

INTRODUCTION

Crisis and Opportunity in a Changing Climate

The world is warming, and the pace of warming is starting to quicken. In just the time it took to research and write this book, Earth endured seven of the eight hottest years ever measured by meteorological instruments. Its average annual temperature is now roughly one degree Celsius hotter than it was midway through the twentieth century. By the end of the twenty-first century, warming may well exceed two degrees Celsius. Around the world, people are already experiencing gradual and global changes in Earth's climate through local weather events that pass quickly but have lasting consequences. Climate change is not only altering average weather but also the frequency and severity of weather extremes. Present-day warming has intensified storms, prolonged heat waves, and provoked precipitation anomalies in ways that have overwhelmed vulnerable human infrastructure and thereby exacted a fearsome toll on rich and poor societies alike. Ever more extreme weather in our warmer future could threaten the very survival of our civilization.¹

¹ B. Kirman et al., '2013: Near-term Climate Change: Projections and Predictability'. In *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. T. F. Stocker et al. (Cambridge: Cambridge University Press, 2014), 981. Virginia Burkett et al., *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. (IPCC WG II AR5, 2014), 13. IPCC, '2014: Summary for Policymakers'. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. C. B. Field et al. (Cambridge: Cambridge University Press, 2014), 7. See also E. M. Fischer and R. Knutti, 'Anthropogenic Contribution to Global Occurrence of Heavy-Precipitation and High-Temperature Extremes'. *Nature Climate Change* (2015): <http://dx.doi.org/10.1038/nclimate2617>.

To properly appreciate and begin to address this defining crisis of our time, we must look to the past. We can gain a sense of the magnitude and causes of global warming by comparing it to the baseline of natural climatic variability, which we can only determine by reconstructing past climatic trends. We can better understand and confront the causes of warming by tracing the human histories that led us to capitalism, globalization, and industrialization. We can acquire insights into how our civilizations can adapt to human-caused warming by determining why many societies suffered, although a few thrived, when natural forces in our distant past changed Earth's climate in smaller but still significant ways.²

This book contributes to that third kind of 'climate history'. Midway through the thirteenth century, average annual temperatures in the Arctic and eventually around the world started falling. It was the beginning of the so-called Little Ice Age, the chilly climatic regime that is the focus of this book. Until the recent onset of global warming, the Little Ice Age may have been the most significant climatic anomaly to affect the Northern Hemisphere in at least 6,000 years.³

Many historians and scientists believe that the Little Ice Age endured for around six centuries, until roughly 1850. Different definitions arise, in part, from a particularly cold period between approximately 1560 and 1720 that was bookended by two frigid, decade-scale climatic regimes: the Grindelwald Fluctuation (1560–1628) and the Maunder Minimum (1645–1720). Atmospheric and oceanic circulation changed in both of these cold phases, causing patterns of precipitation and storminess to shift from region to region. Weather from season to season and year to year was also less predictable than it had been, but overall average global temperatures remained roughly one degree Celsius below the twentieth-century (c. 1900–1960) norm. In the so-called early modern centuries, from around 1450 to 1750, the lives and livelihoods of most people depended on local agriculture. Around the world, the weather of the

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

³ For different perspectives on the term 'Little Ice Age', see Michael E. Mann, 'The Little Ice Age'. In *Encyclopedia of Global Environmental Change*, eds. Michael C. MacCracken and John S. Perry. (Chichester: John Wiley & Sons, Ltd., 2002), 504–509. John A. Matthews and Keith R. Briffa, 'The "Little Ice Age": Re-evaluation of an Evolving Concept'. *Geografiska Annaler: Series A, Physical Geography*, 87:1 (2005): 17–36. Sam White, 'The Real Little Ice Age'. *The Journal of Interdisciplinary History* 44:3 (Winter, 2014): 327–352.

Little Ice Age played a role in triggering harvest failures, commodity price shocks, famine, social unrest, and ultimately death on a vast scale.⁴

Yet a few societies prospered, and none more than the Dutch Republic, the precursor of the present-day Netherlands. Between 1590 and 1715, its coastal regions underwent an extraordinary golden age that precisely coincided with the coldest stretch of the Little Ice Age. For centuries, these regions – collectively known as the ‘Low Countries’ – had differed in important ways from the rest of Europe. Salt marshes and peat bogs made them mostly uninhabitable until medieval settlers in huge numbers dug up peat, drained bogs, and reared cattle that trampled what was left. The land sank in response, until it dropped below the level of the sea, and the settlers in turn built a huge web of river embankments, dikes, and drainage channels to hold back the water. They created a strange network of walled-off farmland and waterways that had few parallels anywhere else in the world.⁵

This engineered landscape was perpetually menaced by the ‘water wolf’: the sea that always threatened to spill over Dutch coastal defences. Yet water also helped provide the motivation and means for fantastic profits. In the fourteenth century, floods destroyed farmland across the Low Countries and prompted merchants to import from the nearby Baltic Sea. Port towns accommodated this new trade and fostered the

⁴ John Brooke, *Climate Change and the Course of Global History: A Rough Journey*. (Cambridge: Cambridge University Press, 2014), 383. Shaun A. Marcott et al., ‘A Reconstruction of Regional and Global Temperature for the Past 11,300 Years’, *Science*, CCCIX (2013), 1198. Geoffrey Parker and Lesley M. Smith, eds., *The General Crisis of the Seventeenth Century*. (Oxford: Routledge, 2005), 7. M. J. Ingram, G. Farmer and T. M. L. Wigley, ‘Past Climates and Their Impact on Man: A Review’. In *Climate and History: Studies on Past Climates and Their Impact on Man*, eds. M. J. Ingram, G. Farmer and T. M. L. Wigley. (Cambridge: Cambridge University Press, 1981), 17. Hubert Lamb, *Climate, History and the Modern World*, 260. Jean M. Grove, ‘The Century Time-Scale’. In *Time-Scales and Environmental Change*, eds. Thackwray S. Driver and Graham P. Chapman. (Oxford: Routledge, 1996), 40. Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century*. (London: Yale University Press, 2013), 26. Ljungqvist, ‘A New Reconstruction of Temperature Variability in the Extra-Tropical Northern Hemisphere during the Last Two Millennia’, 445.

⁵ Piet H. Nienhuis, *Environmental History of the Rhine-Meuse Delta: An Ecological Story on Evolving Human-Environmental Relations Coping with Climate Change and Sea Level Rise*. (New York: Springer, 2008), 54, 87. M. van Tielhof and P. J. E. M. van Dam, *Waterstaat in Stedenland: het Hoogbeemraadschap van Rijnland voor 1857*. Utrecht: Matrijs, 2006. William TeBrake, *Medieval Frontier: Culture and Ecology in Rijnland*. (College Station: Texas A&M University Press, 1985). Audrey M. Lambert, *The Making of the Dutch Landscape: An Historical Geography of the Netherlands*. (London: Academic Press, 1985), 203.

skills and infrastructure that permitted the rise of new industries on land and at sea. When the Spanish Habsburg Empire absorbed the Low Countries late in the fifteenth century, the region's cities had become hubs in a continent-straddling commercial network. Yet they were also divided by a bewildering patchwork of local laws and customs, and frayed by the spread of Protestantism. Spanish attempts to centralize the region under Catholic rule ignited a revolt that eventually united the northern provinces of the Low Countries within a radical new kind of political structure: a loose confederation largely governed by councils of urban merchants.⁶

This 'Dutch Republic' gave rise to a remarkably dynamic economy that thrived while its competitors faltered amid the chilliest decades of the Little Ice Age. Dutch entrepreneurs invented or implemented technologies that sharply increased the efficiency of, for example, shipping, shipbuilding, firefighting, and land reclamation. Merchants, many of them immigrants from the war-torn southern Low Countries, cultivated new industries and circumvented Spanish embargoes by establishing the Dutch East and West India Companies. The East India Company quickly came to dominate the lucrative trade that sent precious metals to Asia in exchange for spices and textiles. Burgeoning Amsterdam became the financial and commercial capital of Europe; a major hotbed for mapmaking and publishing; and the first truly global nexus for importing, trading, and exporting goods. For decades, the republic's level of urbanization, rates of literacy, robust fiscal system, stable and effective governments, diverse commercial economy, and efficient sources of energy set it apart within contemporary Europe. Its economic booms and busts, frequently triggered by financial speculation and accompanied by environmental degradation, resembled those of present-day capitalism. The precocious dynamism of the Dutch economy made the republic a great power with global reach, but it was not to last. By the middle of the seventeenth century, Dutch commercial success provoked protectionist legislation, costly wars, and – worst of all – emulation in France and especially England. Meanwhile, falling commodity prices, increasing labour costs, and a series of natural disasters undermined the republic's agricultural productivity.

⁶ Louis Sicking, *Neptune and the Netherlands: State, Economy, and War at Sea in the Renaissance*. (Leiden: Brill, 2004), 209. Jonathan Israel, *The Dutch Republic: Its Rise, Greatness, and Fall, 1477–1806*. (Oxford: Clarendon Press, 1998), 209. Maarten Prak, *The Dutch Republic in the Seventeenth Century*. (Cambridge: Cambridge University Press, 2005), 8. Alastair Duke, *Reformation and Revolt in the Low Countries*. (London: Hambledon Press, 1990), 11.

In the face of these challenges, the republic's economy changed and ultimately declined in the eighteenth century, just as Earth's climate started warming.⁷

There was something about the Dutch Republic that let its citizens thrive during the coldest decades of the Little Ice Age. This book demonstrates, first, that weather was a dynamic natural agent that shaped the history of the Dutch Golden Age. It shows, second, that weather trends in the chilliest phases of the Little Ice Age had mixed but overall beneficial consequences for distinctively Dutch ways of conducting commerce and waging war, which the culture of the republic registered and reinforced. Climate changes that led to particularly cold stretches of the Little Ice Age certainly presented challenges for Dutch citizens, but they also offered opportunities that merchants, sailors, soldiers, and inventors aggressively exploited.

Most histories of the Little Ice Age focus on agriculture. Yet domestic agricultural production was less important for the prosperity and security of the Dutch Republic than it was for most other states. This book therefore explores diverse and, until now, largely unstudied links between climate change and early modern history. It shows that complex relationships

⁷ Violet Barbour, *Capitalism in Amsterdam in the 17th Century*. (Ann Arbor: University of Michigan Press, 1963), 12. Bas van Bavel, 'Manors and Markets. Economy and Society in the Low Countries (500–1600): A Synopsis'. *Tijdschrift voor Sociale en Economische Geschiedenis* 8:2 (2011): 63. J. L. Price, *Dutch Society, 1588–1713*. (New York: Longman, 2000), 70. 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), 357. C. A. Davids, 'De technische ontwikkeling in Nederland in de vroeg-moderne tijd. Literatuur, problemen en hypothesen'. *Jaarboek voor de Geschiedenis van Bedrijf en Techniek* 8 (1991): 9. Oscar Gelderblom, *Zuid-Nederlandse kooplieden en de opkomst van de Amsterdamse stapelmarkt (1578–1630)*. (Hilversum: Uitgeverij Verloren, 2000), 114. Victor Enthoven, 'Early Dutch Expansion in the Atlantic Region, 1585–1621'. In *Riches from Atlantic Commerce: Dutch Transatlantic Trade and Shipping, 1585–1817*, eds. Johannes Postma and Victor Enthoven. (Leiden: Brill, 2003), 23. Gerrit Knaap and Ger Teitle, eds., *De Verenigde Oost-Indische Compagnie: Tussen Oorlog en Diplomatie*. (Leiden: KITLV Uitgeverij, 2002), 4. Jonathan Irvine Israel, *Dutch Primacy in World Trade, 1585–1740*. (New York: Oxford University Press, 198), 213. Clé Lesger, *Handel in Amsterdam ten tijde van de Opstand: kooplieden, commerciële expansie en verandering in de ruimtelijke economie van de Nederlanden ca. 1550 – ca. 1630*. (Hilversum: Uitgeverij Verloren, 2001). P. C. Emmer, *The Dutch in the Atlantic Economy, 1580–1880*. (Aldershot: Ashgate, 1998), 14. Jan Luiten van Zanden, 'Economische Groei in Holland tussen 1500 en 1800'. *NEHA-Bulletin* 16:2 (2001): 65. J. L. van Zanden, *Arbeid tijdens het handelskapitalisme: Opkomst en neergang van de Hollandse economie 1350–1850*. (Hilversum: Uitgeverij Verloren, 1991), 11. E. M. Jacobs, *In Pursuit of Pepper and Tea: The Story of the Dutch East India Company*. (Walburg: Walburg Pers, 2009), 11.

between global climatic trends and local environments influenced the transportation networks that sustained the Dutch trading empire. Weather that became common in cooler climates encouraged new discoveries and industries in distant seas, quickened the journeys of departing East India Company ships, hampered some elements of Baltic commerce while possibly enriching others, and altered how travellers moved within the republic.

The book also demonstrates that climate change affected how the Dutch defended their republic and expanded its commercial empire. From 1568 to 1688, Dutch military operations generally benefitted from cold, wet, and stormy weather that became more common in especially chilly phases of the Little Ice Age. However, in the 1630s and 1650s, weather typical of an interruption in the Little Ice Age aided Dutch offensives in the Spanish Netherlands and then thwarted the republic's naval operations during the First Anglo-Dutch War.

Finally, the book reveals that climate change influenced the dynamic culture of the Dutch Golden Age. By tracing weather patterns through time, some Dutch citizens developed a vague awareness of what we would call climate change. Dutch artistic responses to weather expressed the conviction that even the extremes of a frigid climate could be endured and, occasionally, exploited. Little Ice Age weather encouraged social spaces and technologies that contributed to the resilience of the republic in the face of climate change.

That concept – ‘resilience’ – is notoriously difficult to define. Other scholars have used it to refer to an adaptive social capacity that mitigates loss amid changing environmental conditions. According to that definition, ‘vulnerability’ means the potential for loss. In this book, ‘resilience’ also encompasses the largely unavoidable natural circumstances that can make shifting environmental conditions more or less damaging in a particular place, for a particular society. Resilience, therefore, is not just about what humans decide to do, but also about the choices environmental circumstances allow them to make. A society that is vulnerable to climate change could simply be in the wrong place, at the wrong time.⁸

⁸ Grove, ‘The Century Time-Scale’. 80. Georgina H. Endfield, ‘Exploring Particularity: Vulnerability, Resilience, and Memory in Climate Change Discourses’. *Environmental History* 19 (2014): 305. Christian Pfister, ‘Climatic Extremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth and Early Seventeenth Centuries’, *The Medieval History Journal* 10:1&2 (2007): 44. Field et al., ‘Climate Change 2014: Impacts, Adaptation, and Vulnerability, Summary for Policymakers’, 5.

We can therefore imagine resilience to climate change as a negotiation between environmental fluctuations, on the one hand, and the characteristics of a society, on the other. If a climatic shift is too extreme, no society can endure. If a society depends on a particularly delicate environmental equilibrium, even a hint of climatic variability can be dangerous. Societies can be vulnerable for very different reasons. Today, developed states strain or exceed the capacity of environments that climate change will make less hospitable. In the early modern world, by contrast, many societies depended on the meagre yields and slight surpluses of agricultural systems that could rarely cope effectively with shifting climatic conditions. As we will see, the Dutch Republic was not one of those civilizations.

A NEW APPROACH TO THE HISTORY OF CLIMATE CHANGE

Scientists have long understood that Earth's climate has never been entirely stable, yet most historians have only recently accepted that climate changes influenced human history. The Little Ice Age in particular belatedly entered the mainstream of the historical profession owing to the pioneering work of scholars such Emmanuel Le Roy Ladurie, Hubert Lamb, and Christian Pfister, who first developed rigorous methods for reconstructing past climate changes and tying them to human histories.⁹ In recent years, scholars have drawn on these methods and used a broadening range of textual and scientific sources to write increasingly sophisticated histories of the Little Ice Age. Still, nearly all conclude that cooling made life more difficult for just about everyone in the early modern world. They focus on examples of decline and disaster: admittedly the most common fate of premodern societies confronted with sudden or severe shifts in the environments they exploited. Yet most ignore societies that prospered in cold periods of the Little Ice Age, which means that they

⁹ Rudolf Brázdil et al., 'Historical Climatology in Europe – the State of the Art'. *Climatic Change* 70:3 (2005): 366. Hubert Lamb, *The English Climate*. (London: English Universities Press, 1964), 12. Emmanuel Le Roy Ladurie, *Times of Feast, Times of Famine*, 10. Gustaf Utterström, 'Climatic Fluctuations and Population Problems in Early Modern History', *Scandinavian Economic History Review* 3:1 (1955): 3. Behringer, *A Cultural History of Climate*, 86. Emmanuel Le Roy Ladurie, *Times of Feast, Times of Famine: A History of Climate since the Year 1000*. (Garden City, NY: Doubleday & Company, Inc., 1971), 293. Lamb, *Climate, History and the Modern World*, 232. Christian Pfister, 'The Little Ice Age: Thermal and Wetness Indices for Central Europe', *The Journal of Interdisciplinary History* 10:4 (1980): 665. Christian Pfister, 'The Climate of Switzerland in the Last 450 Years'. *Geographica Helvetica* 35 (1980): 15.

rarely consider how individuals and communities could endure, adapt to, and exploit changes in the natural world.¹⁰

I therefore began my research for this book by searching for weather references, not disaster stories, in early modern Dutch documents. Occasionally, I specifically sought texts written during weather extremes, but even then I did not concentrate solely on the kinds of weather that other historians have associated with societal crises. By approaching my sources with an open mind, I found that relationships between climate change and human activity were, and perhaps remain, more complex and counterintuitive than narratives that stress decline, or ‘declension’ typically allow. There were winners and losers in the early modern struggle with climate change, just as there are today and will be in the future.

To trace the human consequences of climate change, in this book I carefully measure percentages and gauge probabilities. One of the book’s most important principles is that seemingly slight changes in environmental conditions or human arrangements can have disproportionate consequences for people and their societies. The reason lies in the relationship between long-term trends and short-term events. A trend need only trigger one event for it to have major historical significance. More importantly, superficially slight trends are often expressed in short-term extremes. For instance, although Earth’s average temperature has, as of 2017, risen by just over one degree Celsius since the conclusion of the Little Ice Age, severe heat waves are now four times more common around the world than they were in 1850. To take another example, a 30 per cent

¹⁰ Fred Pearce, *Climate and Man: From the Ice Ages to the Global Greenhouse*. (London: Vision Books, 1989), 31. Neville Brown, *History and Climate Change: A Eurocentric Perspective*. (London: Routledge, 2001), 262. Bauernfeind and Woitek, ‘The Influence of Climatic Change on Price Fluctuations in Germany during the 16th Century Price Revolution’, *Climatic Change* 43:1 (1999): 307. Pfister, ‘Climatic Extremes, Recurrent Crises and Witch Hunts’, 39. Leo Noordegraaf, ‘Dearth, Famine and Social Policy in the Dutch Republic at the End of the Sixteenth Century’. In *The European Crisis of the 1590s: Essays in Comparative History*, ed. Peter Clark. (London: George Allen & Unwin, 1985), 67. Joëlle Gergis, Don Garden, and Claire 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* 15(3) (2010): 485. Wolfgang Behringer, *A Cultural History of Climate*. (Cambridge: Polity Press, 2010), 141. Adam R. Hodge, “In Want of Nourishment for to Keep Them Alive”: Climatic Fluctuations, Bison Scarcity, and the Smallpox Epidemic of 1780–82 on the Northern Great Plains’. *Environmental History* 17(2) (2012): 400. See also Sam White, Richard Tucker, and Ken Sylvester, ‘Climate and American History: The State of the Field’. In *Cultural Dynamics of Climate Change and the Environment in Northern America*, ed. Bernd Sommer. (Leiden: Brill, 2015). Sam White, *The Climate of Rebellion in the Early Modern Ottoman Empire*, 12–14.

decline in the grain harvest could double the price of bread in many parts of early modern Europe, yet a 50 per cent reduction quintupled it. All of this should give us pause as we contemplate our warmer future.¹¹

To write a book about such a vast topic, I had to draw some sharp and at times painful limits. The Little Ice Age undoubtedly affected land reclamation, agricultural production, pastoralism, and industry within the Dutch Republic. It influenced Dutch fisheries within the waters of the republic, the North Sea, and beyond. It helped cause catastrophic storm and river flooding, and it altered the efficiency of the West India Company, the Levantine trade, the Archangel trade, and other profitable but often brutal expressions of Dutch commercial might that are not covered in this book. Some scholars have either examined or started to examine how climate change influenced these and other aspects of the Dutch Golden Age. All the same, I was tempted to write a book that briefly touched on all these topics, one that was, in other words, a mile wide but an inch thick. Such a book, however, would have reflected a problematic trend in histories of climate change.

These histories can be wonderfully broad, covering a dizzying array of possible interactions between climate change and human affairs. But many also skip lightly over the ways in which global environmental change really affected people on the level of the transient local activities that ultimately shape human history. By ignoring how the influence of climate change cascades across different scales of space, place, and time, such books can also rest on one-dimensional understandings of causation. Ultimately, big histories like this one can either attempt to cover every aspect of a historical relationship, or give examples that reflect a broader pattern. I opt for the latter approach by exploring some of the best-sourced interactions between climate change and the history of the Dutch Golden Age. That has led me to examine weather patterns and social arrangements rarely examined by other historians, and it has, I hope, provided a novel perspective on humanity's long experience with climate change.

PREVIOUS SCHOLARSHIP AND FRESH SOURCES

The coastal regions of the Low Countries have long been especially susceptible to climate changes. They lie so far beneath sea level that even

¹¹ Parker, *Global Crisis*, 20. Fischer and Knutti, 'Anthropogenic Contribution to Global Occurrence of Heavy-Precipitation and High-Temperature Extremes', 1.

minor fluctuations in average temperature, precipitation, and storminess have made them vulnerable to flooding. Their average winter temperatures have usually lingered near freezing, so modest cooling or warming has dramatically altered the duration and extent of the ice that can form on their many waterways. They are relatively close to major extremes in atmospheric pressure, so they can endure profound changes in prevailing wind directions. Scholars have long studied how farmers and engineers have shaped the unusual environments of the Low Countries. Yet strangely, very few have investigated how the Little Ice Age changed those environments during the best-known period in the history of the Low Countries: the Golden Age of the Dutch Republic.

The reasons may lie in the dominant themes that run through historiographies of both Dutch environmental history and climate change. Historians of the Low Countries usually focus not on how environmental changes have influenced human actions, but rather on how human actions have led to environmental changes. They may mention weather, especially when describing life at sea, but they rarely describe how weather patterns changed over time in ways that mattered for people.¹² Meanwhile, historians of the Little Ice Age are often especially interested in the destructive consequences, for human beings, of climatic cooling or variability. From that perspective, the relative success of the Dutch Republic during decades of cooling and crisis might suggest that it was scarcely affected by climate changes. The prosperous Dutch appear only briefly in histories of the Little Ice Age, when they are mentioned at all.¹³

¹² For descriptions of how storms affected Dutch voyages to and within Asia, for example, see Jaap R. Bruijn, 'Between Batavia and the Cape: Shipping Patterns of the Dutch East India Company'. *Journal of Southeast Asian Studies*, 11:2 (1980): 260. Femme S. Gaastra, *The Dutch East India Company: Expansion and Decline*. (Zutphen: Uitgeversmaatschappij Walburg Pers, 2003), 114. Robert Parthesius, *Dutch Ships in Tropical Waters: The Development of the Dutch East India Company (VOC) Shipping Network in Asia 1595–1660*. (Amsterdam: Amsterdam University Press, 2010), 52. Maarten Hell and Wilma Gijsbers, 'Geborgen of gezonken, gered of verdronken: Papieren getuigen van scheepsrampen rond Texel (1575–1795)'. *Tijdschrift voor Zeegechiedenis* 31:2 (2012): 45. This book draws from two erudite collections of weather-related primary sources and histories: J. Buisman and A. F. V. van Engelen (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. IV 1575–1675*. (Franeker: Uitgeverij Van Wijnen, 2000). J. Buisman and A. F. V. van Engelen (ed.), *Duizend jaar weer, wind en water in de Lage Landen, Vol. V 1675–1750*. (Franeker: Uitgeverij Van Wijnen, 2006).

¹³ Behringer, *A Cultural History of Climate*, 111. Lamb, *Climate, History, and the Modern World*. 2nd ed., 228. Brian M. Fagan, *The Little Ice Age: How Climate Made History, 1300–1850*. (Boulder: Basic Books, 2000), 113. Brooke, *Climate Change and the Course of Global History: A Rough Journey*, 422.

The few scholars who have examined the experiences of the Dutch during the Little Ice Age have tackled one of three big topics. The first involves the long, characteristically Dutch struggle against the sea. For decades, scientists have debated the extent to which medieval warming and early modern cooling influenced the historical geography of the Low Countries. They have recently reached a rough consensus. Climate changes, it seems, played a decidedly secondary role in the hydraulic history of the Dutch Republic, one that was always mediated by human activities. Scholars in many disciplines are still struggling to sketch the precise character of these relationships, and this book draws on their efforts.¹⁴

The second big topic focuses not on the material consequences of water, but rather on the famous art of the Golden Age. For decades, interdisciplinary scholars have argued that winter scenes painted by Dutch artists in the sixteenth, seventeenth, and eighteenth centuries depicted real landscapes in a frigid climate. Very recently, scholars such as Ingrid Sager and Alexis Metzger have reinterpreted such paintings in light of the most recent scholarship on the Little Ice Age. This book draws on their findings, but takes a more sceptical approach to the relationship between cooling and art.¹⁵

The third and final topic – the one that most concerns this book – deals with whether the Little Ice Age helped or hindered the Dutch during their Golden Age. One group of scholars has tried to incorporate Dutch history within bigger narratives of disaster during the Little Ice Age. In 1985, Leo Noordegraaf wrote a short but groundbreaking article that connected cool, wet conditions in the Low Countries during the late sixteenth century to harvest failures, high food prices, decreases in the purchasing power of wages, and ultimately crisis. More recently, Adam Sundberg has examined the consequences of environmental disasters in the Low Countries that overlapped with climate changes in the early eighteenth century. Most famously, Geoffrey Parker wrote a landmark book that

¹⁴ Nienhuis, *Environmental History of the Rhine-Meuse Delta*, 240. Gottschalk, *Stormvloeden en rivieroverstromingen in Nederland*, Vol. II, 817. Gottschalk, *Stormvloeden en rivieroverstromingen in Nederland*, Vol. III, 414.

¹⁵ Alexis Metzger, 'Le froid en Hollande au Siècle d'or. Essai de climatologie culturelle'. (PhD diss., University of Paris, 2016). Ingrid D. Sager, *The Little Ice Age and 17th Century Dutch Landscape Painting, a Study on the Impact of Climate on Art*. (Dominguez Hills: California State University, 2006). Alexis Metzger, *Plaisirs de Glace: Essai sur la peinture hollandaise hivernale du Siècle d'or*. (Paris: Editions Hermann, 2012). Peter Robinson, 'Ice and Snow in Paintings of Little Ice Age Winters'. *Weather* 60:2 (2005): 37.

blames seventeenth-century cooling for catastrophes around the world, including three Dutch coups d'état. As this book shows, the weather that accompanied the chilliest phase of the Little Ice Age certainly did end lives and ruin livelihoods across the Dutch Republic. Yet, climate change also offered important commercial, military, and even cultural benefits for Dutch citizens.¹⁶

A second group of scholars has therefore viewed the Dutch Republic as a rare success story in the calamitous seventeenth century. In 1978 and 1980, Jan de Vries argued that the chilly and erratic climate of the Little Ice Age did not spell disaster for important elements of the Dutch economy. Years later, Louwrens Hacquebord found correlations between climatic cooling, bow-head whale behaviour, and years of plenty for the Dutch Arctic whaling industry. In 1996, J. R. Jones consulted scientific literature to conclude that easterly winds – that is, winds that blow from the east – and storms during the Little Ice Age aided Dutch attempts to leave port, and hindered English blockades, during the Anglo-Dutch Wars. In the following year, De Vries and Ad van der Woude briefly speculated that ‘longer-term manifestations of the [Little Ice Age] offered, on balance, more benefits to the Dutch than they imposed costs’. This book sides with that view, focusing not only on long-term correlations but also short-term relations between climate change, weather, and human affairs.¹⁷

¹⁶ Noordegraaf, ‘Dearth, Famine and Social Policy in the Dutch Republic at the End of the Sixteenth Century’, 75. Adam Sundberg, ‘Claiming the Past: History, Memory, and Innovation Following the Christmas Flood of 1717’. *Environmental History* 20:2 (2015): 238. Parker, *Global Crisis*, xvi. Jan de Vries, ‘The Crisis of the Seventeenth Century: The Little Ice Age and the Mystery of the “Great Divergence”’. *Journal of Interdisciplinary History* 44:3 (2013): 369. See also Parker and Smith, *The General Crisis of the Seventeenth Century*. Maria A. Schenkeveld, *Dutch Literature in the Age of Rembrandt: Themes and Ideas*. (Amsterdam: John Benjamins Publishing, 1991), viii. Israel, *The Dutch Republic*, 20.

¹⁷ Parker did describe Dutch successes (and Portuguese failures) in Asia, but argued that they cannot be linked to climate change. Parker, *Global Crisis*, 417. Recently, articles in a volume on Dutch admiral Michiel de Ruyter briefly linked cold winters during the Little Ice Age to events in the military and economic histories of the Dutch Republic. Prud’homme van Reine, ‘Michiel Adriaenszoon de Ruyter and his Biographer Gerard Brandt’. In *De Ruyter: Dutch Admiral*, eds. Jaap R. Bruijn and Ronald Prud’homme van Reine. (Rotterdam: Karwansaray BV, 2011), 38. Jaap Jan Zeeberg summarized some scientific reconstructions of the polar environment in the late sixteenth century, in his description of Dutch polar expeditions. Jaap Jan Zeeberg, *Terugkeer naar Nova Zembla: de laatste en tragische reis van Willem Barents*. (Zutphen: Walburg Pers, 2007), 75. Jan de Vries, ‘Measuring the Impact of Climate on History: The Search for Appropriate Methodologies’. *Journal of Interdisciplinary History*, 10:4 (Spring 1980): 626. Jan De Vries, *Barges and Capitalism. Passenger Transportation in the Dutch Economy, 1632–1839*. (Utrecht: HES Publishers, 1978), 295. Louwrens Hacquebord,

This book reaches fresh conclusions because it relies on a combination of the newest scientific scholarship and diverse textual sources, such as letters, intelligence reports, diary entries, and logs kept aboard ships, which explicitly show how weather affected human affairs. People whose lives and livelihoods depended on the weather wrote most of these documents. For example, the author of a particularly important diary, Claas Ariszoon Caeskoper, lived on the western coast of the Zaan near Amsterdam, where he worked a windmill that pressed oil. Wind and temperature influenced both the efficiency of his mill and, more substantially, the transportation of the commodities it helped produce. By affecting the extent of sea ice in the far north, weather even influenced the success of Caeskoper's investments in Arctic whaling. It is no surprise that he kept a daily record of changes in weather.

Few relied on weather more than sailors. When European mariners embarked on journeys that took them far from familiar coastlines, they started to keep detailed logs that meticulously recorded weather. One reason was that the leaders of increasingly bureaucratized admiralties and merchant companies wished to evaluate the performance of their officers. Wind direction and velocity not only provided the power supply of a sailing ship, but also constrained the ship's capacity to move where its crew desired it to go. By the fifteenth century, ships and their crews had acquired the ability to 'tack' (that is, sail) against the wind, but this was usually difficult, time-consuming work, and it was often impossible in high winds. In storms, coasts and underwater sandbanks, known as shoals, imperilled ships when they were in a 'lee' position relative to that vessel, which means that the wind blew towards the shoals and therefore pushed the ship in that direction. To a far greater extent than it does today, competent command of a merchant vessel or warship depended on exploiting, enduring, and at times anticipating the weather.¹⁸

The more important reason that sailors kept logs, however, had to do with the limits of early modern navigation. From the mid-seventeenth century, sailors could determine latitude with reasonable accuracy, but they could not easily discern longitude once they left behind known coastal landmarks. To estimate their longitude, most sailors relied on

'The Hunting of the Greenland Right Whale in Svalbard, Its Interaction with Climate and Its Impact on the Marine Ecosystem'. *Polar Research* 18:2 (1999): 155. J. R. Jones, *The Anglo-Dutch Wars of the Seventeenth Century*. (London: Longman, 1996), 18. De Vries and van der Woude, *The First Modern Economy*, 23.

¹⁸ Jaap R. Bruijn, *The Dutch Navy of the Seventeenth and Eighteenth Centuries*. (Columbia: University of South Carolina Press, 1990), 44.

‘dead reckoning’, a technique that required knowledge of three essential variables: a ship’s speed, measured by log line; its course, determined by compass; and any drift by the ship from its course. That last variable responded primarily to the direction and velocity of the wind. A ship sailing from east to west would drift south, for example, if the wind blew from the north. To have even a rough sense of where they were, sailors needed to obsessively keep track of the wind. Most ship logbooks therefore abound with reliable, detailed, and almost unbroken weather observations that sailors wrote down whenever the wind changed.¹⁹

Many landlubbers also had the means, training, and time to meticulously record even those environmental conditions that only indirectly influenced their lives. They also described how weather helped shape human activities. For instance, Adriaen van der Goes, a lawyer for the Court of Holland in The Hague, wrote letters to his brother that included detailed reports of weather in towns across the Low Countries. Meanwhile, less privileged artists and authors sketched, painted, or wrote about weather in ways that appealed to their customers.

Finally, the leaders of the republic managed affairs of state that, in a maritime country, frequently depended on weather. They are the final group of Dutch citizens whose records inform this book. The most important were the civil servants who set the agenda for the provincial council of Holland, and thereby often shaped national policy for the entire republic. Some of these officials, called ‘Land’s Advocates’ until 1619, and thereafter ‘Grand Pensionaries’, received thousands of letters during their careers. Many described how weather influenced the movement of the Republic’s fleets, the conduct of its diplomats, and the commerce of its merchants.²⁰

METHOD AND MEANING

It is very hard to clearly link climate changes, which are always gradual and global, to a local weather event that comes and goes in a matter of

¹⁹ Dennis Wheeler, ‘British Naval Logbooks from the Late Seventeenth Century: New Climatic Information from Old Sources’, *History of Meteorology* 2 (2005), 136. H. E. Lansberg, ‘Past Climates from Unexploited Written Sources’, *Journal of Interdisciplinary History*, No. 10 (1980), 631. See also R. García-Herrera et al., ‘CLIWOC: A Climatological Database for the World’s Oceans 1750–1854’, *Climatic Change* 73 (2005): 1–12.

²⁰ Bert Koene, *De Caeskopers: Een Zaanse koopmansfamilie in de Gouden Eeuw*. (Hilversum: Uitgeverij Verloren, 2011), 11. C. J. Gonnet, ‘Inleiding’. In *Briefwisseling tusschen de gebroeders van der Goes (1659–1673) Vol. I*, ed. C. J. Gonnet. (Amsterdam: Johannes Müller, 1899), XXIV.

hours or days. That makes it equally difficult to connect climatic trends to human activities on similarly short and local scales. Scientists can establish these relationships as they play out today by using supercomputers that help them interpret meteorological data collected by thousands of weather stations the world over. Since historians work with relatively limited sources, we do not have that luxury. We must wrestle with the reality that, while climate change can make some kinds of weather more or less likely to occur, all but the most extreme kinds of weather can happen in any climate, warm or cold. A weather event made more common by climate change may have altered the course of human history, yet it was not necessarily caused by climate change. The atmospheric conditions that made it possible might have been entirely anomalous. Moreover, weather that was unusual in a climatic regime could influence human history as significantly as weather that conformed to the climatic norm.²¹

I use a three-step method to address these issues of scale and causation. First, I figure out how long-term global climate changes during the Little Ice Age influenced local environments across short timeframes. For instance, I might discover that climatic cooling increased the frequency of autumn storms in the North Sea. Second, I uncover many examples of such short-term, local environmental changes affecting human activities on similar temporal and geographic scales. I might find that shipwrecks usually coincided with storms, and that survivors or weather observers often blamed them on storms. Third, I establish the big relationships between climate change and human history as they played out across decades, often in large regions. I might conclude that climatic cooling, by increasing the frequency of storms, also increased the risks associated with travel through the North Sea. The second step of this method varies with each topic I explore in this book. When I examine commerce, I connect local environments to voyages and voyagers; when I investigate war, I link them to battles; when I turn to culture, I consider distinct cultural responses, like the creation of a painting or poem. The details differ, but the method stays the same.²²

²¹ Tapio Schneider, Tobias Bischoff, and Hanna Plotka, 'Physics of Changes in Synoptic Midlatitude Temperature Variability', *American Meteorological Society* 28:6 (March 2015): 2312. Edwards, *A Vast Machine*, 289.

²² Bernstein et al., *Climate Change 2007: Synthesis Report*, 30. Fernand Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II, Vol. I*. (California: University of California Press, 1995), 102. *The Global Climate 2001–2010: A Decade of Climate Extremes – Summary Report*. (Geneva: World Meteorological Organization, 2013), 2.

Even after taking these steps, historians who study climate change – ‘climate historians’ – are still left to confront one of the thorniest concepts in climate scholarship: probability. Of course, most historical narratives deal in probability, because historians can rarely establish beyond doubt all the little connections that together link historical trends and events. They use the best evidence they can find to write the most plausible narratives that bind the general to the particular. Yet in climate scholarship, the trends are especially vast, and connecting them to distinct events on a human scale is particularly daunting. Some of the steps in my method therefore yield more probable relationships than others. The connections between weather and human activities that I trace in this book, which unfold on similar scales, rest on firmer ground than those I establish between weather and climate change, or between climate change and the grand sweep of human history.

There is also another kind of probability that climate historians should consider. Historians of all stripes can fall into simplistic determinism – the idea that a single force or set of forces predetermined the course of human history – but that trap may be especially dangerous for climate historians. Historians have only recently had access to scientific climate reconstructions and methods for deciphering weather information in old documents that permit them to track the consequences of climate change at the local level. In past decades, scholars in various disciplines repeatedly made sweeping assumptions about relationships between climate changes and human history on century timescales that provoked deep and enduring scepticism among mainstream historians.²³ In fact, the big structures that give shape to human history – cultural, socioeconomic, and political – have always mediated, or channelled, how weather influenced by climate change affected individual people. Decisions made by individuals in the face of these pressures then reshaped historical structures in ways that transformed how they registered climate change. Ultimately, this book shows that climate changes led to weather that limited or expanded the choices open to people, but did not determine their actions.²⁴

²³ For a classic example, see Robert Claiborne, *Climate, Man and History*. (London: Angus and Robertson, 1973).

²⁴ Helge Salvesen, ‘The Climate as a Factor of Historical Causation’. In *European Climate Reconstructed from Documentary Data: Methods and Results*, ed. Buckhard Frenzel. (Stuttgart: Gustav Fischer Verlag, 1992), 219. Elizabeth Jones, ‘Climate, Archaeology, History, and the Arthurian Tradition: A Multiple-Source Study of Two Dark-Age Puzzles’. In *The Years without Summer: Tracing AD 536 and Its Aftermath*, ed. J. D. Gunn. (Oxford: Archaeopress, 2000), 31.

Climate historians deal with quantified data that reflect gradual and often global shifts in environmental conditions. For that reason, it might seem appropriate that they consider human activities only by using quantitative evidence on a similar scale. For example, a climate historian examining a country or continent might connect century-scale climatic cooling to an overlapping decrease in the length of the growing season, and a corresponding decline in living standards in agricultural economies. Climate historians can certainly make good use of big data, but they should try to support their analyses of vast quantitative trends with qualitative accounts of short-term events on a local level. Quantitative records, after all, do not necessarily provide a more accurate or objective picture of the past. They still reflect the subjective judgements of human beings, and their meaning is always determined by their context. It is therefore problematic for historians to link quantitative datasets based solely on the presence of overlapping statistical trends. Correlation need not imply causation.

Climate historians should instead attempt to link climate change to local, short-term human activities by establishing a chain of probable causality that binds the general to the particular. To grasp how a big trend affected human history, historians need to understand how that trend manifested on the small scale that mattered to individual people. This book therefore reaches firm conclusions only when convincing qualitative sources are available to connect different quantitative trends by providing first-hand accounts of how weather influenced human affairs. To gain further insight into these interactions, most chapters in the book compare trends or events in colder, wetter, stormier decades of the Little Ice Age with those in warmer, drier, and more tranquil periods. Such comparisons can make it easier to isolate the influence of climate change in human history.²⁵

The history of climate change is closely linked to the history of energy. The chilliest phase of the Little Ice Age unfolded in an era of organic economies. In them, human or animal muscles joined technologies such as the sail and mill to harness energy only recently released by the sun. Most people lived off the land, in dispersed communities that had little to trade with one another. It took the extensive exploitation of ancient solar

²⁵ Fernand Braudel, *The Mediterranean and the Mediterranean World in the Age of Philip II*, 355. Edwards, *A Vast Machine*, 4. Jan de Vries, 'The Economic Crisis of the Seventeenth Century after Fifty Years'. *Journal of Interdisciplinary History* 40:2 (2009): 164.

energy bound up in fossil fuels to transform these conditions. Historians have debated whether the Dutch Republic exceeded the limits of the organic economy. The republic's high levels of urbanization, extensive networks of trade, thriving industrial centres, and commercialized agriculture are often perceived as symptoms of, and stimulus for, an unusually efficient energy supply.²⁶

This book finds that the resilience of the republic in the face of the Little Ice Age partly reflected how the Dutch used energy, and how much they had to use. In organic economies, cool temperatures, precipitation extremes, and unpredictable weather ruin harvests and thereby reduce the dominant source of useable energy, often with disastrous consequences for human beings. Many climate historians accordingly assume that climate change most directly impacted human history by altering the growth and health of staple crops. Yet the Dutch imported a substantial share of their food in the same way that they established a world-straddling commercial empire: by exploiting the energy of wind on the relatively friction-free surface of water. Often, weather that undermined the supply of useable energy for farmers and pastoralists actually increased how much energy the Dutch could use on their ships. Dutch admirals even developed strategies to exploit as much of this energy as possible. Entrepreneurs also invented technologies that helped the Dutch efficiently harness energy from wind, water, and peat during the chilliest decades of the Little Ice Age. The impacts of climate change on Dutch commerce and conflict, at least, do not seem to have been less direct or less important than the impacts on agriculture. A focus on energy therefore calls into question some long-standing assumptions in climate history.²⁷

²⁶ E. A. Wrigley, *Continuity, Chance and Change: The Character of the Industrial Revolution in England*. (Cambridge: Cambridge University Press, 1988), 57. R. W. Unger, 'Energy Sources for the Dutch Golden Age; Peat, Wind and Coal'. *Research in Economic History* 9 (1984): 228. C. A. Davids, *The Rise and Decline of Dutch Technological Leadership: Technology, Economy and Culture in the Netherlands, 1350–1800*, Vol. I. (Leiden: Brill, 2008), 17. Karel Davids, 'Technological Change and the Economic Expansion of the Dutch Republic, 1580–1680'. In *The Dutch Economy in the Golden Age: Nine Studies*, eds. C. A. Davids and L. Noordegraaf. (Amsterdam: Nederlandsch Economisch-Historisch Archief, 1993), 83. Vaclav Smil, *Energy in World History*. (Boulder: Westview, 1994), 248. John Landers, *The Field and the Forge: Population, Production and Power in the Pre-Industrial West*. (New York: Oxford University Press, 2003), 7.

²⁷ Chantal Camenisch et al., 'The 1430s: A Cold Period of Extraordinary Internal Climate Variability during the Early Spörer Minimum with Social and Economic Impacts in North-Western and Central Europe'. *Climate of the Past* 12 (2016): 2118.

THE STRUCTURE OF THIS BOOK

Chapter 1 introduces the human and environmental histories that frame this book. It describes why climates change, explains how scholars reconstruct past changes, and surveys what the Little Ice Age looked like globally and across the Low Countries. The book then unfolds in three parts, each with two chapters that establish connections between climate change and a pillar of Dutch prosperity.

The first part of the book traces how the Little Ice Age affected Dutch commerce by altering the ability of mariners and merchants to move through their world. It argues that climate changes occasionally hampered but often benefitted different kinds of Dutch trade and travel. Chapter 2 shows that the Little Ice Age influenced Dutch attempts to establish and maintain commercial connections with Asia. It starts by examining Dutch expeditions to the Arctic in the sixteenth and early seventeenth centuries, which were undertaken to map a new route to Asia. The local consequences of climatic cooling helped thwart attempts to chart a passage, but also led to discoveries that transformed understandings of the Arctic and encouraged the growth of a lucrative but ecologically destructive whaling industry. Next, the chapter considers trade undertaken by the Dutch East India Company (*Vereenigde Oostindische Compagnie*, or VOC) along the southern passage to Asia. It concludes that changes in atmospheric circulation over the Atlantic Ocean increased the risks, but also the speed, by which goods, people, and information moved between the republic and Asia.

Chapter 3 begins by examining how climate change influenced Dutch commerce in the Baltic Sea. The chapter traces how winter freezing and frequent storms hampered travel through the Baltic during the chilliest periods of the Little Ice Age. Yet it demonstrates that the republic's merchants also responded creatively to the risks imposed by frequent gales, and profited when climatic shocks contributed to higher grain prices elsewhere in Europe. The chapter continues by investigating travel within the republic's borders. It reveals that the Dutch Republic's diverse networks of transportation helped its citizens maintain their mobility during even the coldest phases of the Little Ice Age.

The second part of this book investigates how climate changes affected Dutch armies and fleets in the wars that established the Republic and preserved its commercial primacy. It argues that complex relationships between global climate changes and regional environments provided important advantages to Dutch forces during the chilliest decades of the

Little Ice Age. Chapter 4 finds connections between a shifting climate and the Dutch struggle for independence from the Spanish Empire, known as the Eighty Years' War (1568–1648). It describes how climatic cooling exacerbated existing vulnerabilities in Spain's control of the Low Countries and thereby helped provoke a rebellion in 1568. It continues by examining relationships between climate change and different phases of the Eighty Years' War. Cold, wet, and stormy conditions, common during a chillier climate, impeded offensive operations from the escalation of the Dutch rebellion in 1572 to the signing of the Twelve Years' Truce in 1609. Such weather usually offered important advantages to Dutch soldiers and sailors as they fought to defend their rebellion from Spain. Yet in the late 1620s and the 1630s, a warmer, drier break in the Little Ice Age provided advantages for offensive campaigns just as France allied with the republic and as the Spanish Empire entered another war. Dutch armies then expanded the republic's borders by exploiting both favourable strategic circumstances and beneficial weather.

Chapter 5 investigates hostilities between the Dutch Republic and its rising commercial competitor, England, during the onset of the Maunder Minimum. It explains that key differences between English and Dutch naval systems led each to respond differently to climatic cooling and its associated changes in atmospheric circulation. It shows that, in the first Anglo-Dutch War (1652–1654), prevailing westerly winds granted crucial advantages to English fleets. Yet easterly winds grew more common as the Maunder Minimum deepened, benefitting Dutch fleets, which had adopted English tactics and technology. Frequent and persistent easterlies would later aid the republic's invasion of England during the Glorious Revolution of 1688.

The third part of this book argues that the culture of the Dutch Golden Age responded to the Little Ice Age in ways that contributed to the resilience of the republic in the face of climate change. Chapter 6 shows that some of the republic's citizens developed a vague awareness of climate change, which may have informed commercial and military strategies aimed at exploiting the opportunities it offered. The chapter then explains how the paintings of the Golden Age occasionally depicted the real consequences of climate change and often reflected the pragmatic attitudes of the Dutch amid the weather of the Little Ice Age.

Chapter 7 traces how climate changes influenced texts and technologies. It reveals that symbols in many maps and pamphlets partly registered the weather of the Little Ice Age. It then investigates weather metaphors in Dutch poetry and the rise of a poetic genre that responded

to real weather-related disasters. Next, the chapter traces the development of ice cultures that emerged in frigid winters, and explains the reluctance of Dutch citizens to persecute so-called witches for weather-related disasters, restraint unusual in early modern Europe. Finally, it reveals how and why the Dutch invented or implemented technologies that helped them thrive amid the chilliest phases of the Little Ice Age.