242, 15 October-28 October 1662. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

⁴⁰ Gerritsz Boos, *Maarseveen* logs, records 69243 – 69251, 29 October – 6 November. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

now also blew from the West, while their intensity declined dramatically. On 8 November the wind was recorded as *stil* or exceptionally calm; the ship travelled only 4 German miles that day, and but a single German mile the next, as the *opperstuurman* again recorded “*mou koelte*.” By then the winds had shifted to issue calmly 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, for an average of 12.5 German miles a day. Once again calm, contrary winds had taken their toll.⁴¹

One month after the *Maarseveen*’s first recorded log the ship’s pace quickened again, 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*” – or completely nonexistent – while the ship remained virtually stationary in torrential rains. Overall, from 15 October to 30 November the *Maarseveen* travelled over 840 German miles, having journeyed from the mouth of the English Channel to a position just west of Guinea.⁴² An analysis of the ship’s log book reveals first that changes in weather could have a very significant impact on the course and speed of a seventeenth century vessel. When winds were favourable and strong the East Indiaman sometimes travelled over thirty times faster than it did when the weather produced weak and unfavourable winds. The winds that correlated most strongly to delays in the ship’s course typically stemmed from the West or South-west, while the

⁴¹ Gerritsz Boos, *Maarseveen* logs, records 69252 – 69260, 7 November – 15 November. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>. Logs from other vessels indicate the *Maarseveen* was not required to slow down as it passed through the Canary Islands.

⁴² Gerritsz Boos, *Maarseveen* logs, records 69261 – 69277, 16 November – 2 December. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

most advantageous blew from the North or North-east. Low, contrary winds were often accompanied by rain; the worst days in fact seemed to mingle *doodstil* winds with *harde regen*. Research by Hubert Lamb, Rüdiger Glaser, Dennis Wheeler and others indicates that these meteorological conditions were influenced by the climatic conditions of the deepening Maunder Minimum.⁴³

The CLIWOC database was compiled primarily by climatologists as a tool through which to study climatic changes during the final phase of the Little Ice Age; as such it focused on a large volume of quantitative data over a relatively limited period. Aside from the logbooks considered in this paper, logs predating 1748 were therefore ignored. To begin to remedy this Dennis Wheeler, a member of the CLIWOC team, analysed 52 British logbooks dating from the late Seventeenth Century, “with a smaller sub-set of randomly selected duplicate logbooks to act as checks for consistency of the record.” Wheeler inspected a total of 5500 days of data (as compared to roughly 1500 considered for this study), most of which originated from ships sailing in the English Channel. This is significant, because research by V.C. Slonosky has recently suggested that weather over the English Channel reflects broader meteorological patterns over a far wider swath of the North-east Atlantic, including the areas sailed through by the *Maarseveen*. Wheeler’s data clearly revealed the unsettled nature of the Maunder Minimum climate, which was prone to severe fluctuations from month-to-month and year-to-year. However, the logs indicated that overall Easterly winds were more common during the Maunder Minimum than they are today. For some months Westerlies were absent altogether, and entire years exhibited a remarkable dominance of Easterlies.⁴⁴

⁴³ In general while a great deal of data on climatic fluctuations exists over Northern European landmasses, very little exists that pertains to oceanic conditions. Wheeler and Lamb are perhaps the best sources for determining the influence of climatic fluctuations over the Northeastern Atlantic, in part because both authors are among the few who employ ship logbooks. Dennis Wheeler, “Understanding Seventeenth-Century Ships’ Logbooks,” 1.

⁴⁴ Ship logs are particularly good sources for wind direction because winds over sea are less prone to being altered by geographical features. Dennis Wheeler, “British Naval Logbooks from the Late Seventeenth Century,” 141.

Wheeler's study supported the conclusions he presented in an earlier piece examining the logbook of the *Dunkirk*, a British frigate just over half the size of the *Maarseveen*. Covering 1678/9 and the southern extremes of the English Channel, the *Dunkirk*'s logs confirm that the number of Westerly winds during the Maunder Minimum was often severely reduced. This reduction was particularly acute for winds originating from the Southwest. Today Westerlies usually account for 60% of winds in the Channel, but the *Dunkirk* recorded winds from the Southwest, West-Southwest and West in only 28% of its entries.⁴⁵ One element of Wheeler's research does not match the weather patterns experienced by the *Maarseveen*: the *Dunkirk* recorded Westerlies dominating only in October, while September, December and March were marked by a preponderance of Easterly winds. However, during October 65% of winds experienced by the VOC ship blew from the East. The logs of the *Maarseveen* and *Dunkirk* were, of course, separated by 15 years, and it is possible that 1662 was an extreme year of particularly few Westerlies. This is strongly supported by the exhaustive research undertaken by Hubert Lamb, who recorded a decline in South-westerly surface winds in England around 1660, with a deeper drop beginning around 1675.⁴⁶

The meteorological data contained within the *Maarseveen*'s ship logs therefore confirms the conclusions gleaned from the British logbooks analyzed by Dennis Wheeler and the various sources examined by Hubert Lamb: winds during the Maunder Minimum were less likely to come from the West, especially the Southwest, and more likely to come from the East. This trend seems to have begun around 1660, though further research is required to fill in remaining

⁴⁵ Dennis Wheeler, "Understanding Seventeenth-Century Ships' Logbooks," 12. See Appendix 7 for current trade wind patterns; generally winds in the part of the Atlantic sailed through by the *Maarseveen* blow from the West.

⁴⁶ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 31. Because the available data on winds is often a decade removed from the *Maarseveen*'s voyage, of insufficient resolution or recorded in geographical locations that are slightly afield, it is only using a variety of sources and combining them with the data recorded in the *Maarseveen*'s logs that a reliable image of changes in prevailing winds emerges. In this case all available data on the Maunder Minimum supports a general, sometimes very significant increase in Easterlies and decrease in Westerlies over the Northeastern Atlantic as compared to periods of relative warmth.

temporal and spatial holes, and increase the resolution of climatic reconstruction. During the two major delays during the *Maarseveen*'s travels through the North-eastern Atlantic the ship was therefore impacted by weather more typical of a warmer climatic regime. The ship's initial delay was marked by a 15% reduction of Easterlies when compared to the conditions it experienced for the whole of October, and the slowest three days were all dominated by Westerlies. Meanwhile, 67% of days constituting the vessel's second delay were marked by Westerlies. If the number of Easterlies was increasing in the 1660s, the *Maarseveen*'s logbook confirms this was the beginning rather than the height of a decades-long trend.

That said, during the quicker stretches of their journey the crew of the *Maarseveen* enjoyed favourable Easterly or North-easterly winds rendered more frequent by the beginning and deepening of the second great nadir of the Little Ice Age. Lamb has argued that these changes in the patterns of prevailing wind were caused by increased meridional airflow. In the middle latitudes air usually flows from west to east, but this system can break down, enabling the persistent movement of air from other directions. During the Maunder Minimum it is likely that such a breakdown occurred over the Northeastern Atlantic as a result of the intrusion of frigid Arctic air from the Norwegian Sea, a phenomenon particularly significant for the voyage of the *Africa*.⁴⁷ What remains uncertain is whether the climatic changes of the Maunder Minimum rendered still or unusually calm winds more likely. Often severe fluctuations in weather from day-to-day, month-to-month and season-to-season characterized the coldest phases of the Little Ice Age, and it seems likely that the debilitating calms that hindered the voyage of the *Maarseveen* were intensified or multiplied by the influence of a shifting climate. These calms

⁴⁷ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 30.

were significantly more influential than shifts in wind direction, but far more quantitative, interdisciplinary research is required before any definite conclusions can be reached.⁴⁸

This paper has revealed that voyage of the *Maarseveen* was influenced by the weather the ship encountered, and that such weather was typical of that rendered more frequent by the Maunder Minimum. It would, however, be impossible to argue that these conditions and their effects were influenced by a climatic shift without some reference to ship voyages and meteorological phenomena under a very different climatic regime. The Little Ice Age was characterized by fluctuation: decades of cooler, wetter climate broken by sustained periods of relative warmth and dryness, though of course these climatic shifts were also interspersed with variability on smaller regional and temporal scales. If an increase in the frequency of Easterly winds marked the Maunder Minimum in the North-eastern Atlantic during the late sixteenth and early seventeenth centuries, Lamb's research indicated that the number of Westerlies in England during the significantly warmer, drier climate of 1740 matched their highest point in 500 years.⁴⁹ The number of Westerlies dipped slightly after 1740, rebounded in 1750, then dropped very sharply after 1755 as the Dalton Minimum deepened, reaching the lowest point recorded during the Little Ice Age in 1800.⁵⁰

Lamb's conclusions for the mid-eighteenth century can be verified by examining ship logbooks from the VOC vessels *Africaensche Galey*, *Admiraal de Ruyter*, *Akerendam*, *Bos en Hoven*, *Landskroon*, *Oud Haarlem*, *Schagen*, *Scholtenburg*, *Spaarzaamheid*, and *Westerveld*, which record this transition. All 10 ships sailed between 1750 and 1775. The first 14 days of their logbooks were examined, these corresponding both with the *Maarseveen*'s first delay and

⁴⁸ The frequency of storms has been measured by Wheeler, De Kraker, Lamb and many others, but this is, of course, not the same as measuring average wind forces. Although it is counterintuitive, extremes of weather include not only intense winds but also their virtual absence.

⁴⁹ Jean M. Grove, *Little Ice Ages Ancient and Modern*, Vol. 1. (London/New York: Routledge, 1988), 8.

⁵⁰ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 31.

the portion of the North-eastern Atlantic most convincingly covered by existing climatic data. For these first two weeks of their journeys the vessels recorded an average of 58% Easterly winds, 39% Westerly winds, and 3% still winds, variable winds, or purely Northerly or Southerly winds. The three ships which sailed in the early 1750s, however, recorded averages of 69% Westerly winds and 31% Easterly winds; the seven ships which sailed in or after 1755, by contrast, measured 64% Easterly winds, 32% Westerly winds and 4% Other. This selection of ships from a warmer but changing climate therefore enables the tentative expansion of Lamb's data over the much larger geographic expanse of the North-eastern Atlantic. When these eighteenth century logbooks are combined with the records of the *Maarseveen* and the logs examined by Wheeler it is evident that colder periods during the Little Ice Age influenced a long-term shift in winds leading to a significantly increased amount of Easterlies over the North-eastern Atlantic.

The logbooks of these 10 vessels also help confirm that ship voyages themselves were influenced by the meteorological conditions more common during the nadirs of the Little Ice Age. The ship logbooks examined between 1750 and 1775 were selected because all originated from VOC vessels taking the same route as the *Maarseveen*; as such they function well as a control against which the *Maarseveen*'s voyage can be compared.⁵¹ The average speed of all 10 ships during the first two weeks of their voyages was 21.8 German miles for every day. 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

⁵¹ The ships serving as controls for the three seventeenth century ship journeys examined were selected for their similarity to the seventeenth century vessels. Nevertheless the eighteenth century VOC ships did have significant differences in design when compared to, for example, the *Maarseveen*, which might influence results. Perhaps most prominent concerned changes in weaponry: once the VOC established hegemony in Southeast Asia it was no longer necessary for its vessels to field as many cannons. The *Akerendam*, for example, had a deadweight tonnage of 1150 tons but carried only 28 cannons. Cannons were typically the heaviest items carried by East Indiamen, and reducing their number might have resulted in quicker speeds, especially considering the dimensions of sails remained essentially unchanged. Harm Stevens, *Dutch Enterprise and the VOC*, 19.

increased to 22.2. The 14% shift in average speeds reflects the over 30% leap in the number of Easterlies VOC ships recorded after roughly 1755. The influence of winds 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 also 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 24.5 German miles for the typical day. Interestingly, Easterly winds typically aided ships while Westerly winds often hindered, irrespective of whether vessels were heading North to their European ports, or South towards the Cape of Good Hope. The influence of the shift in prevailing winds was even more strikingly felt because during many voyages winds tended to blow from either one direction or the other for long durations. This phenomenon was likely exacerbated because the climatic shifts of the Little Ice Age were often expressed through extremes. The first two weeks of the *Africaensche Galey's* journey in 1750, for example, were marked by a 93% prevalence of Westerlies; the ship travelled a mere 12.1 German miles for the average day. Meanwhile, during the first 14 days of its travels in the 1766 the *Scholtenburg* experienced Easterly winds 93% of the time, and averaged a remarkable 29 German miles per day. Ultimately, the reasons for the almost invariably favourable impact of Easterlies require further consideration. It is possible that Easterlies were typically more intense, but unfortunately the uncertain nature of the archaic Dutch contained within VOC logbooks renders precise measurements of wind intensity problematic at present.⁵²

⁵² C. Mattijsen, *Africaensche Galey* 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

The weather conditions recorded within the *Maarseveen*'s logbook generally echo those listed in the eighteenth century logbooks of the 1760s and 1770s. The ship suffered through a slow start, marked by Westerlies during the most sluggish stretches. However, the *Maarseveen* experienced Easterly winds more often than Westerly winds, and therefore averaged 18.3 German miles a day during the first 1.5-months of its journey. The general prevalence of Easterly winds enjoyed by the *Maarseveen* was likely influenced by the beginning of the climatic shifts of the Maunder Minimum. However, when compared to the travels of the eighteenth century vessels the *Maarseveen*'s journey was marked by an unusual degree of acceleration and delay, accompanied by continual shifts between Easterly and Westerly winds. It is possible this was caused by the transition between the warmer climatic regime of the mid-seventeenth century and that of the Maunder Minimum, although the meteorological manifestations of this shift as it happened require further research.

When comparing the voyage *Maarseveen* to those of the 10 eighteenth century ships the problems of resolution and seasonality are particularly pronounced. Winds and weather conditions more generally varied from season to season; as such it can be problematic to compare ship voyages from different months between different years, with the assumption that the conditions reported by vessels in one month reflect those that typified the year more generally. Unfortunately, however, only two Dutch ship logbooks contained within the CLIWOC database recorded journeys through the North-eastern Atlantic during October or November: that of the *Westerveld* in 1764, and the *Spaarzaamheid* in 1751. Curiously, both logbooks record an abundance of Westerly winds, though both also generally reveal the ships sailing faster when winds shifted to the East. Five of the other eighteenth century ship logbooks originated from

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. Database available from <http://www.knmi.nl/cliwoc>.

ships travelling as part of the Christmas Fleet, while two journeyed with the Easter Fleet, and one sailed in August.⁵³ This problem is partially resolved due to the many hundreds of days over multiple seasons covered by the eighteenth century logbooks, and because their records broadly match Hubert Lamb's findings over England. Nonetheless, still more quantitative research is required to support these results and further clarify how the voyage of the *Maarseveen* was influenced by weather conditions typical of a cooler, wetter climate.

Another, final meteorological condition appearing frequently within the logbook of the *Maarseveen* was precipitation. During the Maunder Minimum warm, moist air pushed north by the sub-tropical Azores anticyclone would have encountered colder than usual waters in the North-eastern Atlantic, leading to amplified fogginess and precipitation. This rise in precipitation was not localized merely to the Atlantic, as increased precipitation during the Maunder Minimum was felt across Europe, especially during the months crucial to the harvest.⁵⁴ In the logbooks rain appears often during days of nonexistent or very calm winds, suggesting but not proving that some correlation might have existed. Rain therefore often accompanied delays, but it remains uncertain whether precipitation exacerbated delays by, for example, drenching ships and sails, or whether increased rainfall was merely a symptom of more important meteorological conditions like calm, contrary winds. Indeed, the ship logs of the 10 eighteenth century vessels also recorded rain during gusty days, suggesting that rain was likely far less of a factor than changes in the direction and intensity of winds.⁵⁵ Still, the counterproductive winds and often accompanying rainy conditions that influenced the major delays of the *Maarseveen*'s journey

⁵³ As more and more VOC ships sailed to and from Asia in the eighteenth century the three-fleet system was beginning to break down. Femme S. Gaastra, *The Dutch East India Company*, 111.

⁵⁴ Rudiger Glaser, "The temperatures of Southwest Germany since 1500 – The examples of Lower Franconia and Northern Wurttemberg." In *European climate reconstructed from documentary data: methods and results*, ed. Buckhard Frenzel. (Stuttgart: Gustav Fischer Verlag, 1992), 119. Ultimately increases in precipitation were at least as important as decreases in temperatures in enabling the expansion of glaciers in Europe and elsewhere.

⁵⁵ It is also possible that different types of rain resulted in different influences, but the logbooks do not record precipitation with enough precision to easily distinguish between different forms of rain.

through the North-eastern Atlantic were clearly influenced in turn by the climatic shifts of the Maunder Minimum.

On 12 April, 1677 the VOC East Indiaman *Africa* departed Texel, an island in North Holland wedged between the Wadden Sea and North Sea. Like the *Maarseveen*, the vessel was bound for Batavia; built in Rotterdam in 1673 its deadweight tonnage was also similar to that of the *Maarseveen* (if slightly inferior), at 1100 tons. The ship's logbook was compiled by *opperstuurman* Adriaen Jongekoe, who provided no detail on length, width, height or armament. The *Africa*, however, departed in very different circumstances than the *Maarseveen*. The *rampjaar* or "disastrous year" of 1672 had, among other things, witnessed the declaration of war on the United Provinces by France, Britain, Cologne and Münster. Admiral Michiel de Ruyter inflicted sufficient damage to the combined Anglo-French battle fleet to prevent a landing, but all navigation from Dutch ports was suspended for two years. When an exhausted England retired from the struggle in 1674 the Dutch Republic reclaimed its dominant position in global trade, buttressed by a muscular navy that blockaded French ports.⁵⁶ The war against France would last past 1677 and into 1678; as a result the *Africa* sailed in a convoy of ships and took "the back way" into more northerly waters, past Scotland, around Ireland, then down towards the course taken by the *Maarseveen*.⁵⁷

The *Africa*'s logs did not give a measurement for longitude until 21 April, 1677, when it was positioned just north of Scotland, although measurements given for latitude reveal the ship creeping up the English Channel. The position of the *Africa* is only noted in Appendix 8 when both longitude and latitude are established. Near the Netherlands navigation was possible, indeed preferred close to shore using coastal navigation based on familiar landmarks. Therefore it was

⁵⁶ Jonathan Irvine Israel, *Dutch primacy in world trade*, 340.

⁵⁷ See Appendix 8 for a map of the *Africa*'s voyage, traced using the location of the ship given in every log.

only when the *Maarseveen* and *Africa* left the North Sea or English Channel that meticulous measurements of longitude and latitude were necessary.⁵⁸ Although the ship's logs did not list longitude for the first 9 days of its journey, meteorological conditions were faithfully recorded. On 12 April, 1677 the logs described *slappe* or “weak” winds from the Southeast; the next day was marked by *mooi weer* – “nice weather” – and favourable winds from the Southwest. The vessel travelled 14 German miles that day, but only 7 miles the next, when the wind was virtually nonexistent for part of the day before striking up from the West. However, the wind blew from the East or Southeast for 7 out of the 10 days before a longitude was given. Three of those days were marked by fog, but only one by rain; unfortunately the distance travelled that day was either not recorded or indecipherable to those compiling the CLIWOC database.⁵⁹

On 21 April winds were steady from the North-Northeast, although *matroos* (“sailor”) Asmus Welmans fell overboard and drowned. The next day the *Africa* crossed 28 German miles, powered by strong winds from the North-Northeast. On 23 April, however, the weather was marked by bouts of rain and contrary if variable winds from the West-Southwest; as a result the *Africa* sailed only 11 German miles. While the winds blew from the Southeast for much of 24 April by the evening they had shifted to a very favourable East-Northeast, and a storm was building, drenching the vessel with intense rain. The *Africa* covered 20 German miles. The storm blew throughout the next day with favourable winds from the Northeast; as a result the ship leapt forward an incredible 46 German miles or 346.5 km, the highest number recorded in any of the logs examined for this study. The ship had traversed over 4 degrees of longitude; it had begun the day North of Ireland and ended it far to the Northwest of the island. On 26 April strong winds continued blowing from the North, although the storm had mostly subsided; the *Africa* journeyed

⁵⁸ Richard W. Unger, “Introduction.” In *Cogs, Caravels and Galleons*, 10.

⁵⁹ Adriaen Jongekoe, *Africa* logs, records 11248 – 11257, 12 April – 21 April. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

34 German miles on the day. Overall, for the sixteen days in April during which the distance travelled was either recorded or decipherable the *Africa* crossed a total of 375 German miles, averaging a swift 23.4 miles every day. The ship had begun its voyage at Texel, sailed around Scotland, swerved by Ireland, passed to the West of both the Celtic Sea and Bay of Biscay, and on 30 April was positioned at 46.3 °N 18.3 °W, well West of Porto, Portugal.⁶⁰

The first leg of the *Africa*'s journey was defined by two meteorological conditions: the dominance of winds from the North and Northeast, and the presence of a storm that waxed in full on 25 April but certainly influenced weather on preceding and subsequent days. The prevalence of winds from the East has already been tied to the climatic changes of the Maunder Minimum. However, it is also possible to link the increased frequency, power, and northerly winds of storms in the North-eastern Atlantic for the last half of the Seventeenth Century with contemporary climatic shifts. Wheeler's analysis of 52 ship logs in the English Channel confirms that gales were "far more frequent in the closing decades of the seventeenth century than they were three hundred [years] later at the close of the twentieth." These gales were much more common from March to October but during the winter months were actually slightly less frequent than today. It is possible that steeper summer temperature gradients between subtropical and high latitudes drew the polar jet south, "providing the system with a greater potential for active cyclonic development than is the case in the warmer summers that currently prevail."⁶¹

Examining great storms during the Little Ice Age, Hubert Lamb employed a sample of 10 North Sea storms between 1703-1860 to reveal that 45% blew from the North. By analysing 32 North Sea storms between 1860-1989 Lamb was able to conclude that for this warmer period

⁶⁰ Adriaen Jongekoe, *Africa* logs, records 11248 – 11266, 12 April – 30 April. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

⁶¹ Wheeler also explained the relative lack of storms in the winter: "The appearance of well-developed continental anticyclones in winter might provide for 'blocking' situations in which the cyclones would adopt paths that avoided the British Isles, thereby decreasing the incidence of gales at that season." Dennis Wheeler, "British Naval Logbooks from the Late Seventeenth Century," 141.

only 23% blew from the North. The same meridionalty that resulted in shifts of winds from West to East probably also enabled the increasing frequency of northerly winds from the Arctic. In 30% of all cases examined by Lamb the first storm winds would originate from the South before swinging strongly to the North, as they did during the voyage of the *Africa* on 24 April, 1677, likely because of an influx of polar air from the Norwegian Sea to the Northeast.⁶² These trends are confirmed by an examination of the most severe Atlantic gales recorded for the second half of the Seventeenth Century. Wind directions and intensity can be gleaned from ship logs, from the accounts of observers on land who measured storms blowing in from the sea, and from proxy data including the residue of sand-blow events, or the growth of the spit at northern tip of Jutland.

On 18 February, 1662 (OS) a storm front in the North Sea was delayed by strong winds from the Southwest, but these winds veered to the Northwest and continued blowing from that direction for a long time. In 1704 Daniel Defoe still remembered a “very great storm of wind,” and contemporary sources point to an intrusion of cold air, probably from the Northwest or North. On 19 April 1663 (OS) the diary of John Lamont of Newtown recorded “great wynde and rain” leading to the shipwreck of two vessels from Newcastle and the loss of 36 men on coast of Fife near St. Andrews. This was almost certainly a North-easterly storm. Two severe gales in October of the same year blew from the North; in 1676 a North-westerly gale carried clouds of sand before it and buried English fields to a depth of over two feet. Overall, from an analysis of 12 severe storms between 1660 and 1700 for which wind directions were recorded 10 blew from the North, just one from the South during the mild winter of 1698, and one from the West in 1681. Of the storms featuring Northerly winds three had begun with some wind from the South,

⁶² Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 30.

which quickly veered to the North as the storm escalated.⁶³ The evidence indicates that more severe storms during the Maunder Minimum were especially likely to blow from the North.

Comparing the *Africa*'s voyage to a selection of ship journeys from a warmer climatic regime is complicated by circumstances that surrounded the use of "the back way" over Scotland and Ireland. After the war of Austrian Succession was concluded in 1748 the back way was rarely employed by Dutch ships until the conclusion of the eighteenth century, when the United Provinces, long in terminal decline, was finally overthrown by French armies. The collapse of the Republic coincided with the third and final nadir of the Little Ice Age, complicating the use of contemporary ship voyages as points of contrast for the journey of the *Africa*.⁶⁴ Fortunately 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. As mentioned above, the climate over the North-eastern Atlantic in the 1750s was in flux. Still, overall the decade was warmer and drier than the late seventeenth century, enabling the use of these ship logs as a control for the *Africa*'s journey, even if more quantitative research is still required. The *Africa* and the four eighteenth century vessels all travelled within roughly four months of one another, during the spring and summer months. Differences in season, therefore, do not present as much of a problem as for those vessels used as a control for the *Maarseveen*'s journey.

The logs from the four ships faithfully reflect the increasing number of Easterlies recorded for the more southerly waters traversed by the *Maarseveen*, indicating that changes in

⁶³ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 58.

⁶⁴ This is unfortunate, because the CLIWOC database includes many records from ships that took this route in 1790s, including logs from the *Dregterlandt*, *Braave*, *Bellone*, *Greene*, *Havick*, *Hoop*, *Piet Heijn*, *Revolutie*, *Scipio*, *Tromp* and *Vrouwe Maria*. Dutch whaling ships like the *Frankendaal*, *Friedrich*, *Onverwagt* and *Propatria* all travelled past Scotland and into the Norwegian Sea, often as far North as Svalbard, but they were very different ships and typically did not travel along the same route taken by the *Africa*. As such their logs were not used as a control.

wind frequency influenced by climatic shifts during the Little Ice Age were felt throughout the entire North-eastern Atlantic. The logs for 1756 in particular also reveal a higher frequency of Southerly winds more generally when compared to the *Africa*'s records. The *Hercules* reported winds from the South on 100% of the days during which it travelled North of Ireland and Scotland, while the *Jerusalem* experienced winds from the South on 67% of days in the same region.⁶⁵ Travelling in 1760, the *Noordbeveland* reported winds from the South for 69% of days, while the *Sloterdijk* logged winds from the South on only 40% of days. By contrast, the *Africa* recorded winds from the North on 80% of the days during which it travelled in the colder waters North and North-west of the British Isles. The existing climatic data compiled by Lamb only covers Northerly winds in storms, but the data introduced in this paper, while far from definitive or of sufficient quantitative scope, at least suggests that the general shift from winds from West to East was accompanied by an increased frequency of Northerly winds as well.

More importantly, none of the four ship logbooks examined for the 1750s recorded a single storm, let alone a storm with winds from the North. However, in 1769 the *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, suggesting that, perhaps, meteorological conditions were shifting again as the climate grew colder and wetter. Meanwhile, ships sailing during the late eighteenth century – such as the frigates *Dregterlandt*, *Braave* and *Bellone* – all experienced violent weather north of Scotland and Ireland. This weather was marked by gustiness frequently emanating from the North, accompanied by hail and driving rain.

The four ship logbooks dating from between 1750 and 1760 originated from ships travelling in the opposite direction as the *Africa*: back to the Netherlands, rather than away to the

⁶⁵ The area examined for these ship logs lies between roughly 60 °N 15 °W and 60 °N 5 °E, or as far East as the ship logs recorded, given that into the North Sea longitude was generally discarded (see above).

East Indies. Given that none experienced storms or gusty weather it is perhaps unsurprising that all travelled at a relatively sluggish pace, averaging 14.2 German miles in a day. Winds from the South seem to have aided ships travelling back home; the *Sloterdijk* experienced mostly Northerly winds and travelled on 11.2 German miles on the day, while the *Hercules* journeyed 17.5 miles in a day with winds entirely from the South. If storms and violent winds seem to have generally accelerated ship journeys, and indeed if winds from the East seem to have aided ships travelling the *Maarseveen*'s route irrespective of direction, shifts of wind from North to South appear to have influenced ships differently depending on their destinations.⁶⁶

Ultimately, then, both the presence of a storm during the *Africa*'s voyage through the Northern Atlantic and the favourable, North-easterly direction of its winds were meteorological conditions rendered far more likely by the climatic shifts of the Maunder Minimum. The influence of storms on seaborne trade provides an excellent example of the way in which even those natural conditions apparently outside the control of contemporaries – like storms, or climatic fluctuation – were far from direct influences on human affairs. The impact of storms on human populations was (and remains) influenced by a bewildering range of variables that extend far beyond climate – and indeed, beyond wind force and direction.⁶⁷ In the coasts around the North Sea, for example, these included not only other environmental realities like the unusual bending of the Earth's crust in that region but socioeconomic and cultural factors including the

⁶⁶ Adam Ooms, *Agatha* logs, records 11656 - 11676, 3 August – 23 August. Entered by Frank Boekhorst. H. Porwater, *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. Database available from <http://www.knmi.nl/cliwoc>.

⁶⁷ D Camuffo has analysed the many variables that were involved in another seemingly meteorological event: the freezing of the Venetian lagoon during the Little Ice Age. Camuffo described the many environmental conditions involved, including the presence of tides, wind, snow, human constructions and engineering, etc. Freezing was about far more than temperature, just as the impact of storms was about far more than wind force and direction. D. Camuffo, "Freezing of the Venetian lagoon since the 9th century A.D. in comparison to the climate of western Europe and England," 49.

state of sea defences, the extent of peat harvesting which lowered the level of the land relative to the sea, the strength and position of dikes, etc.⁶⁸ Many of the same socioeconomic and cultural variables applied at sea; the full-rigged ship, after all, was the most expensive and advanced technological device of its age. The galleon, the ship design on which the East Indiaman was based, was the largest and most seaworthy ship of the Seventeenth Century. In fact, during the notoriously stormy conditions encountered by the more primitive ships belonging to the Spanish Armada not a single galleon was sunk.⁶⁹

The *Africa*'s encounter with a gale indicates that less severe storms were actually often very advantageous to the pace of a ship's journey, yet this result was dictated in part by the sound, seaworthy design of the cultural construct actually affected: the galleon. The ship was the culmination of a long history of European technological development, crafted according to principals agreed upon by the Heren XVII, designs devised by master shipwrights and techniques applied by shipbuilders, all of which interacted with one another in the unique environment of the Seventeenth-Century Dutch Republic.⁷⁰ It was built to survive a long, treacherous journey many times over; indeed the Dutch East Indiaman survived between 15 and 20 years.⁷¹ All the same, because of their flattened bottoms Dutch ships were prone to roll violently in storms, perhaps not jeopardizing the vessel itself but certainly placing extreme stress on the crew. Crews themselves typically had two options during a severe gale: they could stay at sea and weather it, or make for shelter along the coast. Crews on Dutch ships must have found the latter alternative

⁶⁸ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 34.

⁶⁹ Richard W. Unger, "Introduction." In *Cogs, Caravels and Galleons*, 106.

⁷⁰ This is a very simplistic explanation. Unger introduced some additional factors that went into ship design, writing that "the commodities carried by ships do not determine the design of those ships. Demand does not create technical change. There is no automatic or immediate connection between the needs of shippers and the actions of shipbuilders. Those technicians have other demands to face. The supplies of factors of production, for example, force them to make specific choices about the ways they build their ships and how they shape them. Equally the design of ships does not determine what goods will be traded." Unger, Richard W. "Grain, beer and shipping in the North and Baltic Seas." In *Medieval Ships and the Birth of Technological Societies: Volume I*, 121.

⁷¹ Harm Stevens, *Dutch Enterprise and the VOC*, 24.

particularly attractive, but of course this was less of an option in the oceanic rich trades, where the coast was often inaccessible. In the case of the *Africa* shelter was at least 100 km distant when the storm struck, and it is uncertain whether the ship's captain was presented with an alternative other than riding it out. Still, it is important to note that climatic fluctuations did not directly cause meteorological conditions which then directly resulted in changes to the course and speed of a ship like the *Africa*. This paper deals with varying degrees of influence and probability, not direct causation. The gale of late April, 1677 exerted a vital influence over the speed and course of the *Africa*, but its impact was shaped by the millennia of human interactions that produced the vessel itself, and the training, relationships and ultimately responses of its crew.

In the context of this study the voyage of the *Wesel* is a unique case. Like the other ships the *Wesel* belonged to the VOC, but its logs were compiled in 1699. As such they dated from perhaps the coldest period of the Maunder Minimum, but were over 20 years removed from the voyage of the *Africa*. Unfortunately there is no indication of the principal observer on board the ship; given the craft's size it is likely the Captain kept the log. Built in Amsterdam in 1695 the vessel was a *galjoot* or galliot, a smaller, two-masted ship related to the ubiquitous *fluyt*, its deadweight tonnage listed at a mere 70 tons.⁷² The ship's dimensions are uncertain, but its destinations were clear: the islands Dina and Maarseveen in the Indian Ocean. Unlike both the *Africa* and *Maarseveen*, however, the *Wesel* was launched from the Cape of Good Hope, being a shorter-range vessel.⁷³ Analysis of its ship logs is therefore intended both to provide further evidence of the influence of weather conditions already examined on the course and speed of a

⁷² Harm Stevens, *Dutch Enterprise and the VOC*, 24. See Appendix 9 for a depiction of a typical Dutch galliot.

⁷³ Shorter, perhaps, but by no means "short." In 1696 the *Wesel* was one of three ships commanded by Willem de Vlamingh on a VOC mission to explore the West coast of Australia. "Dutch Explorers and Australia: 1606-1697." In Koninklijke Bibliotheek: Expositions and Collections. Available from <http://www.kb.nl/galerie/australie/inleiding-en.html>.

ship's voyage, and to suggest very tentatively that the Maunder Minimum may well have been a global event.

The voyage of the *Wesel* was marked primarily by extremes. On 31 March, 1699 the ship departed the Cape of Good Hope, at 33.8 °S 17.8 °E.⁷⁴ For the first four days winds were from the North or Northwest, generally favourable as the vessel was heading towards the roaring forties, a stretch of ocean around 40 °S marked by uninterrupted, often intense Westerlies. It was these Westerlies that were harnessed by Commander Brouwer and subsequent VOC Captains on their voyages into Asia. However, as the *Wesel* approached 39 °S the wind grew variable then ceased altogether. The ship travelled only 10 German miles on 4 April; under dark skies the next day the ship was subjected to bouts of intense rain, and moved only 6 German miles. The winds had shifted, blowing calmly from the South or Southeast until 7 April. On the three days from 5 April to 7 April the *Wesel* crossed a mere 16 German miles; however, the dark, oppressive skies foreboded the coming of more intense weather. On 8 April the ship's log recorded thunder and lightning combined with a sudden shift of winds from South to North; the vessel covered 29.5 German miles, or nearly double the total for the previous three days. Dark, unsettled skies would linger for two more days; on 11 April the sky was entirely clear, but on 12 April the clouds returned. On 14 April the log recorded *doodstil* or dead winds, with the ship traversing 12 German miles that day and a mere 8 the next.

The *Wesel's* log continued until May 12, and the conditions recorded during the first two weeks of its voyage were generally those that defined the whole of its short journey. Over 1.5 months the ship encountered no fewer than five storms with thunder and lightning, not including three days of intense rainfall. When it was not storming the winds were often calm and contrary; indeed, winds during the trip were defined by sharp shifts from Northeast to Southwest,

⁷⁴ See Appendix 10 for a map of the *Wesel's* voyage, traced using the location of the ship given in every log.

sometimes occurring on the same day. Meanwhile, skies were generally either dark and brooding or entirely clear. Against such weather the *Wesel's* trip appears to have floundered. Beyond descriptions of meteorological conditions there is no record of the crew's response to the bizarre weather they encountered. The *Wesel's* logs are in fact rather sparse when compared to those of the *Africa* or *Maarseveen* in particular, perhaps because the captain took them and was pressed for time. All that is certain is that the *Wesel* followed a zigzagging, erratic course South of Africa, never even coming close to reaching the Indian Ocean and its ultimate destinations. On 12 May the ship limped back into port at the Cape of Good Hope, its voyage presumably ended in failure.⁷⁵

Naturally this paper does not assume that the meteorological conditions typical of the Maunder Minimum in the North-eastern Atlantic also defined the phenomenon south of Africa. Far more research – particularly more interdisciplinary research - is required to ascertain both whether the Maunder Minimum was a global event like the Grindelwald Fluctuation, and whether it was marked by meteorological extremes in regions like the ocean south of Africa. Still, the ship logs of the *Wesel* are a promising beginning to the study of the Maunder Minimum outside of the Atlantic. At the very least the logbook confirms the different influence of various meteorological conditions on the course and speed of contemporary vessels. Storms were doubtless harrying but often jolted ships forward at high velocity, shortening trips, ending delays or bringing vessels closer to favourable trade winds. A distinction must, of course, be made between relatively common storms and catastrophic gales, which could sink even the hardiest galleon. For the *Wesel* storms often blew from the North or West, providing favourable winds. Contrary winds, however, often delayed voyages, especially when these winds were calm. In the

⁷⁵ *Wesel* logs, records 132682 – 132725, 31 March – 12 May. Entered by Rolf de Weijert. CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

case of all the ships examined these winds generally blew from the Southeast or Southwest. The menace of weak, contrary winds was exceeded only by conditions of complete calm, when winds simply ceased to blow. This was often – though not always - accompanied by rain. The logs examined in this paper reflect a strong correlation between calm winds, often from the South, and precipitation, although the reasons for this link require further research and may be different depending on location.

The *Wesel* was unique both in wandering so far south and, relatedly, in the utterly disastrous nature of its voyage. Hence there is no easy means of comparison between its journey and those of ships during the warmer 1750s. It is, however, possible to analyze the records of ships passing south of Africa, on more regular journeys that rendered them North of most of the *Wesel*'s travels. For example, the *Akerendam*, travelling south of Africa in 1753⁷⁶, recorded just one day marked by storms and a single day of calm winds in 12 days of sailing. Meanwhile, in 9 days the *Bos en Hoven* in 1760 logged just a single day of gustiness. In 13 days the *Spaarzaamheid* in 1754 recorded three days of gustiness, although these were never interrupted by calms and were not accompanied by thunder. By contrast, later that year the *Schagen* recorded no gusts, no storms, and not a single day of dead winds in 11 days south of Africa. On days of storminess or simply gustiness the vessels leapt forward, while calms resulted in delays that could linger over days. On 1 August 1760 the *Bos en Hoven*, for example, had travelled just past the area covered by the *Wesel* when its log recorded “thunder and lightning” with “powerful winds;” that day ship traversed 38 German miles.

Analysis of the four ship logbooks from a warmer climate therefore confirms the meteorological conditions faced by the *Wesel*'s crew were indeed different from those typically

⁷⁶ The logbooks used as a rough control for the *Wesel* were examined for the days when the ships passed between roughly 18 °E 38 °S to 32°E 38 °S. These terminating points mark the Cape of Good Hope to the West – where VOC ships anchored at the halfway point of their journeys - and the Eastern borders of South Africa.

effecting ships in a more temperate climate. On the other hand, the log books of the VOC vessels *Admiraal de Ruyter*, *Scholtenburg* and *Westerveld*, dating from the mid-to-late 1760s, recorded very different weather. In 13 days the *Admiraal de Ruyter* experienced 2 days of storms and 6 days of powerful, gusty winds. In 20 days the *Scholtenburg* weathered fully 6 storms, 2 days of gusty winds, and another 3 days of calm winds. These calms proved so troublesome that, after anchoring at the Cape of Good Hope, the Bengal-bound vessel was forced to drift towards the West before finding favourable winds and returning to an Easterly course. Meanwhile in 13 days the *Westerveld* struggled through 4 days of dead winds, along with a single storm and one day marked by gusts.

The issue of seasonality is again somewhat problematic when comparing the journey of the *Wesel* to this control of seven eighteenth century ship voyages. Of the four ships examined between 1750 and 1760 only the *Bos en Hoven* travelled South of Africa during roughly the same season which witnessed the *Wesel*'s meanderings. Meanwhile, the *Spaarzaamheid*, *Scholtenburg*, and *Westerveld* all sailed past Southern Africa waters during the same season as the *Wesel*. Nonetheless, it does not seem likely that especially severe, erratic weather was only a product of seasonal changes, for in 1767 the *Admiraal de Ruyter* journeyed south of Africa in September and experienced some of the most violent weather recorded in any log, while the *Bos en Hoven*'s trip was almost entirely uneventful.⁷⁷ Ultimately, from the eighteenth century logs examined it seems that as the climate began to shift globally towards a cooler regime the weather south of Africa appears to have grown considerably more violent and often more erratic, with

⁷⁷ 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. 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. Database available from <http://www.knmi.nl/cliwoc>.

mixed effects on the course and speed of ships heading to and from the Indian Ocean.⁷⁸ In the case of the Maunder Minimum the voyage of the *Wesel* suggests – however tentatively – that its influence may well have been global, at least at sea.

An analysis of the logbooks of the *Maarseveen*, *Africa* and *Wesel* reveals that weather exerted a significant influence on the journeys of all three ships. The weather experienced by the crews of the *Maarseveen* and *Africa* – and perhaps the *Wesel* – was rendered more likely and probably influenced by the climatic changes that defined the cooler, wetter Maunder Minimum. Meteorological conditions that both helped and hindered the voyages of ships were a product of the climatic nadirs of the Little Ice Age. In the North-eastern Atlantic both the *Maarseveen* and particularly the *Africa* appear to have been accelerated by weather conditions typical of the Maunder Minimum. An examination of eighteenth century ship logs, however, indicates that while Easterly winds almost always had a favourable effect on ships travelling to the Netherlands through the North-eastern Atlantic, the influence of the Northerly winds probably rendered more frequent by contemporary climatic shifts varied depending on the destination and location of a vessel. Although more quantitative and interdisciplinary research is required to better support these conclusions it is probable that the climatic fluctuation of the Maunder Minimum fielded a similar influence, with Easterlies speeding nearly all ships travelling through the North-eastern Atlantic and Northerlies accelerating only outbound travel. The increased frequency and power of storms exacerbated this influence, generally quickening ship journeys but, during the Maunder Minimum and late eighteenth century, typically blowing from the North or Northeast.

Meanwhile, the voyage of the *Wesel* – if indeed influenced by weather conditions rendered more

⁷⁸ Once again, additional quantitative research examining more ship logs from different navies later in the eighteenth century, while somewhat problematic given changes in ship design and differences in recording meteorological conditions, would nevertheless shed light on the global relationship between climatic fluctuations and violent weather at sea. This would be a vast project but could contribute immeasurably to scholarly understanding of historical climate at sea, the global reach of the Little Ice Age, and the social influence of climatic shifts.

likely during the Maunder Minimum – was almost certainly hindered by them. Overall, however, this paper suggests that during a period in which the Dutch Republic was increasingly embroiled in catastrophic warfare and, ultimately, hampered by economic stagnation in other areas the Dutch oceanic trades at least benefitted from unique weather patterns that quickened the journey of VOC ships in the North-eastern Atlantic, perhaps facilitating trade and communication with Asian ports.

That suggestion pertains to the much broader relationship between the performance of the Dutch economy and contemporary climatic fluctuations, which this paper only begins to examine. The ships examined in this study constituted only a small portion of the Dutch trading fleet,⁷⁹ and only further quantitative analysis of the voyages of VOC ships during times of warmth and cooling can reveal the overall influence of climatic fluctuation on shipping. Voyages from the East Indies also require significant additional research; due to the limitations of the CLIWOC database these could not be examined for the seventeenth century. As previously described, however, ship destinations possessed a critical influence over the advantageous or troublesome nature of the winds influenced by climatic fluctuations. Overall, by increasing or reducing the price of trade by quickening or delaying the journeys of ships, for example, the Maunder Minimum might have influenced the profits of the VOC, and the overall performance of the Dutch economy. Overall records of the VOC's performance in the seventeenth and eighteenth centuries offer some hints, although such general statistics can do little else. The Company's overall expenditures in Asia rose gradually during both centuries, reaching their peak between 1780 and 1790. However, this was not a steady increase; fluctuations existed, and in some places these coincided with decades of climatic deterioration.⁸⁰ Data on so large a scale

⁷⁹ In 1680 there were roughly 125 vessels belonging to the VOC alone, and in 1700 that number had increased to 150. Femme S. Gaastra, *The Dutch East India Company*, 118.

⁸⁰Femme S. Gaastra, *The Dutch East India Company*, 120. See Appendix 11 for a table illustrating these fluctuations.

cannot, of course, lead to conclusions, and wars, foreign competition, the market and other factors undoubtedly played a major role in these fluctuations. Meanwhile, data on overall VOC expenses and sales depicts steady increases into the eighteenth century. There is also ongoing debate over the importance of the VOC to the general Dutch economy, although the VOC's value definitely increased into the eighteenth century, as the economy grew more dependent on the rich trades and other sectors slumped.⁸¹ Still, overall financial results suggest possibilities that can be pursued with increased quantitative analysis of ship journeys and the inspection of VOC financial archives.⁸² Ultimately, it may also prove that the most significant impact of a fluctuating climate's influence on weather rested in the vital role of VOC ships as bearers of messages. The VOC's greatest strength over the Asian market lay in its continental reach; its agents could, for example, compare "the price of silver in Japan, Persia and Amsterdam with that in the market in Surat, China and Indonesia." This advantage was maintained through communications transmitted by an efficient fleet of ships, vessels which were likely influenced by shifting patterns of weather affected by climatic changes.⁸³

The broader relationship between the climatic shifts of the Maunder Minimum and the performance of the Dutch economy can, of course, hardly be established by this study. However, this paper's analysis of the influence of climate on the journeys of three VOC ships and others used as a control at least represents a promising beginning to understanding the relationship between climatic fluctuation and Dutch seaborne trade. Once a link between climatic fluctuation and the performance of the oceanic rich trades can be more firmly established, other forms shipping also require analysis. It seems likely, for instance, that shorter-distance bulk trading was

⁸¹ Femme S. Gaastra, *The Dutch East India Company*, 173.

⁸² Recently published primary sources include: *De archieven van de Verenigde Oostindische Compagnie (1602-1795)*, published in 1992, and *De archieven van de Verenigde Oostindische Compagnie (VOC) en de locale instellingen te Batavia (Jakarta)*, published in 2007.

⁸³ Femme S. Gaastra, *The Dutch East India Company*, 109.

profoundly influenced by the same climatically-influenced meteorological conditions which affected the Dutch East Indiamen. Surviving letters from Yarmouth record, for example, that on 12 September 1695 (OS) 70 coal ships out of a fleet of 200 were beached and shattered in a severe gale blowing from the North. Meanwhile, military shipping was probably also influenced; in the same storm, for example, Dutch warships sailing from the Downs off Kent were forced to return to port.⁸⁴ The affect of changing patterns of weather on fishing and whaling also requires additional research, and the influence of unusual meteorological conditions on colonization ships remains poorly understood.

Finally, this paper has not employed models developed by historical climatologists to conceptualize climatic influence on socioeconomic processes precisely because existing models barely deal with the influence of climate on the actual ships and crews who sustained Europe's trading economies. Crafted from less complex models developed by Hubert Lamb (1982), R.W. Kates (1985) and Pfister himself (1984), Christian Pfister's model of climatic influence is perhaps the most nuanced available in historical climatology, revealing how the direct material impacts of climatic fluctuation and indirect social influences were all related to each another and could, in turn, affect one another. However, in the model "climate variability" impacts "water availability," felt, for example, through transportation or energy production. It is difficult to discern how a shifting climate's influence on the means of transportation themselves (and those who controlled them) can be understood through such a model. In some sense the "adaptive and adjustive mechanisms" Pfister identified as belonging to "impacted societies" suffering from the effects of climatically-influenced changes to the state of health, food production or fuel demand were actually contained within and on board the ships themselves. The core relationships

⁸⁴ Hubert Lamb, *Historic Storms of the North Sea, British Isles, and Northwest Europe*, 55. As mentioned earlier the influence of stormy weather on the Spanish *Armanda* has been examined in limited detail, but far more research is required.

examined in this study - those of climate and weather, weather and the voyages of ships – appear either to require another category in the model or perhaps demand a hybridization of two or more categories.⁸⁵

It would be easier to explain the larger, hypothetical relationship between Dutch seaborne trade and a shifting climate using Marina Fischer-Kowalski and Helga Weisz's Interactive Model. In the model stimuli from a human, cultural sphere and a purely natural theatre affect one another by material and energy flows through the shared space of human bodies and society's biophysical structures.⁸⁶ If climatic changes influenced new patterns of weather, for example, through the model effect of those meteorological conditions would then impact humans and society's biophysical structures – ships and crews, in other words. The Maunder Minimum's ultimate impact on the voyages of ships and their crews would then be transmitted to the human, cultural sphere of profits and economic changes. This would feed back into the system; if the Maunder Minimum in some sense ultimately facilitated trade perhaps more ships journeyed into Asia, feeding into the development of a proto-capitalist economy that would ultimately serve as model and predecessor for Britain and its industrial revolution, with future climatic results. Those ideas – or flights of fancy – are valuable as thought experiments, illustrating the power and limitations of the most sophisticated models available in environmental history when applied to a new field of research in historical climatology. Ultimately, current models probably have limited value in explaining or conceptualizing the relationship between climatic fluctuations, shifting patterns of weather, and the voyages of contemporary vessels and crews. What is needed is additional quantitative, interdisciplinary research, and, ideally, some deeper understanding of

⁸⁵ Christian Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 40. See Appendix 11 for Pfister's model.

⁸⁶ Marina Fischer-Kowalski and Helga Weisz, "Society as Hybrid Between Material and Symbolic Realms. Toward a Theoretical Framework of Society-Nature Interactions," *Advances in Human Ecology* 8 (1999), 240. Verena Winiwarter's subsequent work has helped move this model from abstract idea to practically applicable model.

how Seventeenth Century merchants, shipwrights, crews and “meteorological philosophers” understood the climatic changes of their age.⁸⁷

⁸⁷ Dennis Wheeler, “Understanding Seventeenth-Century Ships’ Logbooks,” 1. Note the difference between climatic changes and meteorological conditions, which were certainly analysed in ship logs, for example.

Appendix 1: cargo manifest for the first shipment of the VOC return fleet of 1679-1680.⁸⁸

A^o. 1680.

G E N E R A L E
C A R G A,

Oftc Ladinge van ses
Ooft-Indifche Retour-Schepen,

Met namen :

't Landt van Schouwen en Tidoor, voor de Kamer van Zeelandt; Europa en S^t. Andries, voor de Kamer van Amsterdam; Schielandt, voor de Kameren van Delft ende Rotterdam; ende Afus, voor de Kameren van Hoorn en Enchuyfen; den laetsten November 1679. van Batavia vertrocken, en den 11 en 12 July deses Jaers 1680. die van de Kameren van Amsterdam, Hoorn en Enchuyfen, in Texel gearriveert, d'andere alsnoch voor 't Landt zynde. Van de Schepen komende van Ceylon, alsnoch de Generale Carga verwacht werdende.

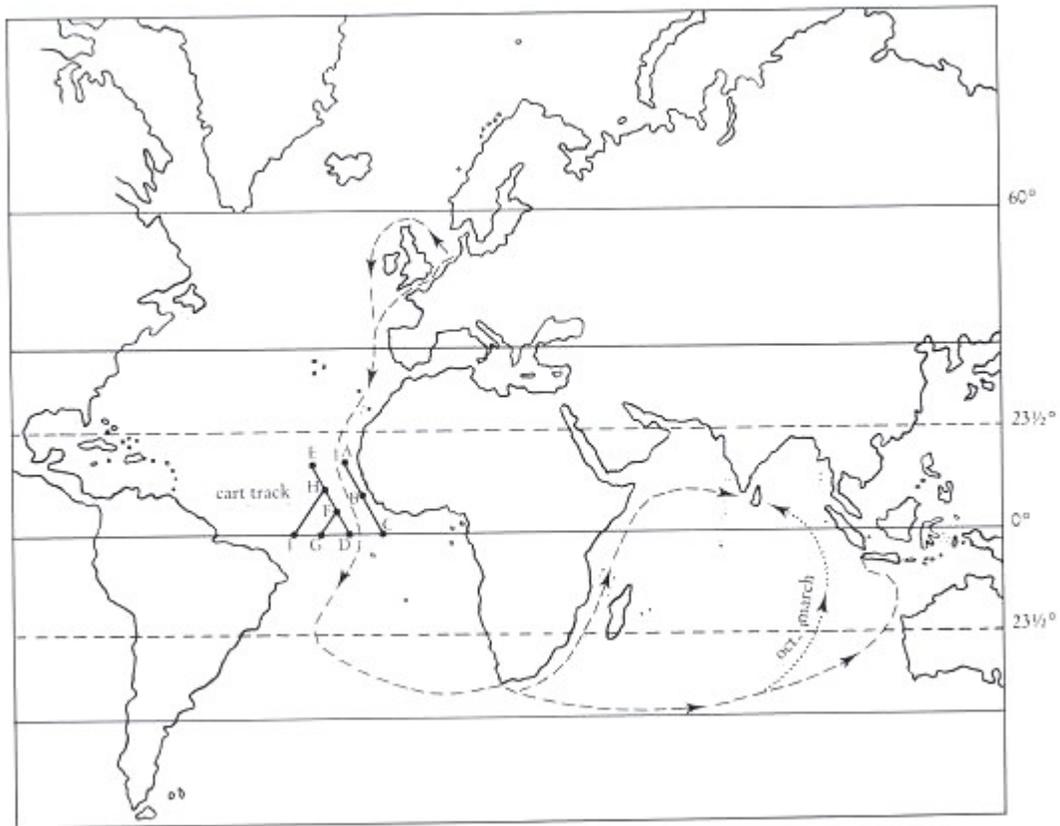
1754400	☞ Salpeter.	Notandum: dat in de bovengemelte Schepen naderhandt noch aen het Princen Eylandt zyn geladen de volgende Koopmanschappen, verstaende boven en behalven het gemene hier vooren staet uytgedruckt.	
1944167	☞ catty bruyn Peper.	17816	☞ diverse Indigo.
377825	☞ divers Sapanhout.	7800	ps. Roemaels d'Ésta.
101948	☞ Foulie of Macia.	2900	ps. Alegias Bethilles.
389997	☞ Nooten Muscaten.	200	ps. groote geruyte Bethilles.
14396	☞ catty Japans Staef-kooper.	200	ps. Callepboe Bethilles.
40041	☞ Spialuter.	200	ps. Sester Ganty Bethilles.
37455	☞ diverse Indigo.	1800	ps. rouwe Bethilles.
1000	☞ Tutia.	570	ps. fyn gebleeck Guinees Lywaet.
4937	☞ Galiga.	940	ps. gemeen gebleeck Guinees Lywaet.
8500	☞ Benjuya.	1440	ps. rouw Guinees Lywaet.
5500	☞ Cardamom.	320	ps. rouw Zeyldoock.
4002	☞ Segellacq.	400	ps. fyne geschilderde Chitfen.
102900	☞ rouwe Perisense Syde.	800	ps. gebleeckte Bethilles Ternatanez.
88612	☞ rouwe Bengaelse Syde.	500	ps. rouw dito.
8401	☞ catty witte Chinese Syde.	11982	☞ Florette Garen.
16230	ps. divers Guinees Lywaet.	4552	☞ Bengaelse Syde Bunny.
720	ps. rouwe Salampouris.	3996	ps. Armofynen.
7100	ps. diverse Bethilles.	1000	ps. Sanen.
7500	ps. Chia vonys d'Oirnael.	3491	ps. Caffa Bengale.
18080	ps. divers Zeyldoock.	2386	ps. Mallemolen.
28480	ps. diverse Chitfen.	2100	ps. Roemaels Bengaels.
600	ps. Salpicado Gingans gebloemt.	4000	ps. Patrenaese Chitfen.
960	ps. Allegias Patchery.	1900	ps. Garras.
300	ps. Allegias Bethilles.	1000	ps. nieuwe modeste Stoffen.
320	ps. Negros Kleden.	1200	ps. Gerberys.
382	ps. Hammans.	400	ps. Afies Begy.
100	ps. Romaels.	3200	ps. effene Gingans.
3200	ps. Kannekyns.	1000	ps. Sologesjies.
1000	ps. diverse Bastas.	202	ps. Tanticpa.
7145	ps. Tonquinse en Chinese Pelings.	1507	ps. Dourialfen.
25442	☞ catty witte Peper.	535	ps. Hammans.
1871	☞ Oly van Nooten Muscaten.	21120	☞ Boracx.
6360	☞ Mannetges Nooten Muscaten.	183760	☞ Canneel.
23000	ps. Geconfyte Nooten Muscaten.		
1240	☞ Sandelhour.		
5440	ps. diverse Geartoeneerde Deeckens.		
64000	☞ Canneel.		
10075	☞ stuxx rouwe Robynen.		
	☞ eenige stuxx Peerien.		
500	☞ Hennep tot een preuve.		

Nota: 1 Catty is 1½ lb.

i Amsterdam / by Laurent Mathijs / Drucker van V.C. Heeren Vereenigheren der Oost-Indische Compagnie / in de Steefsteeg / in 't Nieuwe-lood gedruckt.

⁸⁸ Femme S. Gaastra, *The Dutch East India Company*, 131.

Appendix 2: standardized VOC ship routes according to the “Sailing Orders.”⁸⁹



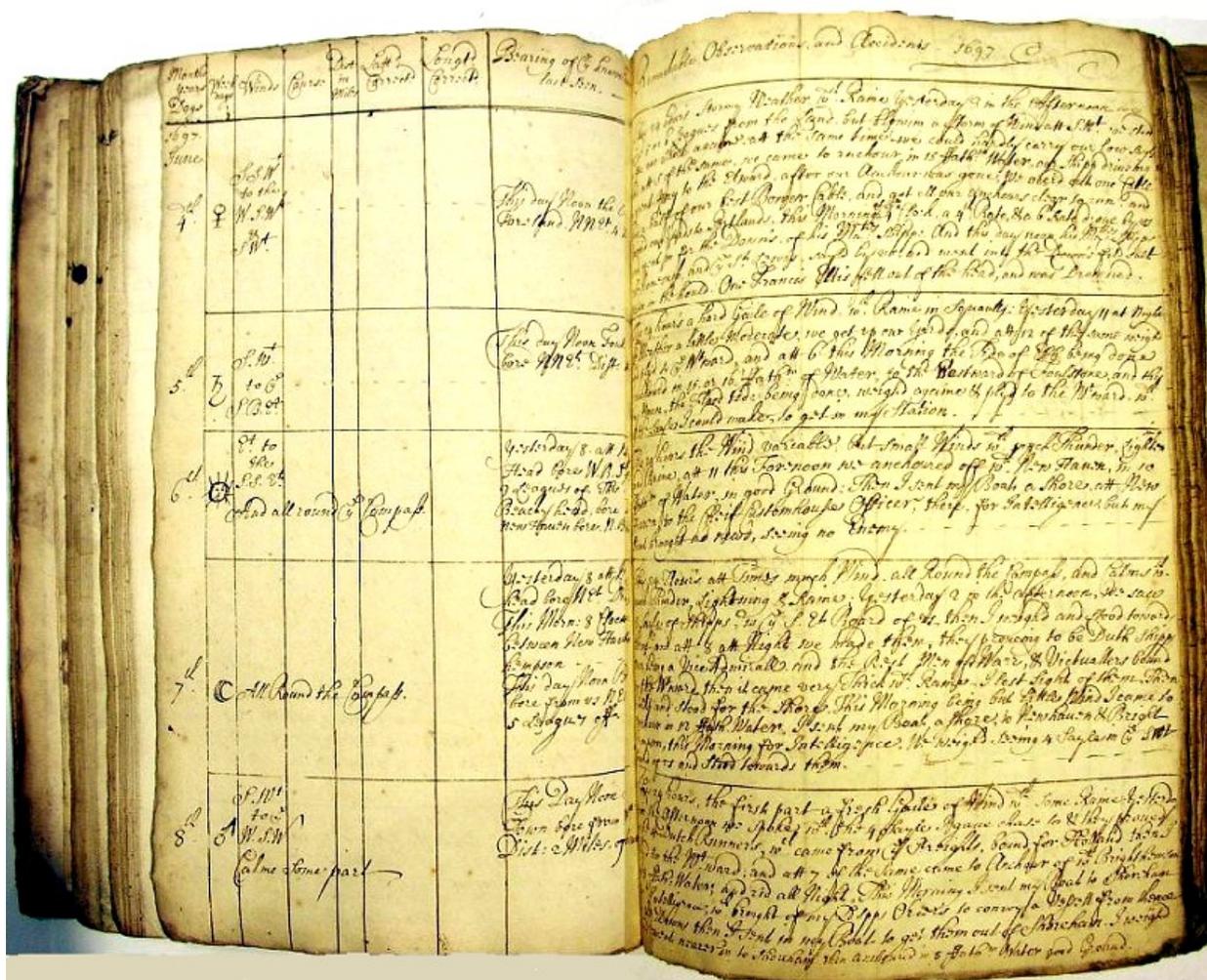
⁸⁹ Femme S. Gastra, *The Dutch East India Company*, 110.

Appendix 3: model of the *Prins Willem*, a large Dutch East Indiaman similar to the *Maarseveen* and *Africa*.⁹⁰



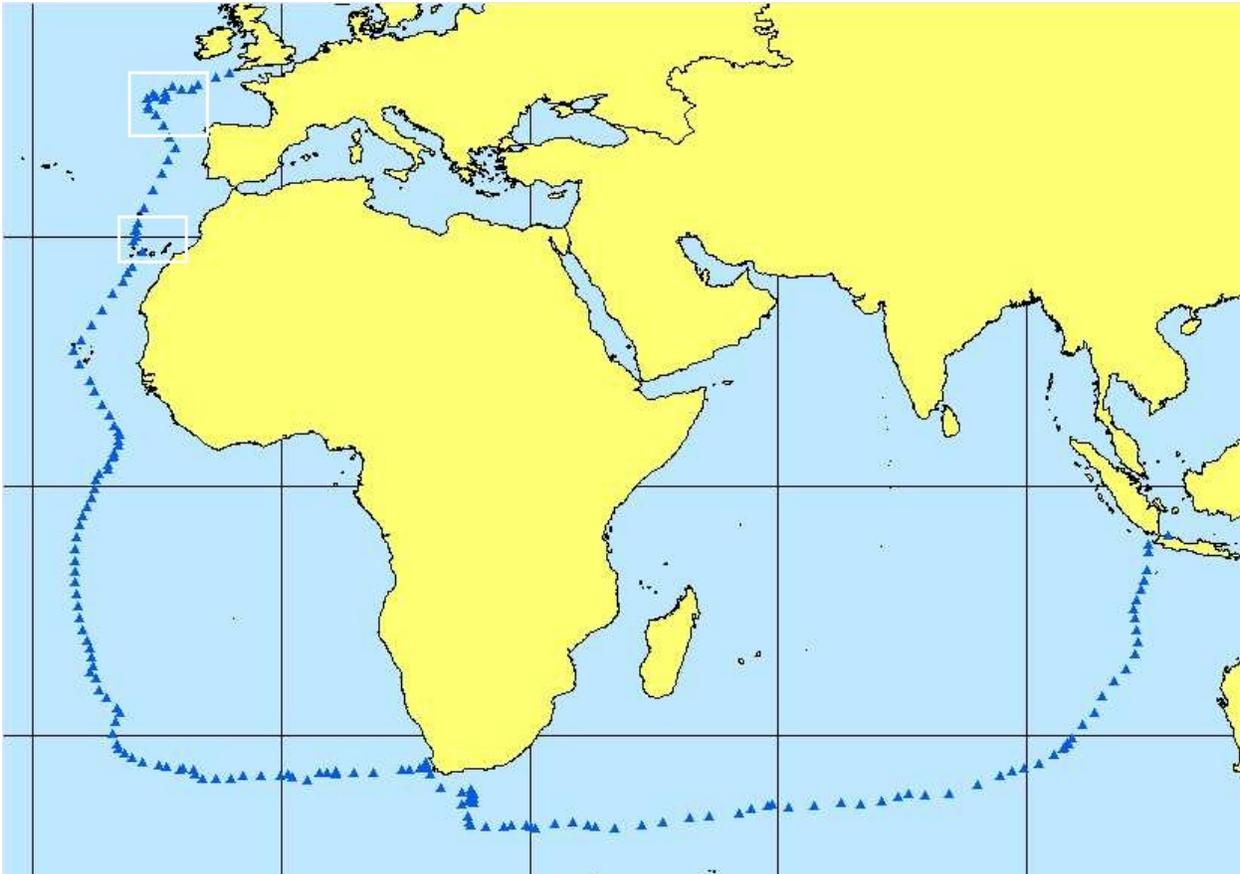
⁹⁰ “Masterpiece Ship Collection.” Available from: <http://www.masterpieceshipcollection.nl/model/prinswillem.uk.php>. See also: Harm Stevens, *Dutch Enterprise and the VOC*, 21. Note the flat bottom and squeezing of two cannons towards the rear of the vessel; already by the mid-17th Century these were typical features on large Dutch ships.

Appendix 4: typical Seventeenth-Century British ship logbook.⁹¹



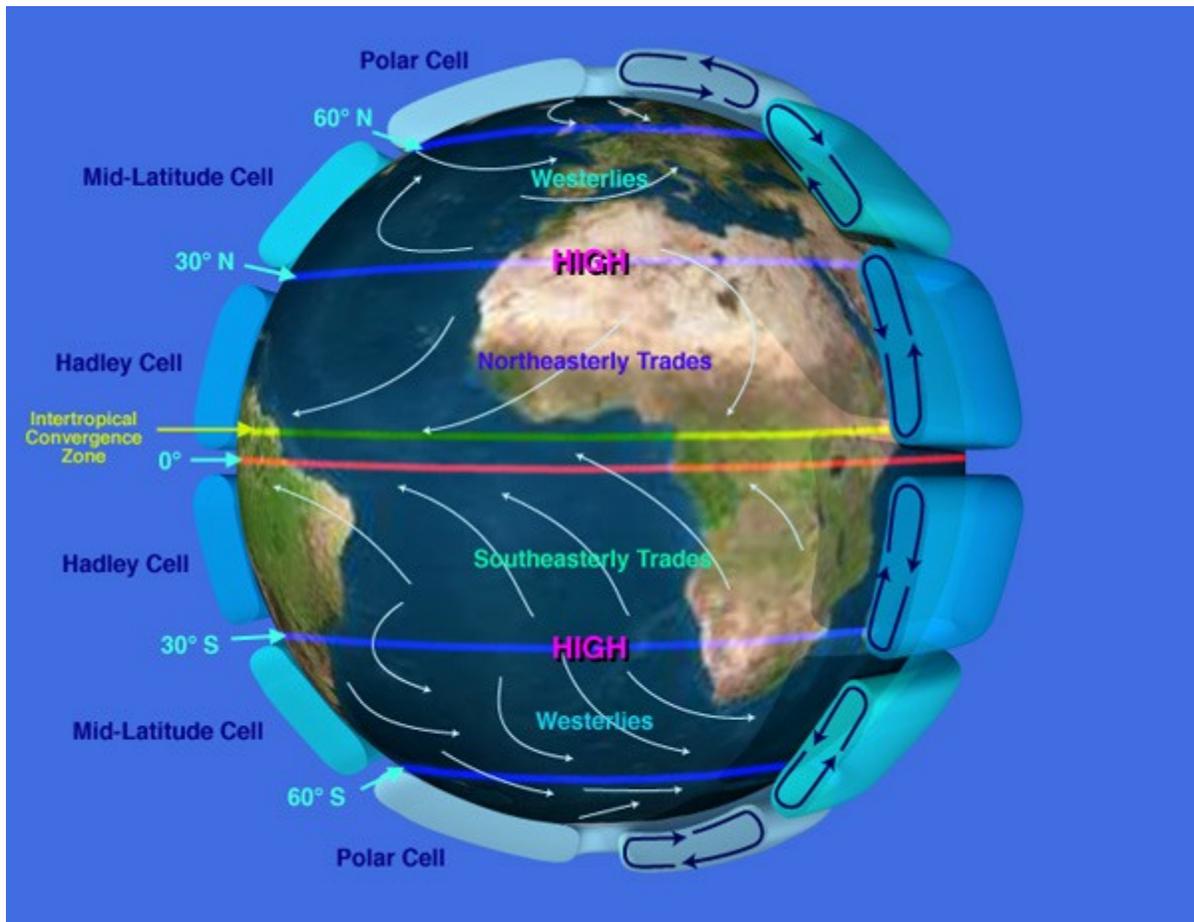
⁹¹ Dennis Wheeler, "British Naval Logbooks from the Late Seventeenth Century," 134. Wheeler explained that this image of a British ship logbook reveals "the degree of detail contained within those venerable documents. On the left-hand page were recorded the date, latitude, longitude, bearings, wind directions and ship's course. The right hand side contained a daily account that includes notes on wind force and weather. Other information recorded here were the formal proceedings and accounts of the management of the vessel." Ibid.

Appendix 6: voyage of the *Maarseveen*; delays examined are highlighted.⁹³



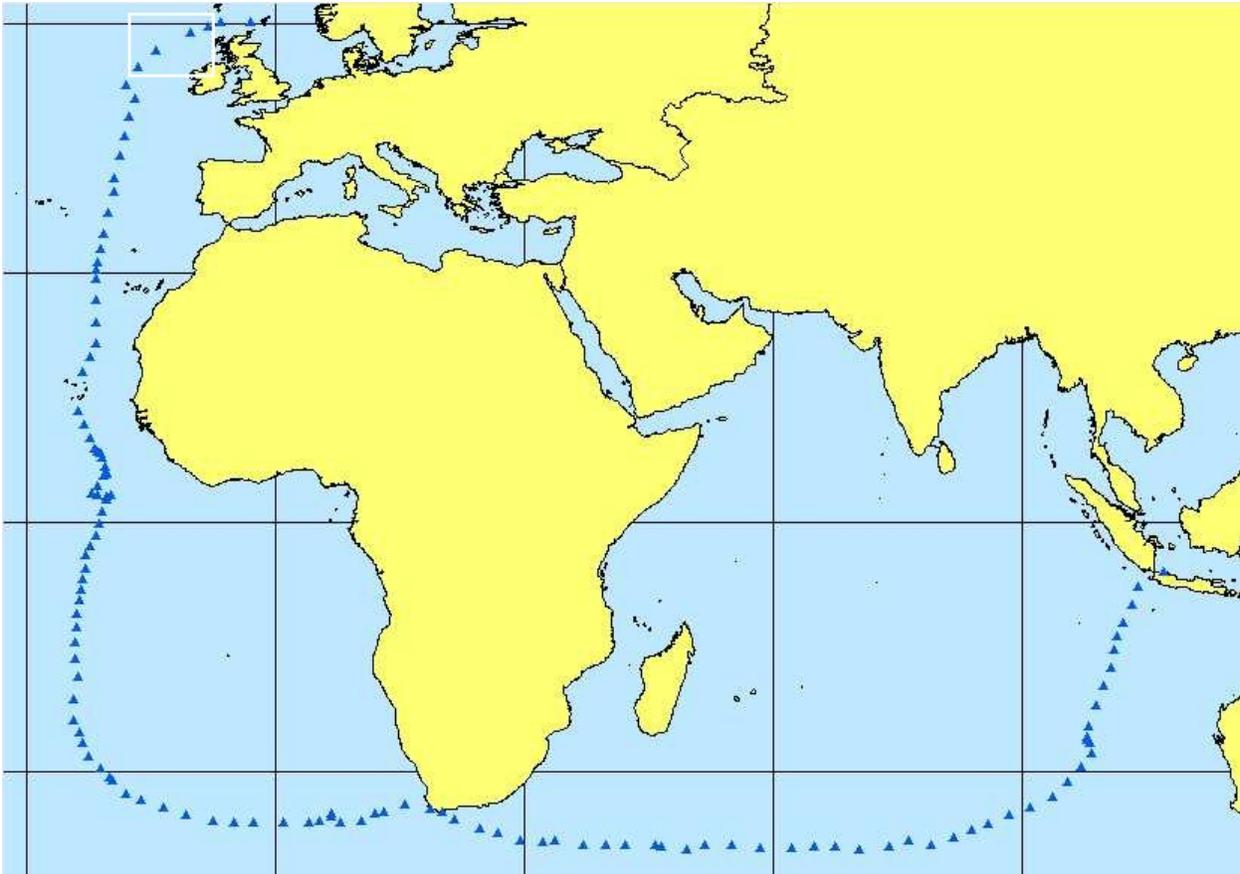
⁹³ "Cliwoc Data Position Plots: Maarseveen (CLIWOC Meta Data)." Available from: http://www.knmi.nl/cliwoc/cliwocmeta_maarseveen.htm. Every blue triangle designates a location of the ship as recorded in a log entry.

Appendix 7: the current pattern of prevailing trade winds.⁹⁴



⁹⁴ Note the prevalence of Westerlies and the abundance of southerly winds over the North-eastern Atlantic. During the Maunder Minimum winds from the North and East were more common.

Appendix 8: voyage of the *Africa*; storm examined is highlighted.⁹⁵

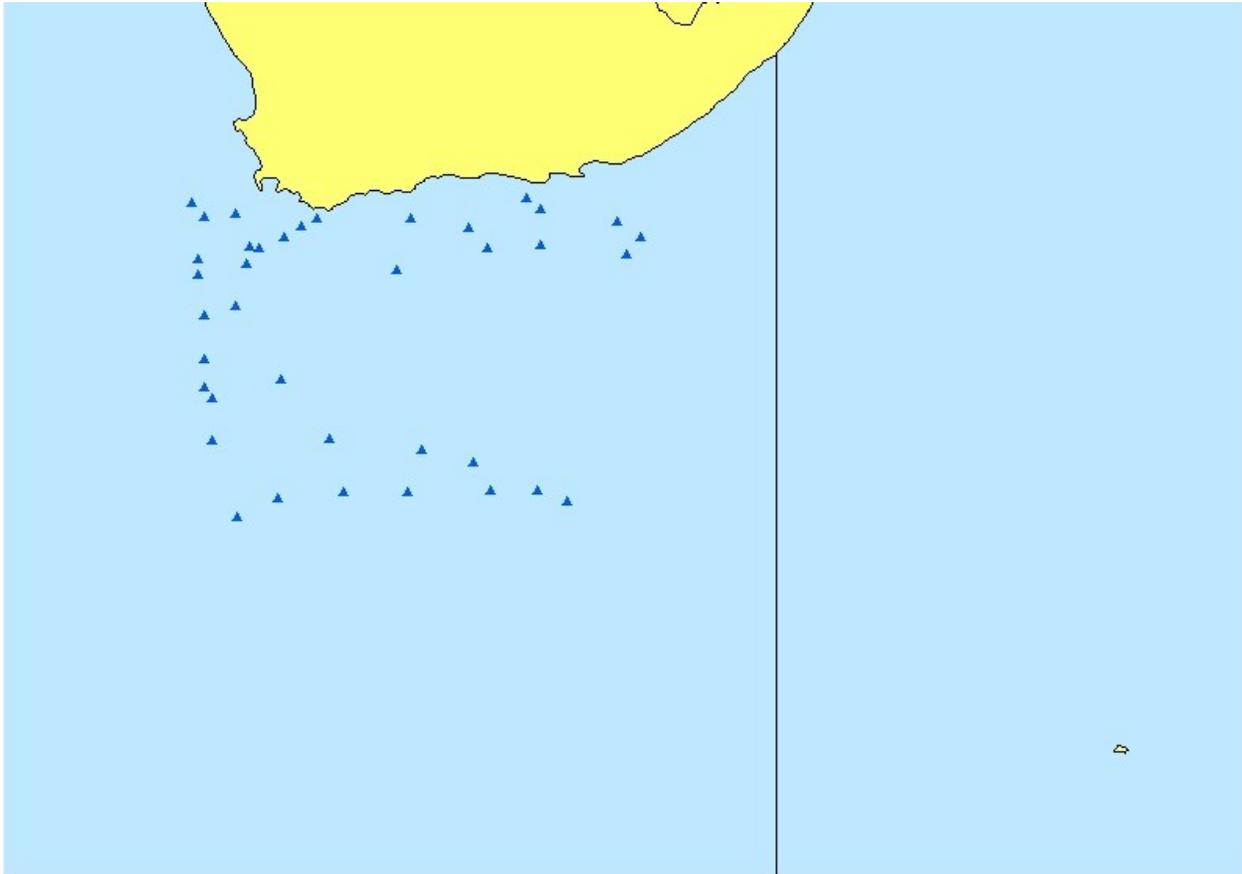


⁹⁵ “Cliwoc Data Position Plots: Africa (CLIWOC Meta Data).” Available from: http://www.knmi.nl/cliwoc/cliwocmeta_africa.htm. An interesting avenue for future study concerns the much quicker journey of the *Africa* as compared to that of the *Maarseveen*. With the possible exception of the *Africa*’s delay through the cart track the ship’s overall voyage was faster in almost every geographical location when compared to that of the *Maarseveen*. Could climatic fluctuations have played a role?

Appendix 9: model of a typical Dutch galliot, similar to the *Wesel*.⁹⁶



⁹⁶ “Schepenlijst.” Available from http://www.dereedevantexel.nl/nederlands/frameset_historie/schepen.htm.

Appendix 10: voyage of the *Wesel*.⁹⁷

⁹⁷ "Cliwoc Data Position Plots: Wesel (CLIWOC Meta Data)." Available from: http://www.knmi.nl/cliwoc/cliwocmeta_wesel.htm.

Appendix 11: financial results of the VOC in Asia, 1620-1790.⁹⁸

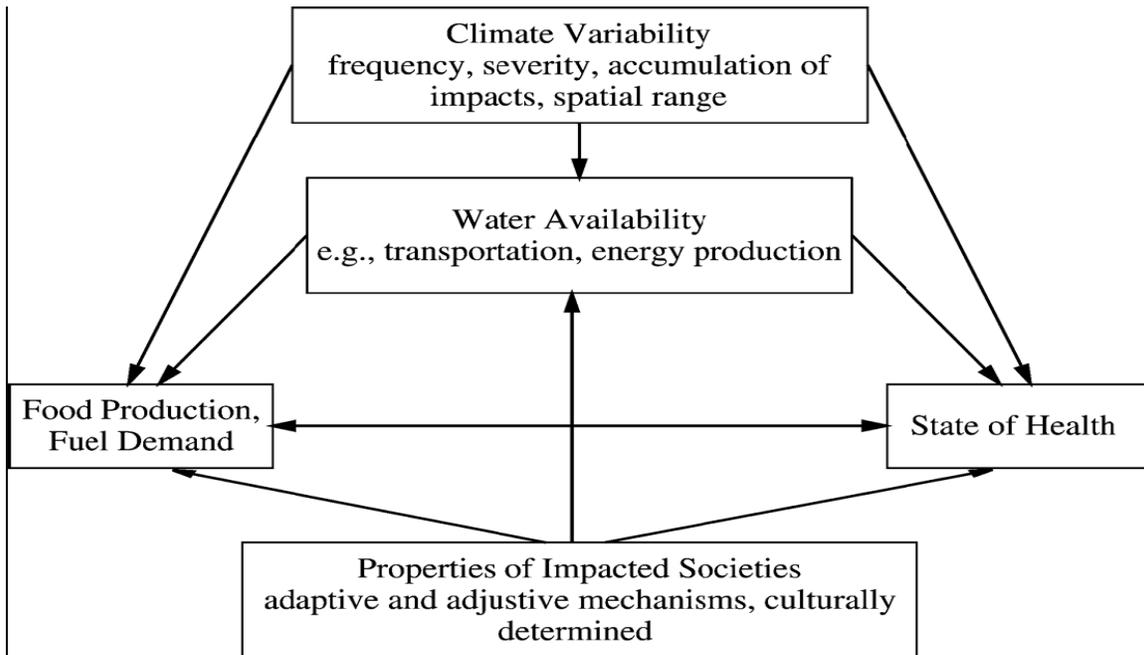
Table 18 The financial results of the VOC in Asia, 1620-1790 (in guilders, rounded off to the nearest hundred thousand)

	expenses	income	profit	loss
1621-1630	17 400 000	18 300 000	900 000	
1631-1640	16 400 000	28 400 000	12 000 000	
1641-1650	27 000 000	37 400 000	10 400 000	
1651-1660	38 400 000	40 700 000	2 300 000	
1661-1670	41 500 000	57 900 000	16 300 000	
1671-1680	44 900 000	47 300 000	2 400 000	
1681-1688	35 700 000	38 700 000	3 000 000	
1689-1700	69 000 000	58 700 000		10 300 000
1701-1710	55 800 000	44 300 000		11 500 000
1711-1720	63 400 000	54 200 000		9 200 000
1721-1730	58 200 000	44 900 000		13 300 000
1731-1740	74 900 000	54 200 000		20 700 000
1741-1750	81 800 000	70 000 000		11 000 000
1751-1760	82 700 000	74 600 000		8 100 000
1761-1768	67 000 000	49 200 000		17 800 000
1769-1780	88 500 000	58 400 000		30 100 000
1780-1790	100 400 000	50 000 000		50 400 000

Source: Gaastra, *Bewind en beleid*, 283-281 (for the period to 1700); De Korte, *De jaarlijkse financiële verantwoording*, 31, 47 and appendix 10.

⁹⁸ Femme S. Gaastra, *The Dutch East India Company*, 120.

Appendix 12: Christian Pfister's model for the social impact of climatic fluctuation, as published in 2007.⁹⁹



⁹⁹ Christian Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts," 40.

Bibliography:

Primary Sources:

Balk, G.L., F. van Dijk, D.J. Kortland; with contributions by F.S. Gaastra, Hendrik E. Niemeijer, P. Koenders. *De archieven van de Verenigde Oostindische Compagnie (VOC) en de locale instellingen te Batavia (Jakarta)*. Leiden: Brill, 2007.

Data Position Plots for: *Maarseveen, Africa, Wesel* (CLIWOC Meta Data). Available from: <http://www.knmi.nl/cliwoc>.

De archieven van de Verenigde Oostindische Compagnie (1602-1795). Edited by R. Raben and H. Spijkerman. Gravenhage: Sdu Uitgeverij Koninginnegracht, 1992.

Letters and diaries available in Lamb, Hubert. *Historic Storms of the North Sea, British Isles, and Northwest Europe*. Cambridge: Cambridge University Press, 1991.

Logbooks of the *Maarseveen, Africa, Wesel, Dregterland, Braave, Bellone, Greene, Havick, Hoop, Piet Heijn, Revolutie, Scipio, Tromp, Vrouwe Maria, Frankendaal, Friedrich, Onverwagt, Propatria, Africaensche Galeij, Admiraal de Ruyter, Akerendam, Bos en Hoven, Landskroon, Oud Haarlem, Schagen, Scholtenburg, Spaarzaamheid, Vlietlust, Westerveld, Agatha, La Flore, Hercules, Jerusalem, Noordbeveland* and *Sloterdijk*. Accessible through the CLIWOC Database. Database available from <http://www.knmi.nl/cliwoc>.

Ollivier, Blaise. *18th Century Shipbuilding: Remarks on the Navies of the English & the Dutch from Observations made at their Dockyards in 1737, by Blaise Ollivier, Master Shipwright of the King of France*. Translated and edited by David H. Roberts. East Sussex: Jean Boudriot Publications, 1992.

Secondary Sources:

Behringer, Wolfgang. "Climatic Change and Witch-Hunting: The Impact of the Little Ice Age on Mentalities," *Climatic Change* 43:1 (1999), 335-351.

Braudel, Fernand. *The Perspective of the World*. London: Collins, 1979.

Brazdil, Rudolf, Christian Pfister, et al. "Historical Climatology in Europe - the State of the Art" in *Climatic Change* 70 (2005), 363-430.

Brown, Neville. *History and Climate Change: A Eurocentric perspective*. London: Routledge, 2001.

Buckland, P.C. *et al.* "Bioarchaeological and climatological evidence for the fate of the Norse farmers in medieval Greenland," *Antiquity*, 70 (1996), 88-96.

- Camuffo, D. "Freezing of the Venetian lagoon since the 9th century A.D. in comparison to the climate of western Europe and England," *Climatic Change*, 10 (1987), 43-66.
- Crosby, Alfred W. *Ecological Imperialism: the Biological Expansion of Europe, 900-1900*. Cambridge: Cambridge U.P., 1986
- 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.
- "Dutch Explorers and Australia: 1606-1697." In *Koninklijke Bibliotheek: Expositions and Collections*. Available from <http://www.kb.nl/galerie/australie/inleiding-en.html>.
- Fischer-Kowalski, Marina and Helga Weisz, "Society as Hybrid Between Material and Symbolic Realms. Toward a Theoretical Framework of Society-Nature Interactions," *Advances in Human Ecology* 8 (1999), 215-251.
- Gaastra, Femme S. *The Dutch East India Company: expansion and decline*. Zutphen: Uitgeversmaatschappij Walburg Pers, 2003.
- Glaser, Rüdiger. *Klimageschichte Mitteleuropas. 1000 Jahre Wetter, Klima, Katastrophen*. Darmstadt: Wissenschaftliche Buchgesellschaft, 2001.
- Glaser, Rüdiger. "The temperatures of Southwest Germany since 1500 – The examples of Lower Franconia and Northern Wurttemberg." In *European climate reconstructed from documentary data: methods and results*, edited by Buckhard Frenzel. Stuttgart: Gustav Fischer Verlag, 1992.
- Grove, Jean M. *Little Ice Ages Ancient and Modern*, Vol. 1. London/New York: Routledge, 1988.
- Grove, Jean M. "The Century Time-Scale." In *Time-Scales and Environmental Change*, edited by T. S. Driver and G. P. Chapman. New York: Routledge, 1996.
- 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. Oxford: Archaeopress, 2000.
- Israel, Jonathan Irvine. *Dutch primacy in world trade, 1585-1740*. New York: Oxford University Press, 1989.
- Ketting, Herman. *Leven, werk en rebellie aan boord van Oost-Indiëvaarders (1595-±1650)*. Amsterdam: Het Spinhuis, 2005.
- Knaap, Gerrit and Ger Teitler, "Inleiding." In *De Verenigde Oost-Indische Compagnie: Tussen Oorlog en Diplomatie*, edited by Gerrit Knaap and Ger Teitler. Leiden: KITLV Uitgeverij, 2002.

Lamb, Hubert. *Climate, History and the Modern World*. London: Methuen, 1982.

Lamb, Hubert. *Historic Storms of the North Sea, British Isles, and Northwest Europe*. Cambridge: Cambridge University Press, 1991.

“Masterpiece Ship Collection.” Available from: <http://www.masterpieceshipcollection.nl/model/prinswillem.uk.php>.

Pearce, Fred. *Climate and Man: From the Ice Ages to the Global Greenhouse*. London: Vision Books, 1989.

Pfister, Christian and Rudolf Brázdil, "Climatic Variability in Sixteenth-Century Europe and its Social Dimension: A Synthesis," *Climatic Change* 43:1 (1999), 5-53.

Richards, John F. *The Unending Frontier*. Berkeley: University of California Press, 2003.

“Schepenlijst.” Available from http://www.dereedevantexel.nl/nederlands/frameset_historie/schepen.htm.

Stevens, Harm. *Dutch Enterprise and the VOC: 1602-1799*. Zutphen: Walburg Pers, 1998.

Unger, Richard W. *Dutch Shipbuilding Before 1800*. Assen/Amsterdam: Van Gorcum, 1978.

Unger, Richard W. “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 Christiane Villain-Gandossi, Salvino Busuttil and Paul Adam. Malta: European Coordination Centre for Research and Documentation in Social Sciences, 1989.

Unger, Richard W. “Introduction,” In *Cogs, Caravels and Galleons: The Sailing Ship 1000-1650*, edited by Robert Gardiner and Richard W Unger. London: Conway Maritime Press, 1994.

Unger, Richard W. *Ships and Shipping in the North Sea and Atlantic, 1400-1800*. Aldershot: Ashgate Publishing Limited, 1997.

Unger, Richard W. *The Ship in the Medieval Economy, 600-1600*. London: Croom Helm Limited, 1980.

Van de Pas, Wil. *Tussen centraal en lokaal gezag: Bestuurlijke organisatie en financieel beheer in Gelre en Holland tijdens de Habsburgse periode*. Hilversum: Verloren, 2004.

Villain-Gandossi, Christiane. “Introduction: Medieval Ships and the Birth of Technological Societies.” In *Medieval Ships and the Birth of Technological Societies: Volume 1: Northern Europe*, edited by Christiane Villain-Gandossi, Salvino Busuttil and Paul Adam.

Malta: European Coordination Centre for Research and Documentation in Social Sciences, 1989.

Wheeler, Dennis. "British Naval Logbooks from the Late Seventeenth Century: New climatic information from old sources." *History of Meteorology* 2 (2005), 133-146.

Wheeler, Dennis. "Understanding Seventeenth-Century Ships' Logbooks: An Exercise in Historical Climatology." *Journal for Maritime Research* (2004), 1-16.