Testing the Limits of Climate History: The Quest for a Northeast Passage during the Little Ice Age, 1594–1597

Dagomar Degroot

Journal of Interdisciplinary History, Volume 45, Number 4, Spring 2015, pp. 459-484 (Article)

Published by The MIT Press

Journal of Interdisciplinary History, XLV:4 (Spring, 2015), 459–484.

Dagomar Degroot

Testing the Limits of Climate History: The Quest for a Northeast Passage during the Little Ice Age, 1594–1597

Average global temperatures have risen by approximately 0.85° C since 1880, and the authors of the most recent United Nations Intergovernmental Panel on Climate Change Summary for Policymakers projects a further 1.5–4° C warming in the coming century. Reconstructions of past climates can reveal the extent to which modern warming is anomalous, as well as its connection to anthropogenic activity. They can also provide the tools that historians require to study relationships between human history and climate change, which can shed new light on the challenges of a warmer future. It is therefore critical that interdisciplinary scholars regularly interrogate the ways in which scientists and historians reconstruct past climate change. However, it is equally important that such interrogation be fully informed about the sources, methodologies, and conclusions developed by historical climatologists, the interdisciplinary scholars of past climates.[1]

A recent issue of the *Journal of Interdisciplinary History* was dedicated to a timely analysis of the evidence for the existence of a global "Little Ice Age" (LIA) between the thirteenth and nineteenth centuries. Many historical climatologists believe that the coldest decades of the LIA cooled the Northern Hemisphere by more than 1° C. For some historians, the LIA can therefore provide historical antecedents for expected interactions between society and a changing climate, but an increasingly embattled bulwark of scholars remain skeptical. In "The Waning of the Little Ice Age," Kelly and Ó Gráda call into question not only the links that

Dagomar Degroot is a Social Sciences and Humanities Research Council postdoctoral fellow, Western University, London, Ontario. He is the creator of HistoricalClimatology.com and the author of "'Never Such Weather Known in These Seas': Climatic Fluctuations and the Anglo-Dutch Wars of the Seventeenth Century, 1652–1674," *Environment and History*, XX (2014), 239–273.

 doi:10.1162/JINH_a_00755

1 Lisa Alexander et al., *Climate Change 2013: The Physical Science Basis*, IPCC WGI AR5, available at http://www.climatechange2013.org/report/.

historians have made between early modern climate change and human history but also the very existence of the LIA. Some of the methodological concerns presented by Kelly and Ó Gráda are useful for historians whose narratives of climate change are too often simplistically declensionist. Yet, the responses to their article by White and by Büntgen/Hellmann eloquently explain why dismissing the LIA is possible only by ignoring the diverse proxy sources and model simulations that inform multidisciplinary climatic reconstructions. The present article is one of many that support the existence of an LIA in regions far removed from the northwestern European focus of Kelly and Ó Gráda.[2]

Ultimately, the debate raises an important but rarely asked question: Given the assumption of an LIA, at what point do attempts to connect its climatic variations to human history break down? For decades, environmental historians have associated the climatic fluctuations of the LIA with changing agricultural yields, economic trends, cultural developments, and social crises in early modern Europe. To shed new light on the complexity of determining these relationships, this article employs climatic reconstructions to investigate the Dutch quest for a Northeast Passage between 1594 and 1597. Three well-documented expeditions set sail during the "Grindelwald Fluctuation," the first major cold phase, or minimum, of the LIA, which Pfister named after the contemporary expansion of the alpine Grindelwald glacier. In Europe, generally cool temperatures endured from approximately 1565 until 1630; this trend was mirrored in the Arctic, where average temperatures fell 0.5° C below the eventual twentieth-century average.[3]

The Dutch expeditions were influenced by the complex environmental changes that accompanied the Grindelwald Fluctuation in the far north. All of them succumbed either to sea ice or to the threat of sea ice before they had pressed far beyond the Barents

2 Morgan Kelly and Cormac Ó Gráda. "The Waning of the Little Ice Age: Climate Change in Early Modern Europe," *Journal of Interdisciplinary History*, XLIV (2014), 301; Sam White, "The Real Little Ice Age," *ibid.*, 328; Ulf Büntgen and Lena Hellmann, "The Little Ice Age in Scientific Perspective: Cold Spells and Caveats," *ibid.*, 353. M. E. Mann et. al., "Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly," *Science*, CCCXXVI (2009), 1257.

3 Emmanuel le Roy Ladurie, *Times of Feast, Times of Famine*: *A History of Climate since the Year 1000* (Garden City, 1971), 10; Christian Pfister, "Climatic Extremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth and Early Seventeenth Centuries," *Medieval History Journal*, X (2007), 39.

Sea. Nevertheless, detailed climatic reconstructions can now refresh traditional narratives of the voyages, which abound with descriptions of heroic failure in the Arctic cold. In fact, the journeys were shaped not by unrelenting cold but by a complex suite of occasionally counterbalancing, sometimes mutually reinforcing, interactions between the regional atmosphere, hydrosphere, cryosphere, and biosphere. The influence of these environmental relationships was mediated by cultural and economic structures that were, in turn, complicated by the personal agency of the explorers and their financiers. The first expedition, in 1594, penetrated deeply into the Arctic, partly because of unusual summer warmth. This success was particularly encouraging for Dutch merchants who were just beginning to compete with their Iberian counterparts for access to Asian markets. In 1595 and 1596, the Dutch financed two more expeditions, which were hampered by sea ice and frigid temperatures more typical of the coldest decades of the LIA. These conditions blocked access to a Northeast Passage but encouraged the exploration of new islands and transformed European conceptions of the Arctic.[4]

The Dutch voyages were conducted across four years, a shorter span than the decadal time frames usually required to link climate change and social developments. However, gradual climate change across broad geographical expanses always influences human history through weather events that are immediate and local. This article's analysis of the three voyages of exploration, undertaken during an unusually cool climate, tests the limits of what we can identify as genuine interactions between past climate change, weather, and historical events. It reveals that environmental historians of past climates should establish four distinct relationships in this regard: (1) short-term weather events and long-term climate change; (2) atmospheric fluctuations and relevant changes in the geosphere, hydrosphere, cryosphere, or biosphere; (3) a substantial quantity of local or regional environmental phenomena and activities conducted

4 Mann, "Global Signatures and Dynamical Origins of the Little Ice Age," 1257; Jan Esper et al., "Orbital Forcing of Tree-Ring Data," *Nature Climate Change*, 2 (2012), available at http://www.nature.com/nclimate/journal/v2/n12/full/nclimate1589.html; William J. D'Andrea et al., "Mild Little Ice Age and Unprecedented Recent Warmth in an 1800 Year Lake Sediment Record from Svalbard," *Geology*, X (2012), 3; Astrid Ogilvie and Graham Farmer, "Documenting the Medieval Climate," in Mike Hulme and Elaine Barrow (eds.), *Climates of the British Isles* (London, 1997), 113.

by human beings; and (4) climate change and human history, which is established on the basis of the first three.[5]

Supercomputer reconstructions of connections between modern climate change and short-term environmental fluctuations are only now becoming possible. Lacking the vast, real-time data networks that measure the global climate today, historians of past climates must incorporate probability into their methodology. Some discussion of probability invariably accompanies historical analysis, particularly in narratives that posit connections between structures and events. However, few historical narratives hinge on probability in the manner that climate histories do. For example, some weather patterns are rendered more or less likely under different climatic regimes, but most expressions of weather can occur under any climate. Indeed, weather that is atypical under a particular climatic regime can influence human history as much as weather that conforms to the climatic norm. Hence, climate historians must acknowledge that their reconstructions of relationships between weather and human affairs rest on firmer ground than narratives that link weather to climate change, or climate change to human history. We should also note that the environmental consequences of climate change were hardly the only, or even necessarily the most important, influences that shaped political, economic, social, and cultural histories.[6]

UNDERSTANDING THE ARCTIC IN A TIME OF SOCIAL AND ENVIRONMENTAL TRANSFORMATION The borders of the world known to Europeans were expanding during the fifteenth century. In voyages made possible by refinements in nautical technology, demographic expansion, economic imperatives, and missionary zeal—not to mention sheer chance—European explorers who began searching for new markets entered the Caribbean in 1492 and landed in India six years later. In

5 Lenny Bernstein et al., *Climate Change 2007: Synthesis Report, an Assessment of the Intergovernmental Panel on Climate Change* (Valencia, Spain, 2007), 30; Charles Tilly, *Big Structures, Large Processes, Huge Comparisons* (New York, 1984), 12; Fernand Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II* (Berkeley, 1995), I, 102.

6 Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (New Haven, 2013); White, *The Climate of Rebellion in the Early Modern Ottoman Empire* (New York, 2011); Wolfgang Behringer, *A Cultural History of Climate* (Cambridge, 2010); Neville Brown, *History and Climate Change: A Eurocentric Perspective* (London, 2001); Hubert Lamb, *Climate, History and the Modern World* (London, 1982), 260.

their wake, Portuguese and Spanish conquistadors established new settlements, entering into complex relationships with indigenous peoples that usually facilitated the expansion of vast new empires. By the late sixteenth century, a gradual shift in economic primacy from Europe's south to its north heralded a new, more capitalist phase of exploration and exploitation. After the uncertain first decades of their rebellion against Habsburg Spain, the coastal provinces of the Dutch Republic jumped to the vanguard of this economic transition.[7]

After 1588, wealthy merchants from the southern Low Countries gradually migrated to the coastal cities of a new Dutch Republic. Some of these merchants, their access to the Iberian market increasingly uncertain, wished to control the lucrative commerce in spices, textiles, and other Asian goods directly from its source. They funded the aggressive Dutch naval and commercial expansion into Asia, which ultimately contributed to the meteoric rise of Dutch industry, finance, and political influence. However, the long-term prospects for trade along southerly routes already charted by the Portuguese during the 1590s were far from certain, and the forceful expulsion of the Iberians was sure to be costly. Contemporary cartographers estimated that a voyage to Asia through the Russian Arctic would shorten most journeys by two-thirds.[8]

Western Europe's knowledge about the Arctic began to improve during the late sixteenth century. Many cartographers represented the Arctic by drawing a towering magnetic rock, surrounded by four polar continents that were home to bizarre civilizations, monsters, and treasure (Figure 1). But English and Dutch expeditions led by Hugh Willoughby in the 1550s, by Olivier Brunel in the 1570s, and by Arthur Pet and Charles Jackman in the 1580s charted the seas around Novaya Zemlya (Figure 2)—an island that seemed to lie in the path of a Northeast Passage; earlier voyages had suggested that it was not an insurmountable obstacle.

7 Geoffrey V. Scammell, *The First Imperial Age: European Overseas Expansion c. 1400–1715* (New York, 1989), 97; Jan Lucassen and Leo Lucassen, "The Mobility Transition Revisited, 1500–1900: What the Case of Europe Can Offer to Global History," *Journal of Global History*, 4 (2009), 82; Jan Luiten van Zanden, "The Skill Premium and the 'Great Divergence,'" *European Review of Economic History*, XIII (2009), 143.

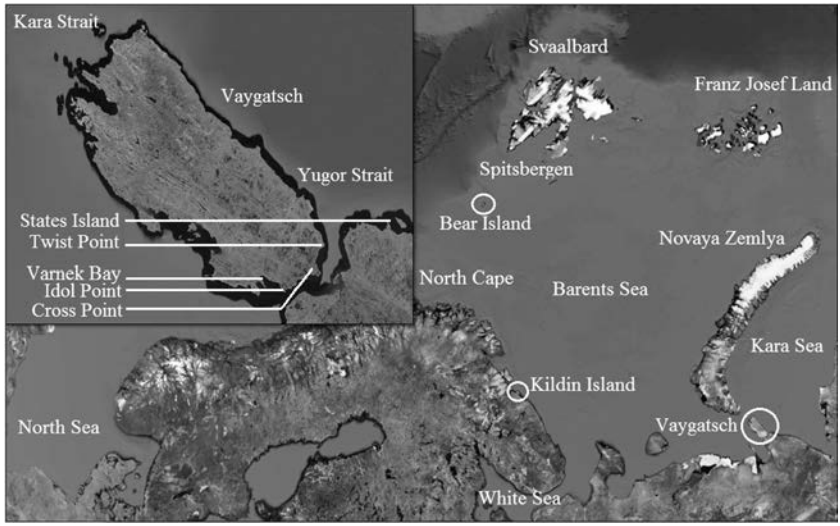
8 Femme S. Gaastra, *The Dutch East India Company: Expansion and Decline* (Zutphen, 2003), 12; Jonathan Israel, *The Dutch Republic: Its Rise, Greatness, and Fall, 1477–1806* (Oxford, 1998), 324.

Fig. 1 The European Perception of the Arctic on the Eve of the Barents Voyages (Novaya Zemlya Highlighted)

SOURCE Gerard Mercator, *Septentrionalium Terrarum descriptio 1595* (Amsterdam, 1595).

In the early 1590s, the merchant Jan Huyghen van Linschoten and the publisher/cartographer Lucas Waghenaer formed a group in Enkhuizen—a town in northern Holland—with the hope of discovering a Northeast Passage to Asia near Novaya Zemlya. Another circle committed to the passage emerged in Amsterdam was headed by publisher Cornelis Claes, cartographer/clergyman Petrus Plancius, and cartographer/navigator Willem Barents, supported by Balthasar de Moucheron, who helped to finance the first polar expeditions of the 1590s and provided the latest cartographical information (Figure 1). Moucheron and the explorers hoped to produce a new, more accurate map that would

Fig. 2 Satellite View of the Arctic North of Europe, with Inset of the Island Vaygatsch and Translated Place Names Given by the Dutch Explorers



SOURCE The European Arctic (November 17, 2013), Google Earth 6.

secure their exclusive rights to potentially lucrative northern trade routes.[9]

Moucheron and the Enkhuizen circle disagreed with Plancius and his associates about the best route. Whereas Moucheron strongly supported further exploration of the passage around Vaygatsch, the

9 Parker, *The Dutch Revolt* (New York, 1985), 57; *idem*, *The Army of Flanders and the Spanish Road, 1567–1659* (New York, 1971), 195; Maarten Praak, *The Dutch Republic in the Seventeenth Century* (New York, 2005), 8; Israel, *Dutch Republic,* 311; J. L. Price, *Dutch Society: 1588–1713* (New York, 2000), 66; Prak, *Gouden Eeuw: Het raadsel van de Republiek* (Nijmegen, 2002), 109; JaapJan Zeeberg, *Terugkeer naar Nova Zembla: de laatste en tragische reis van Willem Barents* (Zutphen, 2007), 36, 26; Rayner Unwin, *A Winter Away from Home: Willem Barents and the North-east Passage* (London, 1995), 4; Peter van der Krogt, "Introduction," in Joan Blaeu, *Atlas Major of 1665* (Taschen, 2012), 35; Gerben Graddesz Hellinga, *Pioniers van de Gouden Eeuw* (Zutphen, 2007), 31; Marijke Spies, *Arctic Routes to Fabled Lands: Olivier Brunel and the Passage to China and Cathay in the Sixteenth Century* (Amsterdam, 1997), 41; V. Ye. Borodachev and V. Yu. Alexandrov, "History of the Northern Sea Route," in Ola M. Johannessen (ed.), *Remote Sensing of Sea Ice in the Northern Sea Route: Studies and Applications* (New York, 2007), 1; Zeeberg, *Into the Ice Sea: Barents' Winter on Novaya Zemlya—a Renaissance Voyage of Discovery* (Amsterdam, 2005), 57. See also Marijke Spies, *Bij noorden om: Olivier Brunel en de doorvaart naar China en Cathay in de zestiende eeuw* (Amsterdam, 1994); V. D. Roeper and G. J. D. Wildeman, *Ontdekkingsreizen van Nederlanders (1590–1650)* (Utrecht, 1993). Pier Horensma, "Olivier Brunel and the Dutch Involvement in the Discovery of the Northeast Passage," *FRAM: The Journal of Polar Studies*, II (1985), 121–128.

Amsterdam group believed that the straits around Vaygatsch were too shallow to afford passage into the seas beyond (see Figure 2). Like many of his contemporaries, Plancius thought that because deep water in rough, open seas could not freeze, they would actually encounter less ice north of Novaya Zemlya, despite the high latitude. Informed by this conviction, earlier explorers and cartographers extrapolated the existence of Arctic continents from the distribution of sea ice.[10]

In fact, ocean currents and, more significantly, variations in regional wind and temperature rather than the depth of water were the key influences on the nature of Arctic ice cover. Interdisciplinary researchers can now trace how these factors were influenced by the Grindelwald Fluctuation in the Arctic north of Greenland. Historical climatologists have employed ice cores, seabed sediments, and other scientifically analyzed "proxy" sources that respond to climatic fluctuations, alongside model simulations and documentary observations, to yield records of average seasonal temperatures across the Arctic during the LIA. These reconstructions reveal that the annual extent of Arctic sea ice directly and consistently responded to changes in regional average temperature. Indeed, proxy data demonstrate that sea ice and glaciation in and around Novaya Zemlya expanded aggressively during the Grindelwald Fluctuation. Logbooks kept by explorers and whalers in the far north also record a sharp annual increase in the extent of sea ice across the nearby Barents Sea. Model simulations suggest that Arctic temperatures in autumn, winter, and spring likely responded dramatically to the climatic oscillations of the LIA; these months were crucial to the expansion of local ice. Projections of significant Arctic cooling during these three seasons, and comparatively modest cooling during the

10 Zeeberg, *Terugkeer naar Nova Zembla,* 41. Hellinga, *Pioniers van de Gouden Eeuw*, 31; Spies, *Bij noorden om*; Roeper and Wildeman, *Ontdekkingsreizen van Nederlanders*; Horensma, "Olivier Brunel and the Dutch Involvement in the Discovery of the Northeast Passage"; J. Braat, "Dutch Activities in the North and the Arctic during the Sixteenth and Seventeenth Centuries," *Arctic*, XXXVII (1984), 473–480; Zeeberg, *Into the Ice Sea*, 57; William J. Mills, *Exploring Polar Frontiers: A Historical Encyclopedia* (Santa Barbara, 2003), II, 521; Captain Jansen, "Notes on the Ice between Greenland and Nova Zembla; Being the Results of Investigations into the Records of Early Dutch Voyages in the Spitzbergen Seas," In *Proceedings of the Royal Geographical Society of London*, IX (1864–1865), 4, 175; National Snow & Ice Data Center, "Dynamics," available at http://nsidc.org/cryosphere/seaice/processes/dynamics.html#wind (accessed January 4, 2013); Nataliya Marchenko, *Russian Arctic Seas: Navigational Conditions and Accidents* (New York, 2012), 5.

summer, mirror reconstructions of average temperature decline in central and northwestern Europe.[11]

In the vicinity of Novaya Zemlya, average temperatures did not shift in an environmental vacuum during the first great minimum of the LIA. In the Arctic, as in Europe, fluctuations in seasonal temperature influenced, and were influenced by, shifts in Arctic wind velocity and oceanic circulation. Moreover, regional atmospheric and oceanic temperatures were likely affected by a 10 percent reduction in the volume of water transported by the Gulf Stream and its relatively warm North Atlantic tributary, which, in turn, also increased sea ice in the Barents Sea and along the western coast of Novaya Zemlya. Meanwhile, increased glaciation was probably tied to enhanced cyclonic activity in the Novaya Zemlya area. Both increased ice cover and, probably, more intense storms ultimately accompanied the reduced average

11 Rudolf Brazdil, Pfister, et al., "Historical Climatology in Europe—the State of the Art," *Climatic Change*, LXX (2005), 364; J. Gergis, D. Garden, and C. Fenby, "The Influence of Climate on the First European Settlement of Australia: A Comparison of Weather Journals, Documentary Data and Palaeoclimate Records, 1788–1793," *Environmental History*, XV (2010), 504; Lamb, *Climate, History and the Modern World,* 148; Elizabeth Crespin et al., "Arctic Climate over the Past Millennium: Annual and Seasonal Responses to External Forcings," *The Holocene*, XXIII (2013), 327; *idem* et al., "The 15th Century Arctic Warming in Coupled Model Simulations with Data Assimilation," *Climate of the Past*, V (2009), 394; K. R. Briffa, T. J. Osborn, and F. H. Schweingruber, "Large-Scale Temperature Inferences from Tree Rings: A Review," *Global and Planetary Change,* XL (2004),18; Marie-Alexandrine Sicre et al., "Decadal Variability of Sea Surface Temperatures off North Iceland over the Last 2000 Years," *Earth and Planetary Science Letters*, CCLXVIII (2008), 140; Gemma Rueda et al., "Coupling of Air and Sea Surface Temperatures in the Eastern Fram Strait during the Last 2000 Years," *The Holocene*, XXIII (2013), 695; Peter Lemke, Markus Harder, and Michael Hilmer, "The Response of Arctic Sea Ice to Global Change," *Climatic Change*, XLVI (2000), 278; Gifford Miller et al., "Abrupt Onset of the Little Ice Age Triggered by Volcanism and Sustained by Sea-Ice/Ocean Feedback," *Geophysical Research Letters*, XXXIX (2012), 4; Flavio Lehner et al., "Amplified Inception of European Little Ice Age by Sea Ice-Ocean-Atmosphere Feedbacks," *Journal of Climate* (forthcoming), 52; Leonid Polyak, Ivar Murdmaa, and Elena Ivanova, "A High-Resolution, 800-Year Glaciomarine Record from Russkaya Gavan', a Novaya Zemlya Fjord, Eastern Barents Sea," *The Holocene*, XIV (2004), 643; Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago* (Berkeley, 2002), 104; Torgny Vinje, "Barents Sea-Ice Edge Variation over the Past 400 Years," *Proceedings of the Workshop on Sea-Ice Charts of the Arctic* (Geneva, 1998), 5; Iver Murdmaa et al., "Paleoenvironments in Russkaya Gavan' Fjord (NW Novaya Zemlya, Barents Sea) during the Last Millennium," *Palaeogeography, Palaeoclimatology, Palaeoecology*, CCIX (2004), 153; Raymond S. Bradley and Philip D. Jones, "'Little Ice Age' Summer Temperature Variations: Their Nature and Relevance To Recent Global Trends," *The Holocene*, III (1993), 359; Rüdiger Glaser, *Klimageschichte Mitteleuropas: 1000 Jahre Wetter, Klima, Katastrophen* (Darmstadt, 2002), 59; J. Buisman and A. F. V. van Engelen (eds.), *Duizend jaar weer, wind en water in de Lage Landen. IV. 1575–1675* (Franeker, 2000), 707; Crespin et al., "Arctic Climate over the Past Millennium," 327; *idem* et al., "15th Century Arctic Warming," 394.

temperatures and altered oceanic currents that reflected LIA minima around Novaya Zemlya.[12]

THE FIRST EXPEDITION (1594): FRUSTRATION AND PROMISE In 1594, when the members of the Enkhuizen and Amsterdam groups departed from the Dutch island of Texel on June 5, these shifts in the Arctic climate were unknown. Although mariners had sought a Northeast Passage near Novaya Zemlya in decades past, the Dutch expedition of 1594 was uniquely prepared and plentifully provisioned, heralding a new phase in the European exploration of the Arctic. Carrying van Linschoten, whose journal provides the most detailed account of its voyage, the fleet sailed under the command of Admiral Cornelis Nay aboard the *Zwaan* and Vice-Admiral Cornelis Rijp aboard the *Mercurius*. Moucheron, who financed the voyage, issued orders to avoid the waters north of Novaya Zemlya in favor of the open sea and eventually a passage to Asia through the Yugor strait between the island Vaygatsch and mainland Russia (Figure 2). However, Barents, who represented the very different interests of Amsterdam aboard the *Het Boot*, convinced Nay on June 29 to divide the fleet, ordering his crew to set sail for the north coast of Novaya Zemlya.[13]

Scientists have discovered that the current through the Yugor Strait changed course from east to west when the Gulf Stream weakened during the minima of the LIA. This relationship between atmosphere and hydrosphere influenced the cryosphere, likely causing sea ice to hamper entry into the Yugor Strait during the expedition of 1594. Nevertheless, van Linschoten reported no sea ice from July 19 until July 24, when the *Zwaan* and *Mercurius* became the first Dutch vessels to approach Yugor Strait since Brunel's voyage more than two decades earlier. As the explorers entered the

12 J. Overpeck et al., "Arctic Environmental Change of the Last Four Centuries," *Science*, CCLXXVIII (2009), 1251; Hilary Birks, "Holocene Vegetational History and Climatic Change in West Spitsbergen—Plant Macrofossils from Skardtjørna, an Arctic Lake," *The Holocene*, I (1991), 216; Zeeberg, *Terugkeer naar Nova Zembla*, 75; David C. Lund, Jean Lynch-Stieglitz, and William B. Curry, "Gulf Stream Density Structure and Transport during the Past Millennium," *Nature*, CDXLIV (2006), 601; Crespin et al., "Arctic Climate over the Past Millennium," 327; Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago,* 66, 105.

13 Van Linschoten, "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten, van bijnoorden om lans Noorwegen, de Noordkaap, Lapland, Finland, Rusland, &c. Anno 1594 en 1595" (Franeker, 1601), in *Reizen van Jan Huyghen van Linschoten naar het noorden (1594–1595)* (S-Gravenhade, 1914), 38; Hellinga, *Pioniers van de Gouden Eeuw*, 32.

strait on July 25, however, they encountered icebergs drifting with the wind and current through the strait from east to west. To the leaders of the expedition, the parallel course of the current and the wind suggested a passage to the sea and thus to Asia. However, the direction of the current suggested that passage through the strait would be unusually icy, and so unusually difficult.[14]

The explorers correctly interpreted the shipwrecks and trees strewn across Vaygatsch as evidence that severe storms had recently raked the island. Additional storms soon imperilled the expedition. As the wind rose on July 26, the Dutch vessels narrowly escaped the strait and its icebergs, with only minor damage. Many among the crews now feared that the icebergs had been dislodged by recent storms and easterly winds from a shallow or, worse, an inland sea beyond the Yugor Strait. In fact, the Kara Sea (Figure 2) is neither shallow nor inland; nor is it affected by warmer currents even in years of maximum Atlantic inflow. Impenetrable ice grinding west from the Kara Sea was therefore to be expected during the Grindelwald Fluctuation. However, most of the icebergs melted in the first week of August.[15]

The weather cleared as the relieved explorers sailed east on August 9. Although sea ice was again visible on all sides, it was not especially solid. Before long, the explorers passed into the Kara Sea, encountering high waves and a vast open sea. Van Linschoten, convinced that this water could not freeze, believed beyond doubt that a passage to China must be ice-free and accessible. On August 11, the explorers were approximately 300 km east of Vaygatsch. From that point, they surmised that the coast curved south to allow passage to China, although the wind quickly encouraged them to abandon the coast and head further to sea. Far from the coast, massive icebergs, some home to aggressive walruses, combined with heavy fog to endanger the ships and convince their crews to turn back while it was still possible.[16]

On August 15, the vessels returned through the Yugor Strait and encountered *Het Boot*. Barents had sailed north of Novaya

14 Lund, Lynch-Stieglitz, and Curry, "Gulf Stream Density Structure and Transport during the Past Millennium," 601; Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago,* 66, 105.

15 Van Linschoten, "Voyagie, of Schipvaart, van Ian Huyghen van Linschoten," 63; Hellinga, *Pioniers van de Gouden Eeuw*, 32; Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago,* 66.

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

Zemlya, but his quest for a passage had been thwarted by impassable sea ice at 78° N, leaving him far less successful than his fellow explorers. Given the paucity of regional sea ice, Barents might have found a way forward, had he not been obliged to reunite with his colleagues. By September 10, the fleet had entered the North Sea; six days later it returned to Texel after a journey of more than three months. While the expedition of 1594 was among the most successful polar voyages undertaken in the age of sail, the subsequent enthusiasm of Moucheron and the Enkhuizen circle was not shared by Barents and Plancius, who advocated a still more northerly route.[17]

In 1594, the penetration of Dutch vessels into the seas above and beyond Novaya Zemlya was a product of synergy between the Republic's economic expansion, cultural values, social structures, and technological evolution—all of them activated through individual agency and informed by environmental conditions. Storms that were probably more severe in the Grindelwald Fluctuation hampered the initial progress of the Dutch expedition, but in the vicinity of Novaya Zemlya, the extent of sea ice was ultimately more important. Interdisciplinary reconstructions of Arctic and European weather can now suggest that the remarkable scarcity of regional sea ice in 1594 was influenced primarily by the nuances of the atmosphere rather than the characteristics of the hydrosphere. Arctic summer temperatures did not decline as much as temperatures in other seasons during the Grindelwald Fluctuation, but even under those conditions, the extent of sea ice during the summer of 1594 indicates that the vicinity of the Yugor Strait would have been particularly warm. Summer warmth in the Arctic therefore mirrored conditions in Northwestern Europe, where the summer of 1594 was only slightly cooler than the twentieth-century average. Short-term meteorological variability can mask the broader signal of a warmer or cooler climatic regime; in 1594, a warm summer disguised the LIA in the same way that a frigid winter can temporarily conceal the influence of modern global warming.[18]

17 *Ibid.*, 136; Hellinga, *Pioniers van de Gouden Eeuw*, 32.

18 Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago,* 66. A.F.V. van Engelen, J. Buisman, and F. Ijnsen, "A Millennium of Weather, Winds and Water in the Low Countries," in Philip D. Jones et al. (eds.), *History and Climate: Memories of the Future?* (New York, 2001), 112; M.V. Shabalova and van Engelen, "Evaluation of a Reconstruction of Temperature in the Low Countries AD 764–1998," *Climatic Change* (March 2000), 225.

Complex and sometimes counterintuitive relationships therefore existed between local weather and regional climate change. Other relationships tied together atmospheric fluctuations and the state of the hydrosphere and cryosphere. The relative success of the 1594 expedition was influenced by the peculiar entanglements between these environmental structures. This examination of the 1594 voyage, however, reveals that establishing the fourth relationship—between a prevailing climate and human activity—can be far more challenging. After all, local sea ice was less plentiful than what was encountered in subsequent expeditions during the Grindelwald Fluctuation. The usual characteristics of the first minimum of the LIA in the vicinity of the Kara Sea did not shape the course of the polar voyages in 1594.[19]

THE SECOND EXPEDITION (1595): FAILURE AND DISCOURAGEMENT

After the voyages of 1594 confirmed the promise of a passage to Asia through the Yugor Strait, Moucheron financed a second, larger expedition in the summer of the following year. On July 2, 1595, seven vessels from Amsterdam, Enkhuizen, and Zeeland departed Texel under Nay's command. Barents served as lead pilot of the Amsterdam ships; van Linschoten was the head merchant on account of his travels in Asia. Accompanying Barents was Jacob van Heemskerck, later to become one of the most famous admirals of the Golden Age. On August 17, Gerrit de Veer, an explorer aboard one of the Dutch vessels, wrote that after braving hard winds, the ships reached the coast of Novaya Zemlya, which was lined with a "great mass of ice."[20]

The profusion of sea ice persuaded the mariners to reconsider their options, but they resolved to pursue their mission by attempting to enter the Strait of Yugor. Broken sea ice forced the crews to alter course, but the squadron arrived at the strait on August 18. When the explorers entered it the next day, they found the water

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

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

near the so-called *Afgodenhoek*, or "Idol Point," closed because of ice (Figure 2). Varnek Bay, which was relatively passable, however, provided shelter from the wind-blown icebergs of the strait. For nearly a week, the vessels anchored in the bay as groups hiked across Idol Point, seeking a prospect from which they might glimpse open water. A small boat sent to scout the Kara Sea could not get past the Strait of Yugor on account of the ice, but on August 23, the Dutchmen encountered a party of Russians preparing to set sail for the Kara Sea who claimed that much of the Kara Sea would soon be frozen, even onto its southern coast. Perhaps prompted by the Russian warning, the explorers made a renewed attempt to enter the sea on August 25, but the ice at Twist Point, the entrance to the Kara Sea, forced them to turn back (Figure 2).[21]

Barents and the other mariners spent a good part of the following week among the inhabitants of the southern coast of Vaygatsch. On September 2, the vessels completed a treacherous journey through the ice to reach Cross Point, a gently protruding stretch of the coast between Idol Point and Twist Point (Figure 2). On September 3, the explorers were 6 km north of Twist Point, but dense sea ice soon forced them to retreat. After hours of desperate maneuvering through ice in variable wind, the mariners correctly guessed that they had sailed back toward the southern coast of Vaygatsh in the Yugor Strait. With the season growing late, on September 4, the vessels were tied to the so-called States Island, which afforded some protection from the ice. The island was southeast of the Yugor Strait in the Kara Sea, but sea ice prohibited progress beyond this forward position (Figure 2).[22]

With their way blocked, the explorers foraged on the island for game and crystals, hoping that the ice would soon shift to open a passage to Asia. On September 6, two sailors died after a group was ambushed by a thin and, apparently, famished bear. The bear was eventually slain, but the encounter demonstrated that the peril of the Arctic environment extended beyond wind-blown ice, frigid temperatures, and severe storms. Moreover, for the explorers, the threats posed by different expressions of the environment around Novaya Zemlya were entwined. Ice floes threatened the ships at sea, and an alien and unforgiving wilderness subjected the crews

21 De Veer, *True and Perfect Description of Three Voyages*, 9; *idem*, *Reizen van Willem Barents*, 36.
22 *Idem*, *True and Perfect Description of Three Voyages*, 13; *idem*, *Reizen van Willem Barents*, 40.

to further dangers even when the ships were in relatively secure harbors.[23]

A short-lived mutiny was quelled only after five of the instigators were hanged. The executions, indirectly stimulated by local environmental conditions, further damaged the already tense relations between the Enkuizen and Amsterdam groups. Between September 9 and 12, the explorers launched three vain attempts to break through the thick ice drifting east of States Island. As if to confirm that it was now too late to linger near Novaya Zemlya, a severe storm struck the fleet on September 13 and 14. On the morning of the 15th, an easterly wind pushed thick sea ice into the Yugor Strait, driving the explorers west and into the Barents Sea. With any passage to Asia now clearly blocked by ice, Nay, Barents, and their subordinates agreed to return to the Republic. The fleet arrived at Amsterdam on October 26, having never left the immediate vicinity of Novaya Zemlya.[24]

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

23 *Idem*, *True and Perfect Description of Three Voyages*, 14; *idem*, *Reizen van Willem Barents*, 41; Hellinga, *Pioniers van de Gouden Eeuw*, 32.

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

and storms may have funneled even more sea ice into the Yugor Strait, where winds typically blew east from the frigid Kara Sea. Fairly direct relationships are traceable in 1595 between the course of the second Dutch expedition for a Northeast Passage and weather events, regional environments, and ultimately the climatic regime of the Grindelwald Fluctuation.[25]

Nevertheless, the influence of a shifting climate and increased regional sea ice was mediated not only by cultural and economic trends that encouraged polar exploration but also by specific decisions made in the spring of 1595. The second voyage left later in the year than the other expeditions, arriving at the Yugor Strait halfway through August; the first fleet had already sailed well into the Kara Sea a year earlier in mid-August. By leaving later, the commanders of the second expedition failed to take advantage of relatively modest summer cooling during the Grindelwald Fluctuation, which may have accompanied even the apparently cold year of 1595. The adventurers probably subjected their efforts to a much greater shift in temperature and, hence, sea ice between summer and autumn than would be the norm today between the same seasons. The fourth relationship—between decadal climate change and human activity—was unusually direct but still far from straightforward during the expedition of 1595.

THE THIRD EXPEDITION (1596/97): DISCOVERY, DISASTER, AND SURVIVAL In the final months of 1595, the passage through the Yugor Strait appeared far less promising than it had a year earlier. Moucheron declined to finance continued Arctic exploration, and both Zeeland and Enkhuizen refused to contribute more ships. However, the abundant sea ice, rendered more common in the climate of the Grindelwald Fluctuation, did not discourage all advocates of a Northeast Passage. Plancius and Barents, never sold on the earlier promise of the Yugor Strait, were eager to pursue their long-preferred course. The voyages of 1594 had suggested that the Kara Sea was not merely a bay or an inland sea, and the disastrous expedition of 1595 could not disprove that the sea's coast curved south toward China. The Amsterdam party reasoned that

25 Zeeberg, *Climate and Glacial History of the Novaya Zemlya Archipelago,* 66; van Engelen, Buisman, and Ijnsen, "Millennium of Weather, Winds and Water in the Low Countries," 112; Shabalova and van Engelen, "Evaluation of a Reconstruction of Temperature in the Low Countries," 225.

although ice had understandably foiled attempts to sail through the shallow Yugor Strait, the deeper waters north of Novaya Zemlya should afford a passage. On March 25, 1596, Plancius obtained grants from townships in Holland, Zeeland, and Utrecht to launch an expedition that would, at last, lie under the unquestioned authority of the Amsterdam "merchant-adventurers."[26]

On May 16, two vessels destined for the far north left the island of Vlie on the mouth of the Zuider Zee. Barents was the intellectual leader of the expedition, but Heemskerck was the captain of his vessel. Jan Cornelisz Rijp commanded the second ship. Once again, De Veer's journals provide a remarkably continuous account of the ensuing months. Barents planned to sail far to the north of Norway before bearing east to avoid the supposed polar continent, a logical extension of the belief among the Amsterdam explorers that deep water could not freeze. Their conviction appeared to have been confirmed by their first days in Arctic waters when no ice was visible, even though they had traveled so far north that, in De Veer's words, they "had no night."[27]

Sea depth actually had no effect on the extent of the ice north of Norway. On June 5, De Veer reported a troubling sign—sea ice on the horizon, "which from afar looked like an oncoming flock of swans." By 4:00 PM on June 6, the ice had become so solid that passage was impossible. The explorers accordingly steered southwest before resuming their north by northeast course along the great mass of ice. At more than 74° N, they were now as far north as they had ever journeyed, but by July 8, the ice had grown so thick that they were again forced to sail south. Before long, they discerned land, which they named "Bear Island" to commemorate a bear that they killed there with great difficulty (Figure 2). Rijp wrongly insisted that the expedition would soon encounter the Yugor Strait if it did not continue north. The expedition departed the island on June 13.[28]

26 Hellinga, *Pioniers van de Gouden Eeuw*, 33; Zeeberg, *Terugkeer naar Nova Zembla,* 46; Zeeberg, *Into the Ice Sea,* 60; Spies, *Arctic Routes to Fabled Lands*, 140.

27 De Veer, *True and Perfect Description of Three Voyages*, 3; *idem*, *Reizen van Willem Barents,* 48; Hellinga, *Pioniers van de Gouden Eeuw*, 33; Zeeberg, *Terugkeer naar Nova Zembla,* 46; *idem*, *Into the Ice Sea,* 61.

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

On June 17, the explorers again encountered thick sea ice that forced them to alter course. At just under 80° N on June 19, they spotted land. Barents thought it to be the long-lost coast of Greenland, but Rijp correctly designated it as "The New Land." Their crews called it *Spitsbergen*, or "Sharp Mountains," because its peaks seemed to pierce the clouds. Halfway between Norway and the North Pole, the explorers had discovered the largest island of the sprawling Svalbard archipelago. On June 21, the men found a remarkable abundance of virgin fauna and flora on shore. Two days later, they began a week-long exploration of the island's coast, their course routinely blocked by sea ice, which prevented them from sailing around Spitsbergen's northern coast, but because the ships were near land, the thick ice did not disprove the notion that deep water could not freeze. The explorers returned to Bear Island on July 1, no closer to a Northeast Passage.[29]

Despite this failure, their discoveries were significant, facilitated by average summer temperatures that, in the Arctic, cooled far less than did average temperatures in other seasons during the Grindelwald Fluctuation. However, the relationship between prevailing weather and the state of the regional cryosphere and hydrosphere was again complex. The summer was not so balmy that the mariners could avoid sea ice altogether, and indeed both model simulations and proxy records indicate that, in the context of preceding centuries, regional water temperatures were colder than average during the 1590s. Passage to high latitudes was therefore neither closed by ice nor entirely open. Instead, relationships between the cryosphere, hydrosphere, and atmosphere, shaped by the nuances of the Grindelwald Fluctuation in the far north, redirected, though they did not immediately prevent, the third Dutch expedition.[30]

On July 1, Rijp insisted on sailing north beyond 80° N to find an opening in the ice, but Barents believed that the coast of Greenland curved east to prohibit a passage. After a heated argument, the two agreed to separate and attempt different passages—Rijp in the ice north of Spitsbergen and Barents around the northern

29 De Veer, *True and Perfect Description of Three Voyages*, 9; *idem*, *Reizen van Willem Barents,* 55; Spies, *Arctic Routes to Fabled Lands*, 143; Lehner et al., "Amplified Inception of European Little Ice Age," 52; Rueda, "Coupling of Air and Sea Surface Temperatures," 696.

30 Lehner et al., "Amplified Inception of European Little Ice Age," 52, Rueda; "Coupling of Air and Sea Surface Temperatures," 696.

coast of Novaya Zemlya. In later testimony before the Republic's governing states-general, Rijp described how he had returned to the waters off Spitsbergen, where his ship had penetrated the ice pack to 79° N. A journal kept by crew member Thenis Claeszoon revealed that further progress was again blocked by impenetrable ice and that his vessel was soon damaged by an iceberg. Working from boats, the mariners repaired the hull before sailing to Novaya Zemlya in pursuit of Barents.[31]

After Rijp and his crew departed on July 1, Heemskerck and Barents headed east toward Novaya Zemlya. Evidently they became less certain regarding the impossibility of ice in deep water; De Veer recorded that given their high latitude, they "much wondered" about the short-lived lack of sea ice on July 4. Twelve days later, they arrived at Novaya Zemlya and began to sail around the island's western coast. On July 19, the explorers reached "Cross Island" (Cape Dyakanova) at roughly 76° N, but found their way blocked by ice. The mariners finally maneuvered around the ice on August 4, two days later passing a peninsula that they named "Cape Nassau." Rijp reached Cape Dyakanova not long after Barents and his crew slipped through, but the way forward was now entirely sealed by ice. Barents and Heemskerck guided their ship nearer the shore after August 10, because the largest icebergs could not enter the shallow water. By navigating through sea ice, the explorers reached the island of Orange; a scouting party atop a hill spotted open water bearing southeast and east-southeast. Barents had worried that Novaya Zemlya was connected to a polar continent, but these fears now appeared groundless. De Veer wrote, "We were much comforted, thinking we had won our voyage."[32]

In fact, the explorers were in an increasingly precarious position; it was now late in the polar summer. On August 20, they had to brave icebergs and thick sea ice to reach "Ice Haven" on the northwestern coast of Novaya Zemlya. They left there on the following day, but a ferocious storm forced them to attach their vessel to an iceberg until August 23. Sea ice began to surround their vessel on August 24, and on August 26, Barents decided that the expedition should retrace its course around the west coast of

31 Zeeberg, *Into the Ice Sea*, 62.

32 De Veer, *True and Perfect Description of Three Voyages*, 14; *idem*, *Reizen van Willem Barents*, 60; Zeeberg, *Into the Ice Sea*, 62.

Novaya Zemlya, abandoning the quest for a passage. However, as the ship passed by Ice Haven later that day, it was entirely trapped by ice, which lifted the vessel four feet above the water on August 27. For more than a week, the ice retreated and returned, keeping the vessel firmly enclosed. On September 11, with winter approaching and the ship again lifted high upon the ice, the explorers realized that imminent escape from Novaya Zemlya was impossible.[33]

Faced with this grim reality, Barents, Heemskerck, and their crew built a house on the shore to escape being crushed by sea ice. Fortunately, on September 11, a scouting party found trees on the coast that had been uprooted in a severe storm. With wood laboriously harvested from these trees, the men began the long and desperate struggle to erect a shelter before the onset of the polar winter. The expedition's carpenter died on September 23, likely from a heart attack, but despite aggressive bears, increasing darkness, and worsening blizzards, much of the *Behouden Huys*, or "Saved House," was completed by October 12.[34]

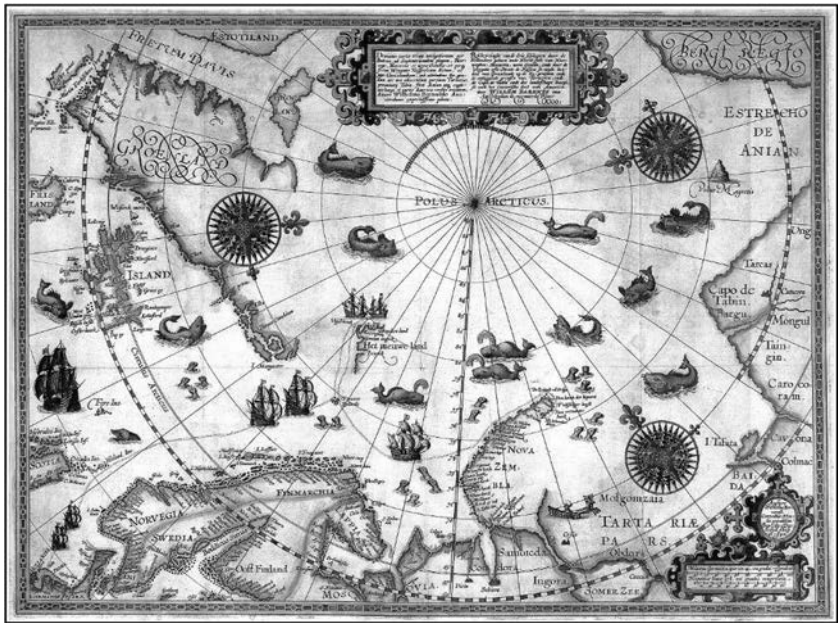
On November 3, the sun vanished beneath the horizon and was not seen again for months. Aside from pregnant females, polar bears in the Russian Arctic are active year-round, but the bears that had routinely attacked the house disappeared with the sun. The crew manufactured pelts from foxes that emerged when the bears retreated, but neither fur nor boiling water could long defend against the cold. Severe blizzards, accompanied by unbearably low temperatures and heavy snowfall, quickly grew routine, blowing on forty-nine days from the beginning of December to the end of March. On January 24, the crew's spirits were raised when the sun appeared to rise after nearly three months of darkness. In fact, De Veer recorded the first written observation of what was thereafter known as the "Novaya Zemlya effect," a polar mirage stimulated by the atmospheric refraction of sunlight.[35]

Despite the illusion, the sun soon returned in truth, and, by May, open water was visible from the coast. The ship, however, could not be dislodged, and storms repeatedly drove thick sea ice

33 De Veer, *True and Perfect Description of Three Voyages*, 23; *idem*, *Reizen van Willem Barents,* 70.
34 *Idem, True and Perfect Description of Three Voyages*, 31; *idem*, *Reizen van Willem Barents,* 79.
35 Steven C. Amstrup and Craig Gardner, "Polar Bear Maternity Denning in the Beaufort Sea," *Journal of Wildlife Management*, LVIII (1994), 1; de Veer, *True and Perfect Description of Three Voyages*, 37; *idem*, *Reizen van Willem Barents,* 87; Unwin, *Winter Away from Home,* 111.

back into the harbor. On May 15, Heemskerck and Barents ordered the crew to prepare small boats to attempt a desperate journey back to the Republic. Weeks of frantic construction ensued, disrupted occasionally by the bears that had returned with the sun. Finally, on June 14, two boats departed Novaya Zemlya; they had not traveled far before Barents succumbed to scurvy. In the following months, rapidly shifting ice, bears, walruses, storms, and navigational blunders all conspired to threaten the journey home. Nevertheless, the explorers reunited with Rijp off Norway and returned to Amsterdam on November 1. Rijp had made an earlier attempt to rendezvous with Barents after an aborted exploration of Spitsbergen only to be thwarted by ice; he had to return home before trying again. Before he died, Barents had recorded cartographical information that was to transform European conceptions of the Arctic (Figure 3). It was now clear to many that deep water could freeze, suggesting that the Arctic ice sighted in previous centuries was no indication of nearby land, let alone an Arctic continent. In

Fig. 3 Map of the North, Engraved by Baptista a Doetichum (1598) Using the Discoveries of the Expedition of 1596/97 (Svalbard marked as *Het nieuwe land* ["the new land"])



subsequent Dutch maps, fictional monsters and continents vanished, and new lands and marine hunting grounds were depicted with unprecedented accuracy.[36]

In 1596 and 1597, weather, broad environmental structures, and the climatic regime of the Grindelwald Fluctuation in the vicinity of Novaya Zemlya were inextricably joined. Complex connections between climate and the fate of the third Dutch expedition are also evident. A relative lack of ice during summer might have encouraged the Dutch explorers to penetrate far into Arctic waters. Barents and his crew might not have slipped past Cape Dyakanova had the summer of 1596 been colder, and Rijp could have followed them if the summer had been warmer. In that case, the expedition would have been reunited much sooner, and Rijp might have convinced Barents to attempt an earlier return to the Republic. But Barents had long argued that they would have to overwinter near the island of Vaygatsch, and in 1596, the explorers were well provisioned for that possibility.[37]

Winter on the northern tip of Novaya Zemlya was an entirely different prospect, however; before 1597, few Western Europeans had ever survived an Arctic winter. In early August, open water off Novaya Zemlya was a passing illusion: Relationships between the atmosphere and hydrosphere in the context of a cold climate were already influencing the cryosphere. The generally cooler climate of the Grindelwald Fluctuation in the Arctic was characterized by an unusually sharp drop in temperatures from summer to autumn. In subsequent weeks, this rapid transition likely increased the difficulty of avoiding, and decreased the possibility of escaping, a sudden thickening of sea ice.[38]

The severe storm that washed the wood ashore and provided the materials necessary for shelter might have occurred outside the Grindelwald Fluctuation, but it is not likely. At least this one probable environmental manifestation of the late sixteenth-century climate in the Russian Arctic helped the explorers to survive a plight that was dramatically worsened by other expressions of that climatic regime. Thereafter, a frigid winter punctuated by the relentless

36 De Veer, *True and Perfect Description of Three Voyages*, 77; *idem*, *Reizen van Willem Barents,* 122; Unwin, *Winter Away from Home,* 131; Hellinga, *Pioniers van de Gouden Eeuw*, 37.

37 Unwin, *Winter Away from Home,* 40.

38 Crespin et al., "Arctic Climate over the Past Millennium," 327; *idem* et al., "15th Century Arctic Warming in Coupled Model Simulations with Data Assimilation," 394.

storms common in the climate of the late sixteenth century conspired with a relatively cold spring to extend the explorers' hardships. The weakness of the Atlantic current in the Barents Sea may have increased the sea ice that they encountered in their struggle to return to the Republic during the summer of 1597. Because their vessels never entered the Yugor Strait, however, the logbook kept by De Veer to record the expedition makes no mention of the regional current.[39]

Increasingly precise reconstructions compiled with diverse, interdisciplinary sources and techniques can now trace how early modern climatic fluctuations altered the Arctic atmosphere, hydrosphere, and cryosphere. Climate historians can contribute to these reconstructions by analyzing and quantifying contemporary documents that describe the Arctic environment during the LIA. When establishing links between human history and environmental change, they must remember that local environmental processes interacted more or less directly with larger environmental frameworks and diverse human activities across different timescales. For example, during the Dutch quest for a Northeast Passage between 1594 and 1597, weather patterns usually, but not invariably, conformed to the climatic norm. Climate historians naturally lack the depth of environmental data that enables supercomputer reconstructions of relationships between climate and weather. Nonetheless, they can infer that weather events common during a particular climatic regime were probably, though not certainly, caused by that climatic regime.

Easier to determine are relationships between local or regional changes in the atmosphere, and the state of the cryosphere and hydrosphere. Nevertheless, missing variables persist. For instance, shifts in patterns of prevailing wind, which accompanied the LIA in northern Europe, may also have attended its minima in the Arctic, influencing the movement of ice in the vicinity of the Kara Sea. Yet, more important for the extent of regional sea ice, and certainly more verifiable, were manifestations of LIA minima that included changes in temperature, shifts in regional ocean currents, and more frequent storms.[40]

39 Zeeberg, *Terugkeer naar Nova Zembla*, 75.

40 Degroot, "'Never Such Weather Known in These Seas': Climatic Fluctuations and the Anglo-Dutch Wars of the Seventeenth Century, 1652–1674." *Environment and History*, XX (2014), 248.

Relationships between shifting environmental structures must be analyzed with as much precision as available sources allow before human history can be tied causally to a changing environment. Even when humans encountered environments at full force, as they did during the Dutch expeditions to the Arctic, interactions between environmental frameworks and human activity were mediated by cultural, economic, and political arrangements. Surviving documents reveal, however, that the Dutch expeditions to the Arctic were clearly influenced by the regional condition of the atmosphere, cryosphere, hydrosphere, and biosphere between 1594 and 1597. Summer warmth helped to enable the success of the expedition of 1594, and the promise of that expedition inspired a second endeavor in 1595. This time, heavy sea ice, cold temperatures, contrary currents, and storms thwarted all attempts to investigate the Kara Sea. That failure only encouraged entrepreneurs in Amsterdam to attempt in the summer of 1596 the more northerly passage for which they had long advocated, with mixed results. Ironically, by encouraging further expeditions, the anomalous warmth of 1594 contributed to the failure of 1595 and the hardships of 1596/97, when conditions typical of the Grindelwald Fluctuation re-asserted themselves.

New reconstructions of the Arctic environment can refresh traditional narratives of the Dutch quest for a Northeast Passage, most of which describe natural structures that serve mostly to demonstrate the heroism of the explorers. The surviving documents do not explicitly mention climate, a concept that was, at best, imperfectly understood by even the most learned and most interested Dutch citizens. Certainly the broad features of the Grindelwald Fluctuation influenced the Dutch expeditions, which would have ended very differently in today's warmer Arctic. Moreover, the nuances of the first minimum of the LIA in the European Arctic likely influenced the course of, at least, the voyages in 1595 and 1596/97. Regionally, the LIA was expressed through a precipitous drop between summer and autumn temperatures, substantial sea ice, storminess, and extreme cold outside of summer—conditions that seriously affected the second and third expeditions to the Kara Sea. The different circumstances surrounding the first voyage highlight the complexity of broadly linking a climatic regime to human history.

Relationships between climate and human history are easier to determine when many events in human history are conjoined with

environmental stimuli across the decadal scales necessary to measure climate change. In the sixteenth and early seventeenth centuries, a long line of Dutch, English, and Danish mariners failed to chart a Northeast Passage. The Barents expeditions were only the most significant and, arguably, most successful of these voyages, all of which failed in ice that no longer forms consistently in today's warmer climate. However, it is as methodologically problematical to associate climate and human history by using simplistic quantitative data as it is to link, for example, urbanization and economic performance by comparing demographic data to annual gross domestic product. Like any human or environmental trend, climatic regimes affect human beings through short-term, local events. If the course of three expeditions across four years cannot be tied to the manifestations of a climatic regime, it is difficult to understand how that climatic regime can be linked to broader trends in human history.[41]

Ultimately, historians of climate must embrace probability. Like other historians, we cannot quantify possible connections between events and trends. Yet, we can determine that the course of, for example, the Dutch quest for a Northeast Passage was probably influenced by the characteristics of the Grindelwald Fluctuation in the Arctic. This caution about drawing definite conclusions should not undermine the discoveries of climate historians for scholars, such as Kelly and Ó Gráda, who pursue more traditional economic or political avenues of historical inquiry. Most historians are interested in increasing the accuracy of their narratives, and climate history furthers that purpose.

But if causal explanations of human history by climate are inherently less certain than, for example, those of human affairs by weather or ice cover, why do many historians explicitly investigate the influence of climate? The answer is that historians cannot help but write in the context of the present. Today, climate change is again influencing attempts to connect Europe and Asia through Arctic waters. Rapid Arctic melting rendered the Northeast Passage completely ice free in the summer of 2008, permitting two German freighters to complete the first of many subsequent commercial

41 Zeeberg, *Terugkeer naar Nova Zembla*, 36; Unwin, *Winter Away from Home*, 4; Samuel Bawlf, *The Secret Voyage of Sir Francis Drake, 1577–1580* (Vancouver, 2003), 48; Tilly, *Big Structures, Large Processes, Huge Comparisons*, 12.

voyages through it one year later. Anthropogenic global warming is a recent phenomenon, but interactions between climatic shifts, weather events, polar ice, and the quest for a shorter route between the East and West through Arctic waters have a long history.[42]

42 Andrew Revkin, "Commercial Arctic Passage Nearing Goal," *New York Times*, 4 Sept. 2009, available at http://dotearth.blogs.nytimes.com/2009/09/04/commercial-arctic-passage-nearing-goal; Artyom Liss, "Arctic Trail Blazers Make History," BBC News, 19 Sept. 2009, available at http://news.bbc.co.uk/2/hi/8264345.stm; Andrew E. Kreamer, "Warming Revives Dream of Sea Route in Russian Arctic," *New York Times*, 17 Oct. 2011, available at http://www.nytimes.com/2011/10/18/business/global/warming-revives-old-dream-of-sea-route-in-russian-arctic.html.