STRANGE AND TERRIBLE WONDERS:

CLIMATE CHANGE IN THE EARLY MODERN WORLD

A Dissertation

by

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ABSTRACT

The study of climate and climatic change began during the Little Ice Age of the early modern world. Beginning in the sixteenth century, European clerics, scientists, and natural philosophers penned detailed observations of the era's unusually cool and stormy weather. Scouring the historical record for evidence of similar phenomena in the past, early modern scholars concluded that the climate could change. By the eighteenth century, natural philosophers had identified at least five theories of climatic change, and many had adopted some variation of an anthropogenic explanation. The early modern observations described in this dissertation support the conclusion that cool temperatures and violent storms defined the Little Ice Age. This dissertation also demonstrates that modern notions of climate change are based upon 400 years of rich scholarship and spirited debate.

This dissertation opens with a discussion of the origins of "climate" and meteorology in ancient Greek and Roman literature, particularly Aristotle's *Meteorologica*. Although ancient scholars explored notions of environmental change, climate change—defined as such—was thought impossible. The translation and publication of ancient texts during the Renaissance contributed to the reexamination of nature and natural variability. In the sixteenth century, most scholars interpreted weather phenomena through the lenses of theology, astrology, and meteorology. None of these provided a model for great winters or long-term climatic change. The first great storms of the Little Ice Age encouraged observant scholars to construct meteorological

chronicles to facilitate the comparison of ancient and modern weather events. The first references to climatic change date to this era, though most observers concluded that contemporary phenomena were no worse than their predecessors. The Scientific Revolution transformed the practice of meteorology in seventeenth-century Europe. Professional scientific organizations encouraged careful observation, standardized reporting, and collaborative research. Late seventeenth-century scientists proposed the first natural, rather than theological, theories of climatic change, while eighteenth century geologists and historians worked to incorporate new weather records into their conclusions. By the early nineteenth century, most scholars acknowledged some degree of climatic change, and many concluded that human civilization bore some responsibility.

DEDICATION

To my parents.

ACKNOWLEDGMENTS

Many historians have reflected on the unusually personal nature of writing history. We invite ourselves into the lives of people we will never meet to explore the world in which they lived. It is a task that requires great caution and respect—especially when writing about the fear that accompanies natural disasters. The study of history, however, is personal in another way: It is always collaborative. This dissertation is based upon seven years of classwork, archival research, writing, and editing, and many individuals—some unknown—have contributed in measures small and great. Space sadly precludes a comprehensive list, but I would like to recognize the contributions of a few people and organizations who made this dissertation possible.

I am indebted to Texas A&M University, the College of Liberal Arts, and the Department of History for the opportunity they provided me to accomplish my goals. I am particularly grateful to Chester S. L. Dunning, the chair of my committee, who has guided me through the completion of my thesis and dissertation. Most importantly, he has become a trusted advisor and dear friend. I am also grateful to professors Joseph G. Dawson III, R. J. Q. Adams, and Peter J. Hugill. Like Professor Dunning, these gentlemen have served as members of my committee for the entirety of my time at Texas A&M. I have learned much from their professionalism, scholarship, and good humor. Several other professors have provided guidance and friendship during my time in College Station. I would like to express my appreciation to Arnold Krammer, David Hudson, Walter Kamphoefner, Andrew Kirkendall, Olga Dror, Philip Smith, Sylvia

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I completed this dissertation after returning home to Northwestern State University in Natchitoches, Louisiana. I am grateful for the opportunity Northwestern provided me to complete my dissertation while teaching geography and history. As an instructor, I have experienced the rare blessing of standing on the other side of the very classrooms where I began my studies more than a decade ago. My great-grandfather, Alexandros Egyptiades (Albert George Alexander), a Greek immigrant from modern-day Turkey, began his career as a literature professor in Natchitoches almost 100 years ago. It has been great fun to follow in his footsteps this year. I would like to express my kind regards to Joe Morris, head of the Department of Criminal Justice, History, and Social Sciences, Lisa Abney, Provost and Vice President for Academic and Student Affairs, and President James Henderson. While at Northwestern, I have been fortunate to study and work with several wonderful historians and geographers, including Susan Dollar, Kent Hare, Charles Pellegrin, Jeff Smith, Kathleen Smith, James MacDonald, Dean Sinclair, Greg Granger, the late Marietta LeBreton, and the late John Price. I am grateful for their friendship, guidance, and support.

I have also been fortunate to study alongside dozens of kind, funny, and brilliant graduate students at Texas A&M. We have shaped each other’s work formally and informally, in class and at dinner, and I am grateful for that experience. Separation is bittersweet, but I expect many of these friendships to endure. Jared Donnelly, Jennifer Heth, Jessica Herzogenrath, and Matthew Yokell provided valuable encouragement and criticism of that most difficult chapter of any project—the first. I am grateful to Brandon Ward and Damon Chengelis for encouraging my research in its earliest phases, and I am thankful for the fellowship I have shared with numerous others, including Ralph Morales, Brad Cesario, Marshall Yokell, and Jeff Crean. I am thankful for the many friends and family who have supported and encouraged me during my time in College Station, and I am especially grateful to Chuck Bourg and Perry Johnson, who helped me return to Louisiana upon completion of my studies.

Finally, I am grateful to my parents, Gil and Kay Gilson. There are no words capable of expressing the gratitude that I have for their support. I wrote most of this dissertation on their patio, surrounded by the sights, sounds, and scents of several spring and summer seasons. To my great amusement, several of those seasons were unusual, including one of the snowiest winters (2013-14), mildest summers (2014), and wettest springs (2015) in recent (and recorded) memory. Earning a Ph. D. in History is difficult, though, and my parents have supported my studies every step of the way. They have sacrificed nights and weekends to visit me in Texas or to read manuscripts of seminar papers and dissertation chapters. I am eternally grateful for their kindness, guidance, and love. Thank you.

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CHAPTER I

INTRODUCTION

The study of climatic change has motivated widespread reassessment of the early modern world. Historians, geographers, and other scholars have increasingly turned to climate to help explain land-use patterns, subsistence crises, and the origins of social upheaval and state breakdown. Some have focused on the history of climate, others the role of climate in history, and still others the history of ideas about climate. The Little Ice Age of 1550 to 1850 is the cornerstone of such research. Conditions varied spatially and temporally, but many climatologists agree that average temperatures in the Northern Hemisphere were about 1°C cooler during the Little Ice Age than in preceding and subsequent centuries. Extreme winters and cool summers were more common. Infrequently-frozen rivers played host to numerous Frost Fairs, and glaciers expanded to limits unknown in the historical era. Like its predecessor, the Medieval Warm Period of 900 to 1300, the Little Ice Age invokes the idea of measurable, coherent, and significant climatic uniqueness. Uncertainties remain, however, about the contours of early modern climate change. This dissertation addresses one aspect of such uncertainty by examining contemporary reactions to the unusual weather of the Little Ice Age. It demonstrates that theories of climatic change are not unique to the twenty-first century, and that quarreling over climate has a very long history.

Widespread historical interest in climatic change is a relatively recent phenomenon. For much of its tenure, professional history provided little room for the examination of environmental circumstances. The loathed moniker of "climatic determinist" served as a powerful deterrent to interest in the subject. Though historians were perhaps late in developing such an interest, scholars of other disciplines began assembling detailed histories of climate and climatic change in the late nineteenth century. Around the end of the nineteenth century, there was a "vigorous," if short-lived, "debate in science and society about global climate variability."[1] Austrian geographer Eduard Brückner was one of the "central protagonists" of this debate. His study of eighteenth and nineteenth century climates led him to conclude that atmospheric and hydrological conditions varied with time; he later suggested that climate changed in cycles of approximately thirty-five years.[2] German sociologist Nico Stehr described Brückner's *Climate Change since 1700* as the first "extensive book-length discussion" of historical climate change.[3] Like many subsequent scholars, Brückner was drawn to the impact of such variations on harvests and grain prices.[4]

Several notable geographers were engaged in aspects of this debate, including Ellsworth Huntington of the United States, Peter Kropótkin of Russia, Halford

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[1] Nico Stehr and Hans von Storch, "Eduard Brückner's Ideas—Relevant in His Time and Today" in *Eduard Brückner—The Sources and Consequences of Climate Change and Climate Variability in Historical Times* (Dordrecht: Kluwer Academic Publishers, 2000), 2.

[2] See Eduard Brückner, "In wie weit ist das heutige Klima konstat?," in *Verhandlungen des VIII Deutschen Geographentages* (Berlin: Dietrich Reimer, 1889); Eduard Brückner, *Klimaschwankungen seit 1700* (Vienna: E.D. Hölzel, 1890); Eduard Brückner, "Zur Frage der 35jährigen Klimaschwankungen," *Petermann's Mittheilungen* 48 (1902).

[3] Stehr and von Storch, "Brückner's Ideas," 7.

[4] See Eduard Brückner, "Der Einfluß der Klimaschwankungen auf die Ernteerträge und Getreidepreise in Europa," *Geographische Zeitschrift* 1 (1895).

Mackinder of Great Britain, and Charles Rabot of France. Mackinder and Kropótkin briefly debated the desiccation of Asia, but Huntington and Rabot dealt more frequently and explicitly with climatic change.[5] Like Brückner, Huntington was interested in the history of climate and its impact on human society. Though often described as a climatic determinist, Huntington's initial goal was to encourage historians and geographers to account for climate.[6] He played an important role in transmitting ideas about climatic change—particularly those of Brückner—to a wide audience of laymen and scholars.[7] Charles Rabot also shared Brückner's interest in the climate of historical times. Drawing on research completed in the Alpine village of Chamonix, Rabot developed the outlines of the climatic period now known as the Little Ice Age. He described a series of glacial expansions and recessions that began "[i]n the last years of the sixteenth century or at the beginning of the seventeenth" and ended with a final

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[5] The contours of this debate are apparent in the discussion surrounding two 1904 publications. See Halford Mackinder, "The Geographical Pivot of History," *The Geographical Journal* 23, no. 4 (April 1904); "The Geographical Pivot of History: Discussion," *The Geographical Journal* 23, no. 4 (April 1904); Peter Kropótkin, "The Desiccation of Eur-Asia," *The Geographical Journal* 23, no. 6 (June 1904); "The Desiccation of Eur-Asia: Discussion," *The Geographical Journal* 23, no. 6 (June 1904). For additional analysis, see Gerry Kearns, *Geography and Empire: The Legacy of Halford Mackinder* (Oxford: Oxford University Press, 2009); Brian Blouet, *Halford Mackinder: A Biography* (College Station, TX: Texas A&M University Press, 1987).

[6] In 1913 Huntington published an open letter in the *American Historical Review* encouraging historians to pay attention to the influence of climate on history. See Ellsworth Huntington, "Changes of Climate and History," *American Historical Review* 18, no. 2 (January 1913).

[7] Stehr and von Storch, "Brückner's Ideas," 8.

advance between 1850 and 1855. Rabot asserted that the subsequent glacial recession marked "a turning-point in the history of [Alpine] glacial vicissitudes."[8]

The term "Little Ice Age" appeared in a 1909 guide to botany, but most scholars first encountered it after its use in a 1939 report by the American Geophysical Union's Committee on Glaciers. American glaciologist François Matthes, chairman of the Committee, used the term to describe the climate of the preceding 4,000 years. Drawing on Rabot's chronology of post-medieval glacial movements, however, Matthes addressed climatic change on both millennial and centennial scales.[9] The two scales were closely related. Matthes argued that the centuries following the Middle Ages were the apogee of the 4,000-year "little ice-age." Later geographers and climatologists, including D. J. Schove and Gordon Manley, worked to refine descriptions of early-modern climate through their respective research on the Little Ice Age and the temperature record of England between 1650 and 1950.[10]

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[8] Charles Rabot, "Récents travaux glaciaires dans les Alpes françaises," *La Géographie* 30 (1914-15): 257. Translation mine.

[9] George F. S. Elliot, *Botany of To-Day: A Popular Account of Recent Notable Discoveries* (Philadelphia: J. B. Lippincott Company, 1909), 226; François Matthes, "Report of Committee on Glaciers, April 1939," *Transactions of the American Geophysical Union* (1939): 519.

[10] Schove's discussion of the Little Ice Age was part of a larger discussion anchored by a C. E. P. Brooks essay. "Causes of Climatic Fluctuations," *The Quarterly Journal of the Royal Meteorological Society* 75, no. 324 (April 1949): 172-85; Gordon Manley, "The Mean Temperature of Central England, 1698-1952," *Quarterly Journal of the Royal Meteorological Society* 79, no. 340 (April 1953); Gordon Manley, "Temperature Trends in England, 1698-1957," *Theoretical and Applied Climatology* 9, no. 3 (December 1958); Gordon Manley, "Central England temperatures: monthly means 1659 to 1973," *Quarterly Journal of the Royal Meteorological Society* 100, no. 425 (July 1974).

The first historians to seriously contend with the role of climate in history were the *Annalistes*, who were associated with the French journal *Annales: Économies, Sociétés, Civilisations*. The *Annalistes* cultivated an interest in climatic change, glaciers, land-use, and harvest dates, but they were reluctant to ascribe much influence to climate because of their opposition to the "cycle-mad" interpretations then prevalent in historical scholarship. The noted French historian Fernand Braudel was among the first in this tradition to write at length on the role of geography and climate in early modern European history. Braudel dedicated one chapter of *The Mediterranean and the Mediterranean World in the Age of Phillip II* (1949) to climate, describing it as the "source of physical unity" of the coastal peoples of the Mediterranean.[11] "It is a matter of some importance to the historian," he wrote, "to find . . . almost everywhere within his field of study the same climate, the same seasonal rhythm, the same vegetation, the same colours, and . . . the same landscapes."[12] Well-aware of the marginal existence of Mediterranean peasants, Braudel also discerned widespread sensitivity to small shifts in temperature and precipitation. He was cautiously intrigued by theories of climatic change. Though more inclined to attribute such alteration to the influence of humans on climate, he acknowledged that the existence of a cool, wet period between 1600 and

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[11] Fernand Braudel, *La Méditerranée et le monde méditerranéen à l'époque de Philippe II* (Paris: A. Colin, 1949); Braudel, *The Mediterranean and the Mediterranean World in the Age of Phillip II*, trans. Siân Reynolds (1972; Berkeley: University of California Press, 2005), I:231.

[12] Ibid., I:235.

1900 would help explain many of the incidences of frost, flood, and migration he had uncovered.

Responses to Braudel's treatment of Mediterranean climates illustrate the transformation occurring within the historical profession. Critics initially called him "imprudent" for his discussion of climate and climatic change. In 1955, however, Swedish historian Gustaf Utterström suggested that Braudel's cautious approach was, in fact, "timid." Utterström asserted that the European climate was unusually cool between 1300 and 1460 and between 1560 and 1700, a period he called the "little ice age."[13] He marshaled a broad array of evidence for such climatic change, including changes in cereal production in Iceland, wine production in England, and glacial expansion. Utterström's publication piqued the interests of the *Annalistes* and particularly that of French historian Emmanuel Le Roy Ladurie. Le Roy Ladurie explored the extent to which social and economic events could be traced to climatic variations, a process that culminated in *Histoire du Climat Depuis l'An Mil* (1967), later published as *Times of Feast, Times of Famine* (1971).[14] Though complimentary of Utterström's "rich harvest of facts and data," Le Roy Ladurie remained unconvinced that there was sufficient evidence to demonstrate a direct relationship. Braudel and Le Roy Ladurie maintained

[13] Ibid., I:272; Gustaf Utterström, "Climatic fluctuations and population problems in early modern history," *The Scandinavian Economic History Review* 3, no. 1 (1955), quoted in Emmanuel Le Roy Ladurie, *Times of Feast, Times of Famine: A History of Climate since the Year 1000*, trans. Barbara Bray (Garden City, NY: Doubleday & Company, 1971), 8-9.

[14] See also Emmanuel Le Roy Ladurie, "Histoire et climat" *Annales* 14, no. 1 (1959).

their interests in the history of climate. When Braudel revised *The Mediterranean World* for republication in the 1960s and 1970s, he closed his chapter on climate with an unequivocal statement: “The ‘early’ sixteenth century was everywhere favoured by the climate; the latter part everywhere suffered atmospheric disturbance.”[15] Though often cautious, Le Roy Ladurie and Braudel introduced many historians to the potential significance of climate, particularly after the translation of their publications into English in 1971 and 1972.

The work of the *Annalistes* generated considerable interest among the growing community of interdisciplinary historians. Subsequent scholars were far more open to incorporating climatic data into their conclusions. In a review of the English translation of *Times of Feast, Times of Famine*, historian John Post suggested that Le Roy Ladurie’s “pessimism and distrust of climatic explanation appears to have been carried too far.” Post’s primary criticism was that Le Roy Ladurie failed to appreciate the “indirect and subtle” impact of climate on human society. The existence of secular economic and demographic trends did not preclude climatic influence; they merely created dynamic situations. Annual temperature variations of only 1°C were deceptively insignificant, he argued, because annual means “often conceal critically large seasonal variations.” Identifying climate as an independent variable required comparing such seasonal variations, within the context of local environments, across large areas. When “phenomena occur synchronously over an international expanse in a traditional

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[15] Braudel, *The Mediterranean*, I:275.

economy," Post asserted, "the primary explanatory factor will invariably prove to be meteorological."[16] He reiterated this position in later research on the "Year without a Summer," 1816, highlighting the significance of volcanic activity in shaping the conditions of agriculture and trade.[17]

Hubert H. Lamb's *Climate, History, and the Modern World* (1982) further narrowed the crevasse between historical and climatological research. Lamb sought to do three things: introduce readers to the mechanics of climate, trace the "record of its vicissitudes," and discuss its impact on human history.[18] One of the most important of these vicissitudes, he argued, was the Little Ice Age. Lamb emphasized the importance of the Little Ice Age for the sixteenth and seventeenth centuries, describing the eighteenth and nineteenth centuries as a period of "wide variability" and erratic recovery.[19] At its apogee, the Little Ice Age was the "coldest regime . . . since the last major ice age" and the "only time for which evidence from all parts of the world indicates a colder regime than now."[20] Lamb did not limit himself to tracing the history of climate. Undeterred by the label of "climatic determinist," which he believed "only tends to restrict freedom of thought," he also addressed the potential consequences of climatic change. Lamb proposed a simple, though elegant, argument that climatic

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[16] John D. Post, "Meteorological Historiography," *Journal of Interdisciplinary History* 3, no. 4 (Spring 1973): 725-28.

[17] See John D. Post, *The Last Great Subsistence Crisis in the Western World* (Baltimore: Johns Hopkins University Press, 1977).

[18] Hubert H. Lamb, *Climate, History and the Modern World*, 2nd ed. (1982. London: Routledge, 1995), 6.

[19] Ibid., 242-43.

[20] Ibid., 212.

change influences history on a multiplicity of levels—some gradual and hard to discern, others, like glacial expansion, unavoidable.[21] For Lamb, human history and climate were "not wholly independent" but rather "partly interactive systems."[22]

Many scholars interested in the climate of the historical past wrote about the Little Ice Age as part of their research. Jean Grove's *The Little Ice Age* (1988) was the first book-length investigation of the subject. Grove, a glaciologist, hewed closely to Matthes' original interest: the expansion and recession of glaciers. She suggested that the Little Ice Age began in the thirteenth and fourteenth centuries, paused for "an interval of more clement conditions," and peaked between the mid-sixteenth and mid-nineteenth century.[23] Grove acknowledged that the term "Little Ice Age" was "originally applied to a quite different time period," though she suggested that Matthes was "well-aware" of more recent glacial fluctuations. Grove paid closer attention to the complexities of Matthes' employment of the term than most scholars, but she did not discuss the sources of his ideas about climatic change. Much of Grove's analysis of Little Ice Age conditions focused on responding to other criticisms of the idea of the Little Ice Age, principally those that implied that it was "insignificant in scale," "not worldwide," and "not an Ice Age."[24] Grove's analysis of the glacial history of Iceland, Scandinavia, the Alps, Asia, Greenland, and North America suggested "a coherence which justifies a single name." This history, she asserted, "provides excellent

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[21] Ibid., 4, 283.
[22] Ibid., 6.
[23] Jean Grove, *The Little Ice Age* (London: Methuen, 1988), 1.
[24] Ibid., 3.

confirmation of Matthes's hunch" that post-medieval glaciation was the critical phase in a 4,000-year period of glaciations.[25]

Though Grove dismissed, and seemed to have disproven, many of the criticisms of the Little Ice Age, several of these uncertainties have become a recurring theme in essays on the subject. In 1992, Philip Jones and Raymond Bradley described Matthes' original employment of the term as "informal (not capitalized)," but they referenced only two of Matthes' publications and offered no discussion of the meaning of formality. They also addressed the "considerable uncertainty" of the timing and coherence of the Little Ice Age. Strongly disagreeing with Grove, Jones and Bradley suggested that the history of climate "is not well-served by the continued use of the term 'Little Ice Age'":

> The period experienced both warm and cold episodes and these varied in importance geographically. There is no evidence for a world-wide synchronous and prolonged cold interval to which we can ascribe the term "Little Ice Age". Only a few short cool episodes (lasting sometimes for up to 30 years) appear to have been synchronous on the hemispheric and global scale. These are the decades of the 1590s-1610s, the 1690s-1710s, the 1800s-1810s and the 1880s-1900s.[26]

Jones, with Astrid Ogilvie, Trevor Davies, and Keith Briffa, reiterated these concerns in 1998. The four scholars suggested that late twentieth-century multiproxy temperature averages, which incorporate data from around the globe, render concepts like the Medieval Warm Period and the Little Ice Age "barely recognizeable." They also found

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[25] Ibid., 5.

[26] Philip D. Jones and Raymond S. Bradley, "Climatic variations over the last 500 years," in *Climate Since A.D. 1500*, ed. Raymond S. Bradley and Philip D. Jones (London: Routledge, 1992), 658.

it "worth noting" that Matthes' applied his "little ice-age" to "the entire period of the past 4,000 years." [27]

Brian Fagan's *The Little Ice Age: How Climate Made History, 1300-1850* (1998) is one of the best-known books about the Little Ice Age. Although Fagan wrote for a wide audience, his history of the Little Ice Age remains a strong introduction for both scholars and laymen. He discussed the Medieval Warm Period, the Little Ice Age, and the Modern Warm Period, as well as the mechanics and historical significance of climatic change. Fagan emphasized the impact of famine, dearth, and the expansion of glaciers on European peasants and Alpine villagers. The book's stylized timelines of historical events and climatic circumstances are among its valuable contributions. Fagan, however, raised many of the same questions about the definition of the Little Ice Age. He took a long view of the epoch's chronology, beginning with the fourteenth century, though he did not discuss the more clement conditions of the early sixteenth century. Fagan also argued that Matthes used the term "little ice-age" in "a very informal way, did not even capitalize the words and had no intention of separating the colder centuries of recent times from a much longer cooler and wetter period that began in about 2000 B.C."[28]

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[27] Philip D. Jones, Astrid E. J. Ogilvie, Trevor D. Davies, Keith R. Briffa, "Unlocking the Doors to the Past: Recent Developments in Climate and Climate Impact Research," in *History and Climate: Memories of the Future?*, ed. Philip D. Jones, Astrid E.J. Ogilvie, Trevor D. Davies, Keith R. Briffa (New York: Kluwer Academic, 2001), 3-4.

[28] Brian Fagan, *The Little Ice Age: How Climate Made History, 1300-1850* (New York: Basic Books, 2002), 47-48.

Ogilvie, with Trausti Jónsson, addressed the terminology of the Little Ice Age once more in 2001. They suggested that it was important to address the early usage of the term, but they referenced few sources published between 1939 and the 1970s. Ogilvie and Jónsson described the Little Ice Age as a "mid-twentieth century construction" that entered popular parlance in the 1970s. They speculated that it gained the title of "ice age" because "climatologists and palaeoclimatologists in the early and middle part of the twentieth century" found it "tempting to compare what they perceived to be an interesting phenomenon with a similar episode (albeit of greater magnitude) in the past."[29] Because its definition has remained "elusive" and often "self-reinforcing," Ogilvie and Jónsson assert that their "preference . . . would be to see it disappear from use."[30]

The quantity of documentary and proxy records of climate has changed dramatically since the early attempts of Utterström and Le Roy Ladurie to assess the chronology and significance of the Little Ice Age. Such records allow historians to draw increasingly specific conclusions about the relationship between climatic change and particular historical events. Geoffrey Parker is the most prominent practitioner of such focused analysis. In both editions of *Europe in Crisis, 1598-1648*, Parker emphasized the importance of the Little Ice Age for the 1640s, the decade "with the highest

[29] Astrid E. J. Ogilvie and Trausti Jónsson, "'Little Ice Age' Research: A Perspective from Iceland," *Climatic Change* 48, no. 1 (2001), in *The Iceberg in the Mist: Northern Research in Pursuit of a "Little Ice Age,"* ed. Astrid E. J. Ogilvie and Trausti Jónsson (Dordrecht, The Netherlands: Kluwer Academic Publishers, 2001), 10-12.

[30] Ibid., 13, 44.

incidence of rebellions and famines."[31] Parker further developed this theme in "Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered," part of an *American Historical Review* forum on the Crisis of the Seventeenth Century. Parker asserted that the mid-seventeenth century was an era of global crisis. Major incidences of state breakdown and social unrest occurred almost simultaneously throughout Europe, Asia, Anatolia, Africa, and the Americas. Societies experienced unusually high levels of mortality, while conflict became more frequent and enduring.[32] Drawing on Voltaire, Parker suggested a synergistic understanding of seventeenth-century unrest that emphasizes climate, government, and religion.[33]

"Crisis and Catastrophe" developed out of a much larger project that Parker completed a few years later. *Global Crisis: War, Climate Change, and Catastrophe in the Seventeenth Century* is arguably the most important contemporary resource for understanding early modern climate. Focusing on the period between 1618 and 1689, Parker examines the consequences of climatic change in China, Russia, Poland-Lithuania, the Ottoman Empire, Germany, Spain, France, Britain, the Mughal Empire, Italy, the Americas, Africa, Australia, and Tokugawa Japan—with particular emphasis on their comparative resilience in the face of environmental change. According to

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[31] Geoffrey Parker, *Europe in Crisis, 1598-1648*, 2nd ed. (Oxford: Blackwell Publishers, 2001).

[32] Geoffrey Parker, "Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered" *American Historical Review* 113, no. 4 (October 2008): 1064, 1073.

[33] Ibid.

Parker, each of these faced the "worst climate-induced catastrophe of the last millennium," during which "one-third of the human population died."[34]

Surprisingly few historians, however, have examined early modern responses to climatic change. Seventeenth and eighteenth century literacy rates were low by twenty-first century standards, but stationers and booksellers nurtured an active market for geographical, astrological, and historical literature. Clerics, natural philosophers, and historians found an eager audience for meteorological publications. Sociologist Nico Stehr, who studies the sociology of knowledge, has written extensively about nineteenth and twentieth century notions of climate and climatic determinism—particularly those of fin-de-siècle geographer Eduard Brückner.[35] Historian James Roger Fleming has written several thoughtful essays about nineteenth-century American meteorology.[36] In *Historic*

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[34] Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (New Haven: Yale University Press, 2013), xv, xx.

[35] See Stehr and von Storch, *Brückner*; Nico Stehr and Hans von Storch, *The Social Construct of Climate and Climate Change,* Max-Planck-Institut Report, no. 137 (Hamburg: Max-Planck-Institut für Meteorologie, 1994); Nico Stehr, Hans von Storch, and Moritz Flügel, *The 19th Century Discussion of Climate Variability and Climate Change: Analogies for the Present Debate?,* Max-Planck-Institut Report, no. 157 (Hamburg: Max-Planck-Institut für Meteorologie, 1995); Nico Stehr and Hans von Storch, "An anatomy of climate determinism" in *Wissenschaftlicher Rassismus—Analysen einer Kontinuität in den Human- und Naturwissenschaften*, ed. Heidrun Kaupen-Haas (New York: Campus-Verlag, 1999).

[36] James Roger Fleming, *Meteorology in America, 1800-1870* (Baltimore: Johns Hopkins University Press, 1990); Fleming, "Charles Lyell and Climatic Change: Speculation and Certainty," in *Lyell: The past is the key to the present*, Geological Society Special Publication 143, ed. D.J. Blundell and A.C. Scott (London: Geological Society, 1998), 161-69; Fleming, *Historical Perspectives on Climate Change* (Oxford: Oxford University Press, 1998); Fleming, "T.C. Chamberlin, Climate Change and Cosmogony," *Studies in the History and Philosophy of Modern Physics* 31, no. 3 (2000), 293-308; Fleming, *The Callendar Effect* (Boston: American Meteorological Society,

Perspectives of Climatic Change (2005), the lone publication of its kind, Fleming outlines several themes of early modern and modern climatic thought. Although he briefly discusses ancient and early modern ideas, Fleming focuses on nineteenth and twentieth-century themes: the expansion of observational networks, early research on carbon dioxide, the "climatic determinism" of Ellsworth Huntington, and twentieth-century global warming. Fleming ascertains that "*huge* changes in concepts and attitudes" have taken place in the study of climate.[37] Historian Vladimir Janković, on the other hand, stresses the "continuity" of meteorological ideas in his examination of eighteenth century publications about meteors.[38] Janković discerns two broad meteorological cultures: urban laboratory science and rural natural history. He demonstrates that experimental and chemical meteorology displaced, rather than transformed, the rural natural history of classical meteorology.[39] Janković and Fleming have collaborated on a number of publications about modern weather and climate.[40]

Although *Global Crisis* is primarily concerned with subsistence crises and state breakdown, it provides valuable insight into early modern interpretations of climatic

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2007); Fleming, *Fixing the Sky: The Checkered History of Weather and Climate Control* (New York City: Columbia University Press, 2010).

[37] James Rodger Fleming, *Historical Perspectives,* viii, 95.

[38] Vladimir Janković, *Reading the Skies: A Cultural History of English Weather, 1670-1820* (Chicago: The University of Chicago Press, 2000), 2-3.

[39] Ibid., 9-13.

[40] See James Rodger Fleming, Vladimir Janković, and Deborah R. Coen, *Intimate universality: Local and Global Themes in the History of Weather and Climate* (Sagamore Beach, MA: Science History Publications/USA, 2006); James Rodger Fleming and Vladimir Janković, *Klima*, Osiris, no. 26 (Chicago: The University of Chicago Press, 2011).

change. Parker asserts that many early modern observers "attributed natural disasters to divine displeasure." Both Protestant and Catholic magistrates responded to environmental catastrophes by ordering "moderation in food, drink and fashion" while proscribing dancing, frivolity, and sensual pleasure. Parker dubs this outlook "peccatogenic," from the Latin word for sin. He further discerns an association between natural disasters, millenarian catastrophism, and the seventeenth-century "witchcraze." According to Parker, "[s]o much abnormal weather led some contemporaries to suspect that they lived in the middle of a major climate change." He provids two tantalizingly brief examples of such perceptions. In a 1675 letter, Madame de Sévigné described that year's bitterly cold summer to her daughter, remarking that "like you, we think the behavior of the sun and of the seasons has changed." Parker also identified a remarkable note by the Kangxi emperor of Qing China, who assembled a collection of weather records in the seventeenth century and determined that "the climate has changed."[41]

Despite the accomplishments of such varied research, several questions remain about the history of early modern climate. When, exactly, was the Little Ice Age? How dramatic and disruptive were the environmental changes that define it? For Jones and Bradley, the thirty year period between 1590 and 1620 represented one of "a few short cool episodes."[42] For the people of northern Europe it may have represented a tragedy rivaled only by the Black Death.[43] What, indeed, did "climate" actually mean to early

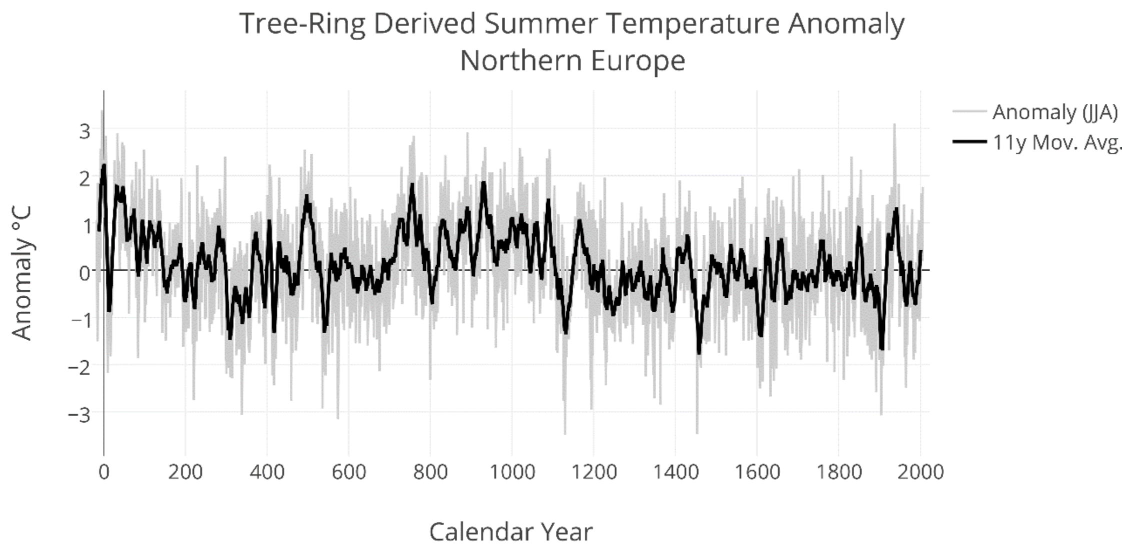
[41] Parker, *Global Crisis*, 7-10, 556, 572-73.
[42] Jones and Bradley, "Climatic variations over the last 500 years," 658.
[43] Peter Clarke, "Introduction" in *The European Crisis of the 1590s: Essays in Comparative History* (London: George Allen & Unwin, 1985), 6-7.

modern natural philosophers and geographers? Did climate, as they understood it, have the potential to change? At what point did observant scholars begin wrestling with such questions, and how did they explain apparent mutability? How did great winters, frosts, and storms influence the construction of new theories of climatic change? Did the idea of the Little Ice Age predate its identification by Matthes and his colleagues? Ogilvie and Jónsson's assertion that it was a "twentieth-century construction" should be measured against the historical record.[44]

Although some scholars have expressed skepticism about the existence of a Little Ice Age, early twenty-first century climatological research suggests that temperatures in many parts of the northern hemisphere turned cooler in the late sixteenth century and remained so, with some variation, into the nineteenth century. Dendrochronology, which examines the characteristics of seasonal tree-rings in living and nonliving wood, and other paleoclimatological proxies provide valuable and relatively objective insight into the atmosphere of the pre-instrumental world. Several studies confirm that northern European temperatures declined by at least 1°C in the late Middle Ages (Fig. 1).[45] The cause of these changes remains a matter of some dispute, but many climatologists agree

[44] Ogilvie and Jónsson, 10-12.

[45] Jan Esper et al., "Northern European summer temperature variations over the Common Era from integrated tree-ring density records," *Journal of Quaternary Science* 29, no. 5 (July 2014): 487-94, data archived at the World Data Center for Paleoclimatology, accessed October 17, 2014, http://www.ncdc.noaa.gov; Fredrik Charpentier Ljungqvist, "A new reconstruction of temperature variability in the extra-tropical Northern Hemisphere during the last two millennia," *Geografiska Annaler: Series A, Physical Geography* 92, no.3 (September 2010): 339-51, data archived at the World Data Center for Paleoclimatology, accessed October 20, 2014, http://www.ncdc.noaa.gov/.



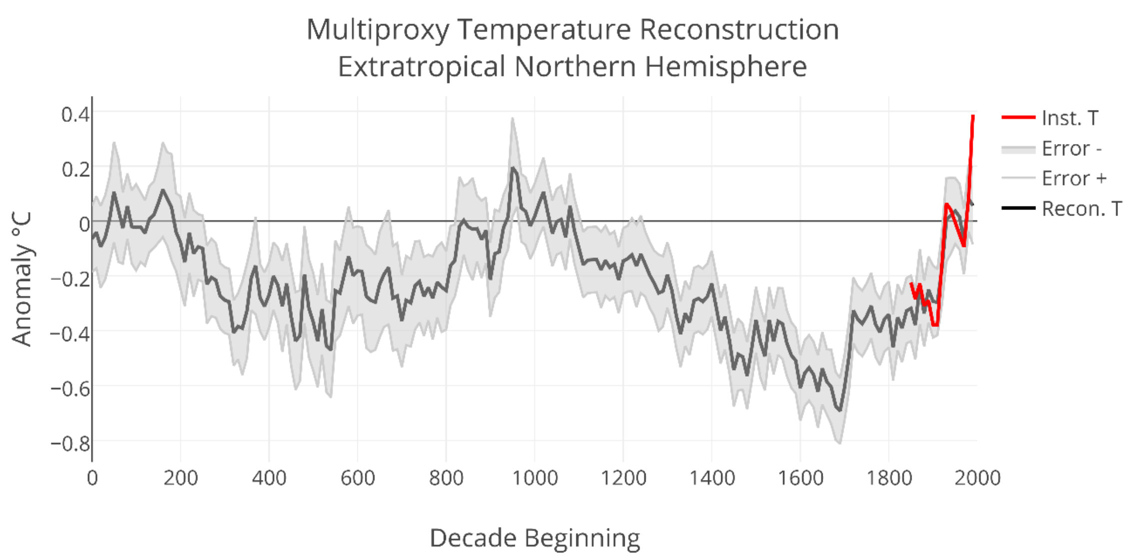


Fig. 1*. Paleoclimatic Temperature Reconstructions. From Top, Esper (2014) and Ljungqvist (2010).*

that frequent volcanic eruptions and a relatively inactive sun contributed to the era's cool and wet conditions (Fig. 2).[46]

Charting the intensity and decadal frequency of temperature anomalies (positive and negative) illustrates the true threat of the Little Ice Age for agricultural societies: the compound influence of consecutive, unusually cool years. Negative temperature anomalies (cold anomalies) were larger during the Little Ice Age, but they also occurred more frequently.[47] Warm temperature anomalies, on the other hand, were quite rare. Between 1580 and 1860, in central Europe, positive summer temperature anomalies exceeded 1σ (one standard deviation above the mean) only eleven times, primarily in the 1660s and 1780s. During the same period, negative summer temperature anomalies exceeded -1σ (one standard deviation below the mean) on seventy-three occasions, including each year from 1591-1610. Positive anomalies were a little more common in northern Europe, but they rarely occurred more than once per decade. During the

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[46] "TSI Reconstruction from IPCC AR5 (based on Krivova et al., JGR, 2010 and Ball et al., A&A, 2012)," data archived at SORCE (Solar Radiation & Climate Experiment, University of Colorado, Boulder, Laboratory for Atmospheric and Space Physics, accessed May 16, 2015, http://lasp.colorado.edu/home/sorce/data/tsi-data/; "Yearly mean total sunspot number," data archived at WDC-SILSO (Sunspot Index and Long-term Solar Observations), Royal Observatory of Belgium, Brussels, accessed May 16, 2015, http://www.sidc.be/silso/datafiles; "Volcanos of the World," data archived at the Global Volcanism Program, Smithsonian Institution, National Museum of Natural History, accessed May 16, 2015, http://www.volcano.si.edu/search_eruption.cfm.

[47] Ulf Büntgen et al., "Central Europe 2500 Year Tree Ring Summer Climate Reconstructions," *Science* 331 (February 4, 2011): 578-83, data archived at the World Data Center for Paleoclimatology, accessed October 17, 2014, http://www.ncdc.noaa.gov; Esper, "Northern European summer temperature variations."

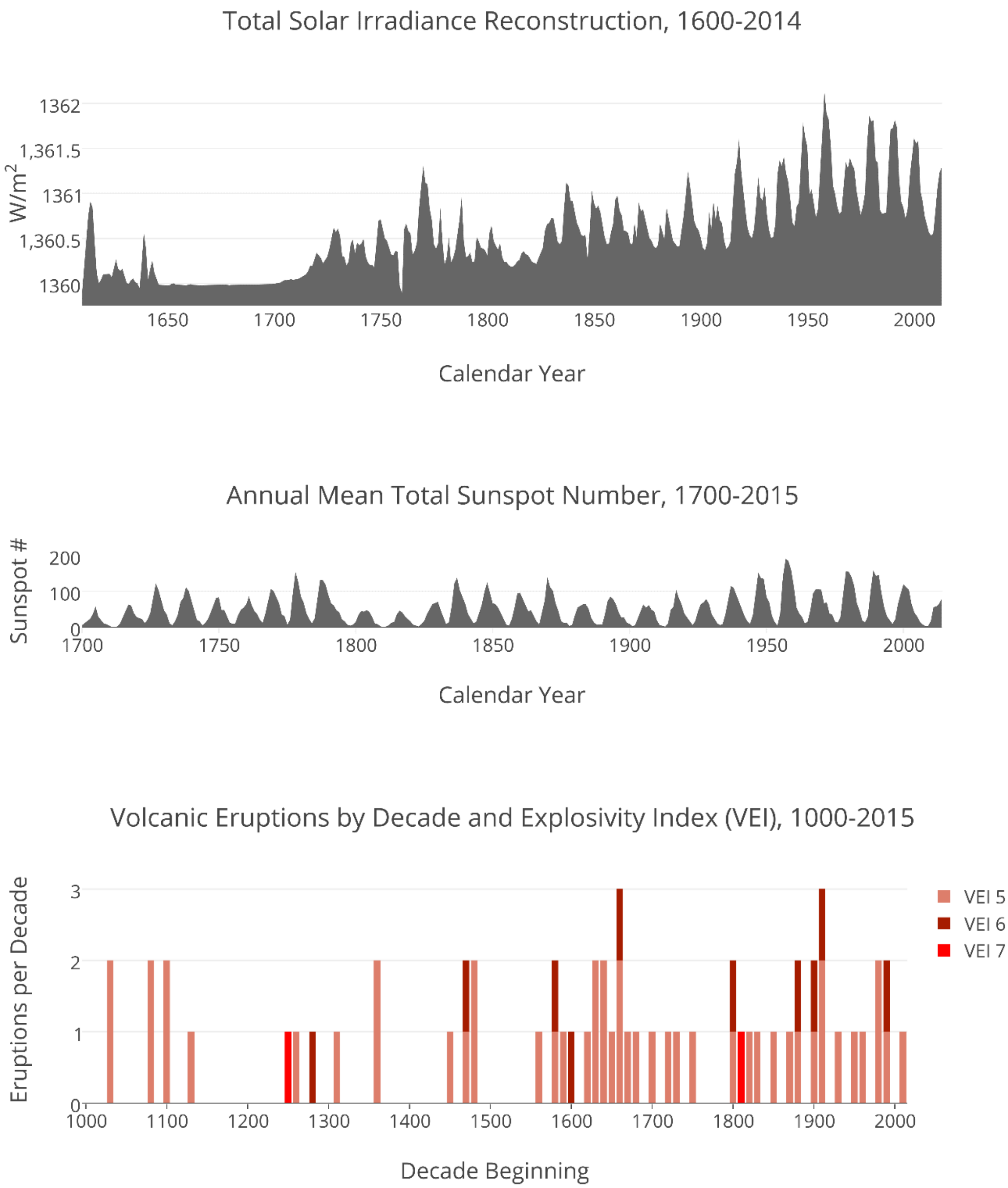

Fig. 2. *Total Solar Irradiance, Sunspots, and Volcanic Eruptions.*

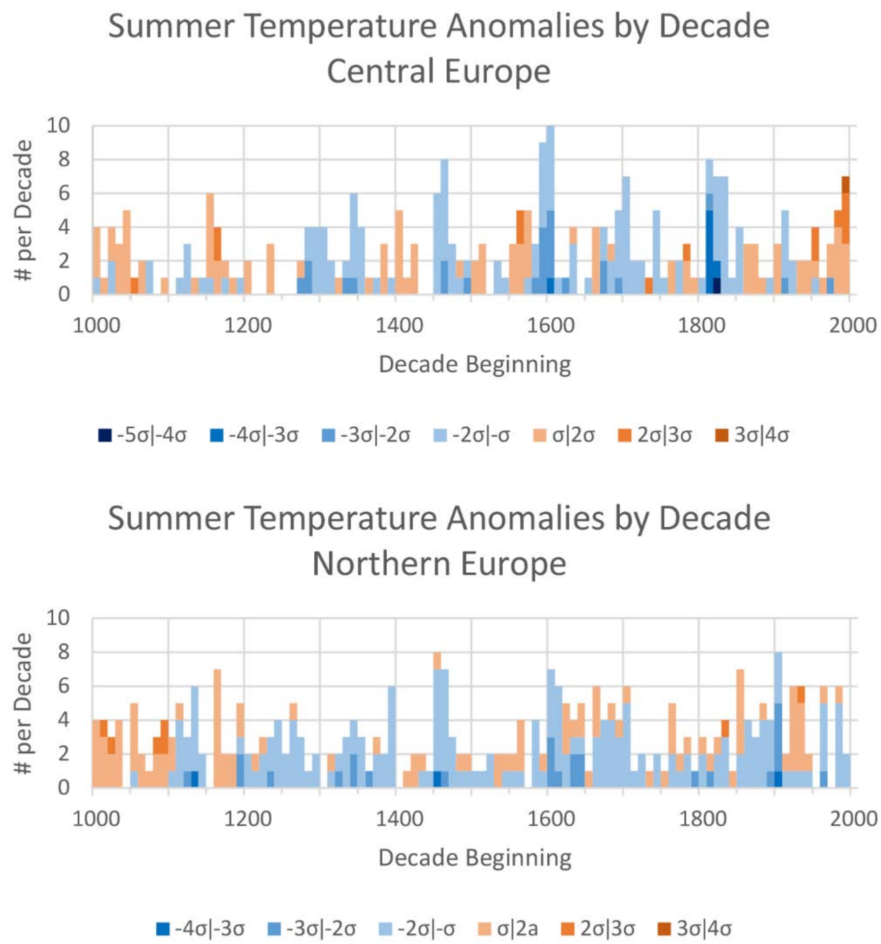

Fig. 3. *European Summer Temperature Anomalies. Decadal charts illustrate the intensity and frequency of summer temperature anomalies in northern and central Europe. From Top, Büntgen (2011) and Esper (2014).*

seventeenth century, negative summer temperature anomalies exceeded -1σ thirty-five times; positive anomalies exceeded 1σ only twelve times (Fig. 3). "Great Winters" like that of 1683 may provide the most enduring images of the Little Ice Age, but unusually mild or cool summer temperatures were a constant feature of the European climate from 1550 to 1850.

This dissertation focuses on an additional method for understanding the early chronology of the Little Ice Age: contemporary efforts to record and contextualize unusual storms, flooding, and winter weather. Early modern natural philosophers and weather observers faced several challenges in recognizing climatic change. Ancient meteorology provided space for atmospheric and hydrological variability, but it offered few models for explaining long-term change. In the sixteenth century, when stationers began publishing the first accounts of weather, fictional and otherwise, three primary interpretations prevailed: theological, astrological, and meteorological. None of these provided a model for explaining long-term environmental change. In fact, few sixteenth century resources offered any insight into the causes of unusually cold winters, so rare had they become. The "Great Frosts" of the Little Ice Age forced clerics, historians, and natural philosophers to wrestle with the history of weather. In the early seventeenth century, most scholars found no evidence for climatic change. As the century wore on, however, more began to question whether the world had fallen prey to elemental warfare and universal decay. Christopher Wren, Robert Hooke, and other fellows of the Royal Society encouraged more careful observation and comparison of weather records, which began to bear fruit in the historical analyses of the eighteenth century. In 1811, Henry Robertson proposed the first cyclical theory of climatic change, a 600-year revolution that encompassed the Medieval Warm Period and the Little Ice Age.

This dissertation utilizes a wide variety of sources to examine the principal themes of early modern climatic thought. These include samples of Greek and Roman science and geography, sixteenth-century astrology and meteorology, seventeenth-century natural philosophy and theology, and eighteenth-century geology and history. Most of the early modern materials are English, Scottish, or French in origin, though a handful of Irish, Flemish, and Dutch sources make important contributions, as well. Many of these sources are available through online subscription services like Early English Books Online and Eighteenth Century Collections Online. French sources may be accessed freely through Gallica, the digital repository of the Bibliothèque nationale de France. Additional documentary research was completed in the Royal Meteorological Archive and Library in Exeter, United Kingdom, the National Archives in Kew, and the James Smith Noel Collection in Shreveport, Louisiana, which offers access to several seventeenth-century works of natural philosophy and science. Research on meteorological instruments was completed at the Museum of the History of Science, University of Oxford, and the Whipple Museum of the History of Science, University of Cambridge. Examination of artwork from the Little Ice Age was completed at the Ashmolean Museum (Oxford), Fitzwilliam Museum (Cambridge), the National Gallery (London), the Royal Museums of Fine Arts (Brussels), the Rijksmuseum (Amsterdam), and the Petit Palais (Paris).

This dissertation opens with a discussion of the origins of “climate” and meteorology in ancient Greek and Roman literature, particularly Aristotle’s *Meteorologica*. The third chapter examines the theological, astrological, and meteorological interpretations of weather that prevailed in the sixteenth century. The fourth chapter discusses the first great storms and frosts of the Little Ice Age, including the North Sea floods of 1570, the terrible winters of the 1590s, and the Great Frost of

1607-08. The fifth chapter describes the Windy Year of 1613, which encouraged several authors to wonder whether the elements were in a state of continual unrest. This chapter also examines the first debate over climatic change, which centered on Godfrey Goodman's theory of Universal Decay. The sixth chapter discusses the role of meteorology and "weather history" in the Scientific Revolution and examines the first natural theories of climate change. The seventh chapter explores the influence of such theories on the study of history and geology in the eighteenth century, with particular emphasis on the comparison of medieval and early modern climatic regimes.

This dissertation demonstrates that climate change and the Little Ice Age are not "mid-twentieth century constructions," as some skeptics have suggested. The dramatic weather of the sixteenth and seventeenth centuries made it difficult to deny the potential for climatic change. Shakespeare captured the zeitgeist of the Little Ice Age in *A Midsummer Night's Dream*, itself a product of the tumultuous 1590s. Titania, incensed by Oberon's theft of a changeling boy, suggests that jealousy had transformed the constitution of the forest:

> And through this distemperature we see
> The seasons alter: hoary-headed frosts
> Fall in the fresh lap of the crimson rose,
> And on old Hiems' thin and icy crown
> An odorous chaplet of sweet summer buds
> Is, as in mockery, set: the spring, the summer,
> The childing autumn, angry winter, change
> Their wonted liveries, and the mazed world,
> By their increase, now knows not which is which.[48]

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[48] William Shakespeare, *A Midsummer Night's Dream*, ed. Edmund K. Chambers, Arden Shakespeare (Boston: D. C. Heath & Co., 1906), 2.1.106-14. References are to act, scene, and line.

Modern climatologists are still exploring “which is which,” and the “mazed” world may yet wonder at unusual summers and winters. But the study of climate and climatic change is the product of another era; it began in the bitter winters of the Little Ice Age.[49]

[49] Parts of this dissertation, particularly Chapters VI and VII, are extensions of research completed for my master’s thesis. See Christopher Gilson, “Warmly Debated: The Little Ice Age and the Construction of Historical Climatic Regimes, 1650-1950” (master’s thesis, Texas A&M University, 2010).

CHAPTER II

THE BIRTH OF METEOROLOGY

The third volume of the *Encyclopedie*, Denis Diderot and Jean Le Rond d'Alembert's epochal contribution to the Enlightenment, includes an intriguing passage about the meaning of the word "climate."[1] D'Alembert, expanding on Ephraim Chambers' 1728 definition, defined climate as a "portion or zone of the surface of the earth, bound by two circles parallel to the equator, and of such a width that the longest day in the parallel closest to the pole surpasses by a certain quantity, for example by a half-hour, the longest day in the parallel closest to the equator." Both Encyclopaedists, however, included a brief note that an alternative definition of climate was becoming more common. D'Alembert explained that the term could apply to "a land different from another, as regards seasons, qualities of soil, or even people who live there, without any relation to the longest summer days."[2] The origin of these apparently divergent definitions can be found in the Greek root of the word climate: κλίμα (*klima*), from the verb κλίνω (*klinō*), a geometrical term that described the inclination or slope of a line.

[1] This text follows the spelling and dating conventions of the source material, the *Oxford Encyclopedia of Ancient Greece and Rome*, and Oxford's *Who's Who in the Classical World.* All translations are identified in the footnotes. Translations from the French edition of Plutarch's *De Placitis Philosophorum* are my own.

[2] Ephraim Chambers, "Climate," in *Cyclopædia: Or, an Universal Dictionary of the Arts and Sciences*, 2 vols., vol. 1 (London, 1728), 237; Jean Le Rond d'Alembert, "Climat," in *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers* (Paris, 1753), 3:532-34. For translation, see Jean Le Rond d'Alembert, "Climate," in *The Encyclopedia of Diderot & d'Alembert Collaborative Translation Project*, trans. Krystyna Piechura (Ann Arbor, MI: MPublishing, University of Michigan Library, 2004), accessed March 31, 2013, http://hdl.handle.net/2027/spo.did2222.0000.267.

When applied to geography, it is often translated as "latitude."[3] As historians of meteorology correctly note, κλίμα remained influential in the eighteenth century.[4] D'Alembert's secondary definition, however, had roots in the classical tradition as well. Natural philosophers, geographers, and historians from Herodotus to Ptolemy explored questions of terrestrial habitability and environmental change. These texts, reintroduced to Europe by the Reconquista, Renaissance, and printing press, provide a framework for understanding early modern interpretations of climate and climatic change.

In its modern application, climate describes the atmospheric and hydrological characteristics of a place during a defined period of time. Because of the impact of meteorological phenomena on native species, the study of climate and climatic change often intersects with study of natural habitats. Although the ancient world had no comparable term, environmental regions and variability were common themes of scientific and geographical literature. This chapter will examine iterations of these themes from classical scholarship available in the early modern era. Sources include Herodotus, Hippocrates, Plato, Aristotle, Theophrastus, Polybius, Strabo, Pliny the Elder, and Ptolemy. This chapter opens with an explanation of the geocentric model of the universe and its relationship with the term κλίμα. It discusses the five-zone model of

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[3] Dmitriy A. Shcheglov, "Ptolemy's system of seven climata and Eratosthenes' geography," *Geographia Antiqua* 13 (2004), 21; Didier Marcotte, "La climatologie d'Ératosthène à Poséidonios: genèse d'une science humaine," in *Sciences exactes et sciences appliquées à Alexandri*e *(III*[e] *siècle av. J.-C. – I*[er] *siècle ap. J.-C.)*, ed. Gilbert Argoud and Jean-Yves Guillaumin (Saint-Étienne, France: Publications de l'Université de Saint-Étienne, 1998), 264.

[4] James Rodger Fleming, *Historical Perspectives on Climate Change* (New York: Oxford University Press, 1998), 11-12.

terrestrial habitability, along with several alternate models. This chapter closes by examining classical notions of environmental change, including Aristotle's concept of "meteorology."

The prevailing understanding of the universe in ancient Greece and Rome was based upon the notion of the two spheres. The *terrestrial sphere* consisted of the earth and its seas. Because of the absence of depth perception in space, the surrounding stars appear equidistant from the earth, as if fixed to the interior surface of an ink-black sphere.[5] This *celestial sphere* included the fixed stars and the seven visible planetary bodies: the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. Viewed from this perspective, the celestial sphere appears to rotate around an axis passing through the poles of the earth. The stationary points where this axis intersects the celestial sphere are the *north celestial pole* and the *south celestial pole*. As the stars rotate around the poles, they appear to "trace" parallel circles on the interior of the celestial sphere.[6] The greatest of these parallels, the *celestial equator*, bisects the celestial sphere.[7]

Most of the planetary bodies appear to "wander among the stars," following idiosyncratic paths around the earth. The sun, however, appears to move in a continuous path around the celestial sphere but in the direction opposite to its rotation. This path,

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[5] Jeffrey Bennett et al., eds., *The Essential Cosmic Perspective* (San Francisco: Addison Wesley, 2003), 39.

[6] J. Lennart Berggren and Alexander Jones, eds., *Ptolemy's Geography: An Annotated Translation of the Theoretical Chapters* (Princeton, NJ: Princeton University Press, 2000), 7.

[7] On a sphere, a *great circle* is created when the plane of the circle passes through the center of the sphere. Recognizable examples include the Equator and all of the earth's meridians. The Tropics of Cancer and Capricorn are parallels of the Equator, but they are not great circles.

tilted about 23.5° to the celestial equator, forms a great circle called the *ecliptic*. It takes one year for the sun to move along the ecliptic; as it does so, it passes through the twelve constellations of the zodiac.[8] Because the ecliptic was tilted, the sun appeared to reach a "high" point as it entered the constellation Cancer on the summer solstice and a "low" point as it entered Capricorn on the winter solstice. The celestial parallel passing through the sun's northernmost transit thus became known as the Summer Tropic and Tropic of Cancer. The parallel tangent to its southernmost point became the Winter Tropic and Tropic of Capricorn. When astronomers and geographers began to divide the terrestrial sphere into matching zones, they maintained the celestial names.[9]

The other important circles of the two spheres depended upon the location of the observer. For any point on the earth, the stars of the celestial sphere divide into three categories: stars that are never visible, stars that rise and set, and stars that are always visible. Greek geographers noted that two parallels separated the three types of stars: "*the greatest of the always visible circles*" and "*the greatest of the always invisible circles*." The terms *arctic circle* and *antarctic circle* were also applied to these parallels. Unlike the Tropics and the celestial equator, these circles varied with location.[10] As one moves north in the northern hemisphere, the north celestial pole rises above the horizon. A greater number of stars—and parallels created by their rotation—thus become "always visible." By comparing the visibility of constellations at two points, an observer could

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[8] Bennett et al., *Cosmic Perspective*, 39.

[9] Berggren and Jones, *Ptolemy's Geography*, 11-12.

[10] Ibid., 8; Horace Leonard Jones, ed., *Strabo: Geography, Books 1—2* (1917; repr., Cambridge, MA: Harvard University Press, 1997), 364-65n2; Plutarch, *De Placitis Philosophorum*, trans. Guy Lachenaud (Paris: Les Belles Lettres, 1993), 2.12.

determine which location was farther north. As one moves north from the equator, the north celestial pole appears to rise at the same rate: at a position 30° N, the pole is 30° above the horizon.[11] Greek astronomers and geographers used the term κλίμα to describe this phenomenon. Initially, κλίμα did not describe a particular zone of the earth or represent a standardized parallel; it could "refer to any latitude whatsoever."[12]

According to the biographer Plutarch (*c*. A.D. 50-120), Thales of Miletus (*c*. 625-547 B.C.), Pythagoras of Samos (*c*. 570-490 B.C.), and their followers were the first to divide the celestial sphere into five zones. Pythagoras, who postulated a spherical earth, may have been the first to divide the earth into five zones, as well. Plutarch wrote that "[a]ccording to Pythagoras, the earth is divided, like the celestial sphere, into five zones: arctic, summer tropical, winter tropical, antarctic, and equinoctial." The middle zone was a "scorching zone," also known as the Torrid Zone. Strabo, the first-century historian and geographer from northern Anatolia, traced the five-zone model to Parmenides of Elea (*c*. 515-450 B.C.). According to Plutarch, Parmenides' contribution was to "define the inhabited regions of the earth" as those in the two "tropical" zones.[13]

[11] At present, the north celestial pole appears to "point" to the so-called North Star, Polaris. This was not the case in the ancient world. Because of precession—the wobble of the earth's axis of rotation around an axis perpendicular to the plane of its orbit—the north celestial pole appears to slowly move through the heavens. One full revolution of the celestial sphere takes about 26,000 years.

[12] D. R. Dicks, "The ΚΛΙΜΑΤΑ in Greek Geography," *The Classical Quarterly* 5, no. 3-4 (July–October, 1955): 249; Shcheglov, "Ptolemy's system," 22.

[13] Plutarch, *De Placitis Philosophorum* 2.12, 3.11, 3.14; Strabo, *Geography*, trans. Horace Leonard Jones (1917; repr., Cambridge, MA: Harvard University Press, 1997), 2.2.2; Jones, *Geography*, 360n3; Lloyd A. Brown, *The Story of Maps* (New York: Dover Publications, 1979), 25-26.

By the fifth century B.C., scholars had begun to divide the earth into five zones, including two defined by their habitability and one defined by its warmth. There were, however, other ways of comparing the environmental characteristics of the earth. In his *Histories*, Herodotus of Halicarnassus (*c*. 484-420 B.C.) identified four environmental regions that largely corresponded to the continents: Ionia, Egypt, Libya, and Scythia. The most favorable environment belonged to the Ionians of Asia Minor, who, "of all men whom we know . . . happened to found their cities in places with the loveliest of climate and seasons." Egypt was distinctive in every way: "Just as the Egyptians have a climate peculiar to themselves, and their river is different in its nature from all other rivers, so, too, have they instituted customs and laws contrary for the most part to those of the rest of mankind." Libya, which encompassed land to the south and west of Egypt was "uninhabited and desert." The snowy lands of northern Eurasia occupied the other end of spectrum. Home of the legendary Arimaspi, Greek traders knew of this region only through the tales of neighboring Issedorian and Scythian traders. "[B]ecause of the winter," Herodotus asserted, "the regions to the north of this continent are uninhabited."[14]

Although Herodotus commented on the environment several times in his *Histories*, he was primarily concerned with collecting information about the societies of the known world. The fifth-century philosopher Hippocrates (*c*. 460-377 B.C.), from the

[14] Herodotus, *Histories*, trans. Alfred Denis Godley (Cambridge, MA: Harvard University Press, 1920), 1.142, 2.34-35, 4.31. Herodotus was a resident of the Ionian city of Halicarnassus (present-day Bodrum, Turkey). It is perhaps unsurprising that he favored the local climate.

neighboring island of Kos, delved more deeply into environmental questions as part of his study of human health and medicine. In one treatise attributed to him—*Airs, Waters, Places*—Hippocrates compared the seasons and atmospheric conditions of Europe and Asia.[15] Like Herodotus, Hippocrates found the climate of Asia superior to that of Europe. "I hold that Asia differs very widely from Europe in the nature of all its inhabitants and of all its vegetation," he explained, adding that "everything in Asia grows to far greater beauty and size." The influence of Parmenides' notion of habitable zones is apparent in Hippocrates' description of the ideal climate: "The cause of this is the temperate climate, because it lies toward the east midway between the risings of the sun, and farther away than is Europe from the cold." The defining characteristic of the Asian climate was the "uniformity" of its seasons, "which show no violent changes either towards heat or towards cold, but are equable."[16]

Hippocrates obliquely described Egyptians as "distressed by the heat," but his passages on Egypt and Libya have been lost. His description of Europe, however, is illuminating. For Hippocrates, Europe meant Scythia, the vast Eurasian steppe north of the Black and Caspian Seas. Scythia existed on the margins of habitability:

> For it lies right close to the north and the Rhipaean mountains, from which blows the north wind. The sun comes nearest to them only at the end of its course, when it reaches the summer solstice, and then it warms them but slightly and for a short time. The winds blowing from the hot regions do not reach them, save rarely, and with little force; but from the north there are constantly blowing

[15] More than sixty treatises, collective called the Hippocratic Corpus, have been attributed to Hippocrates. It is unknown, however, whether he or others in his school at Kos authored the texts.

[16] "[R]isings of the sun" is a reference to the Summer and Winter Tropics. Hippocrates, *Airs, Waters, Places*, trans. W. H. S. Jones (1923; repr., London: William Heinemann, 1957), 12, 16.

> winds that are chilled by snow, ice, and many waters, which, never leaving the mountains, render them uninhabitable. A thick fog envelops by day the plains upon which they live, so that winter is perennial, while summer, which is but feeble, lasts only a few days.

Conditions in the remainder of Europe were not much better: "the changes of the seasons . . . are violent and frequent, while there are severe heat waves, severe winters, copious rains and then long droughts, and winds, causing many changes of various kinds."[17]

Hippocrates' references to the sun and solstice suggest a familiarity with the idea of habitable zones, but he provided no description of the underlying system. Aristotle (384-322 B.C.), student of Plato and mentor of Alexander the Great, was the first to describe the five-zone model in detail. His *Meteorologica*, a lesser-known work today, shaped notions of atmospheric and surface phenomena for almost two millennia. Aristotle conceived of the treatise as one part of a larger corpus of physical works, situating it after *The Physics*, *De Cælo*, and *De Generatione et Corruptione*—which concerned natural motion, stars, and the four elements, respectively—but before his studies of plants and animals. Although it resembles modern meteorology in its attention to weather events, Aristotle's meteorology also explained phenomena now understood to be astronomical or geological in origin. The *Meteorologica* was thus intended to address "everything which happens naturally . . . and which takes place in the region which borders most nearly on the movement of the stars." This region

[17] Ibid., 19, 23.

included storms, earthquakes, rivers, seas, and metallurgy, as well as “the milky way, comets, shooting stars and meteors.”[18]

In the *Meteorologica*, Aristotle adopted a model of habitability that was zonal rather than national or local. He suggested that there were “two habitable sectors” on the surface of the earth, one in each of the northern and southern hemispheres. The habitable zones were “drum-shaped,” and their borders were formed by symmetrical conic sections:

> These sectors are drum-shaped—for lines running from the centre of the earth cut out this shaped figure on its surface: they form two cones, one having the tropic as its base, the other the ever-visible circle, while their vertex is the centre of the earth; and the two cones constructed in the same way towards the lower pole cut out corresponding segments on the earth’s surface.

According to Aristotle, these were the “only habitable regions.” Beyond the “ever-visible” circles, lands were “uninhabitable because of the cold.” Lands between the tropics were uninhabitable because “we know that the earth ceases to be habitable before the shadow disappears or falls towards the south.”[19]

Aristotle’s model thus divided the world into five zones (Fig. 4). From North to South, these were an uninhabitable polar zone, a habitable northern zone, the uninhabitable tropics, a habitable southern zone, and an uninhabitable south pole. Aristotle directly challenged existing maps of the inhabited world, describing them as “absurd” for representing “the inhabited earth as circular.” His calculations suggested that the habitable zone could, “as far as climate is concerned, extend around the earth in

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[18] Aristotle, *Meteorologica*, trans. H. D. P. Lee (1952; repr., Cambridge, MA: Harvard University Press, 1987), 1.1.338a20-25.

[19] Ibid., 2.5.362a32-b10.

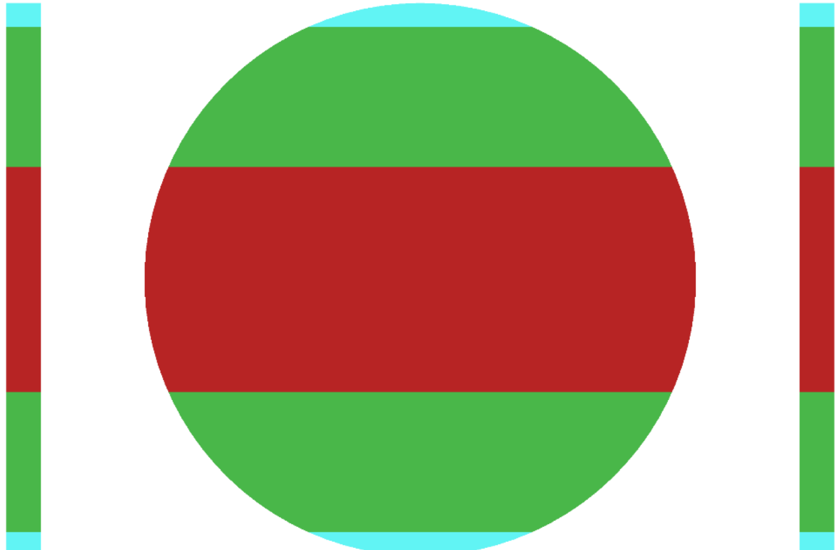

Fig. 4. *Aristotle's five-zone model of habitability. The Frigid Zones are blue; the Temperate Zones are green; the Torrid Zone is red.*

a continuous belt." Journeys throughout the known world offered evidence that habitability was a function of latitude rather than longitude: "For if one reckons up these voyages and journeys . . . the distance from the Pillars of Heracles to India exceeds that from Aethiopia to Lake Maeotis [the Sea of Azov] and . . . Scythia by a ratio greater than that of 5 to 3." It was only the ocean, Aristotle asserted, that "severs the habitable land and prevents it forming a continuous belt around the globe."[20]

Pytheas of Massilia, a Greek navigator of the late fourth century B.C., expanded the range of the known world into the distant north. Pytheas' original account is lost, though parts of it were preserved by Strabo, Pliny the Elder, and the Greek historian Polybius (*c.* 200-118 B.C.). According to Polybius, Pytheas claimed to have explored the

[20] Ibid., 2.5.362b10-30.

western coast of Europe from Iberian Cadiz to the British Isles and the North Sea. Pytheas reported that an additional "Brittanic" island, Thule, could be found six days (by sail) north of Britain. He located Thule where the "circle of the summer tropic is the same as the arctic circle," or where the arctic circle was the "complement" of the Tropic of Cancer: 66° N. In the descriptive language of Lloyd Brown, Pytheas "brought the arctic circle down to earth." Detailing what appears to have been sea ice, Pytheas described Thule's surroundings as

> regions in which there was no longer either land properly so-called, or sea, or air, but a kind of substance concreted from all these elements, resembling a sea-lungs [jellyfish]—a thing in which . . . the earth, the sea, and all the elements are held in suspension; and this is a sort of bond to hold all together, which you can neither walk nor sail upon.

According to Strabo, Pytheas learned of Thule by word-of-mouth, but he claimed to have experienced "the thing that resembles the sea-lungs" firsthand.[21]

Prior to the third century B.C., physicists and geographers could offer only estimates—often quite inaccurate—of the earth's size. Strabo lauded Eratosthenes of Cyrene (*c*. 276-194 B.C.) for introducing "the principles of mathematics and physics into the subject of geography."[22] Eratosthenes benefited from information collected about the world during Alexander the Great's expedition to the East. Invited to Egypt to administer the library at Alexandria, Eratosthenes utilized the collected knowledge of the ancient world to complete one of its most important geographical treatises. Although the

[21] For Polybius' account, a fragment of Book 34 of his *Histories*, see Strabo, *Geography* 2.4.1-2.4.2. For other references to Pytheas, see Strabo, *Geography* 1.4.2, 2.5.8; Jones, *Geography*, 440-41n1; Brown, *Story of Maps*, 40; Pliny, *Natural History*, trans. John Bostock and H. T. Riley (London: Henry G. Bohn, 1857), 37.11.

[22] Strabo, *Geography* 1.4.1.

full text of Eratosthenes' study of geography is lost, subsequent scholars—particularly Strabo—preserved fragments as part of their commentaries.

An astronomer and geometrician, Eratosthenes is best known for his attempt to measure the earth's circumference.[23] His research, however, also helped define the limits of the *oikoumenē*—the inhabited world—and establish a foundation for a system of κλίματα. According to Strabo, Eratosthenes' inhabited world stretched from Meroë, a Nubian city on the Nile River in present-day Sudan, to Thule. This was a distance of

[23] Eratosthenes was the first to measure the earth's circumference using the distance between two known points on a meridian. He knew that the sun rose to the zenith of the sky at Syene (Aswan, Egypt) at noon on the summer solstice. In Syene the *gnomon*, or upright shaft of the sundial, did not cast a shadow into a bowl. At Alexandria, 5,000 stadia north of Syene, its shadow was one-fiftieth of a great circle. If the cities shared a meridian and the sun's rays were parallel, as Eratosthenes believed, the ratio of the distance between the cities would be the same as that of their shadows—one-fiftieth of a circle. Since the two cities were separated by 5,000 stadia, the polar circumference of a spherical earth would be 250,000 stadia. Most commentaries on Eratosthenes, including Strabo, quote a measurement of 252,000 stadia. Cleomedes believed that Eratosthenes added 2,000 stadia to make his measurement divisible by 60 and 360. Edward Gulbekian provides a convincing counterargument, noting that Cleomedes was the only commentator to suggest that Eratosthenes fudged his results. Gulbekian contends that Eratosthenes calculated the distance between Alexandria and Syene as 5,040 stadia rather 5,000 stadia. The accuracy of Eratosthenes' measurement of the earth depends on the length of the *stadion*, which consisted of 600 Greek *podes* (feet) or 540-680 imperial feet. For the earth to measure 252,000 stadia, one stadion would have to equal 520.8 feet. Eratosthenes' measurement thus fell within a few thousand miles of the earth's polar circumference. Since the earth is an oblate spheroid, its equatorial circumference is, of course, slightly greater. See Strabo, *Geography* 2.5.7; Brown, *The Story of Maps*, 28-31; Cleomedes *On the Circular Motion of the Heavenly Bodies*, trans. Ivor Thomas (1941; London: William Heinemann, 1957), 1.10.52; Ivor Thomas, ed., *Selections Illustrating the History of Greek Mathematics*, vol. 2 (1941; repr., London: William Heinemann, 1957), 267-73; Edward Gulbekian, "The Origin and Value of the Stadion Unit used by Eratosthenes in the Third Century B.C.," *Archive for History of Exact Sciences* 37, no. 4 (December 1987): 359-63.

34,600 stadia, or about 3,460 miles.[24] Meroë was located about 3,000 stadia *south* of the Tropic of Cancer, demonstrating that the inhabited world did not perfectly align with the models of Parmenides and Aristotle. Eratosthenes may have also extended the *oikoumenē* beyond Meroë to encompass Taprobane (Sri Lanka) in the East and the Land of Cinnamon in Africa (modern Ethiopia and the Horn of Africa).[25] The length of the habitable world more than doubled its width, stretching 77,800 stadia from beyond the capes of eastern India to the Atlantic islands west of Iberia. The eastern and western boundaries of habitation were not absolute limits; like Aristotle, Eratosthenes asserted that the inhabited world "forms a complete circle, itself meeting itself; so that, if the immensity of the Atlantic Sea did not prevent, we could sail from Iberia to India along one and the same parallel over the remainder of the circle."[26]

Eratosthenes divided the *oikoumenē* along two primary lines: the meridian that passed through Syene and Alexandria; and a parallel of the equator that passed through the Pillars of Heracles (Strait of Gibraltar), the Strait of Sicily, southern Greece, and Rhodes. The Taurus Mountains of Central Asia extended this parallel to the eastern end

[24] As noted above, the length of the *stadion* is unknown. There are between seven and ten stadia in the imperial mile.

[25] Strabo did explicitly state that Eratosthenes extended the *oikoumenē* south of Meroë. Eratosthenes began measuring at Meroë, but Strabo's account of these measurements closes with the following statement: "Accordingly, if we add three thousand four hundred stadia more to the south of Meroë, in order to embrace the Island of the Egyptians, the Cinnamon-producing country, and Taprobane, we shall have thirty-eight thousand stadia." Since Strabo did not explicitly criticize Eratosthenes' placement of the oikoumenē's southern border, it probably included the Land of Cinnamon. See Strabo, *Geography* 1.4.2.

[26] Ibid., 1.4.6.

of the known world.[27] Eratosthenes' measurement of the earth's polar circumference included eight key points: The Land of Cinnamon, Meroë, Syene, Alexandria, Rhodes, the Hellespont, the Borysthenes, and the parallel through Thule.[28] It is a matter of debate among classicists whether Eratosthenes was the first to trace the seven "canonical" climates—divisions based upon length of day—as parallels on a map of the *oikoumenē*.[29] Since the seven canonical climates passed through Meroë, Syene, Lower Egypt, Rhodes, the Hellespont, the mid-Pontus, and the Borysthenes, it is likely that the two concepts are related. Indeed, three of Eratosthenes' points—Thule, Rhodes, and Syene—were already located on parallels, and the Land of Cinnamon represented a rough parallel, as well.[30]

The nature of the Torrid Zone, which began a few hundred miles south of Meroë and the Land of Cinnamon, was a question of spirited debate among Hellenistic

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[27] Ibid., 2.1.1, 1.4.6.

[28] Borysthenes is the ancient name of the Dnieper River; it empties into the northern Black Sea in present-day Ukraine.

[29] See Ernst Honigmann, *Die sieben Klimata und die πόλεις ἐπισημοι: eine Untersuchung zur Geschichte der Geographie und Astrologie im Altertum und Mittelalter* (Heidelberg: Carl Winter' Universitätsbuchhandlung, 1929); Dicks, "The ΚΛΙΜΑΤΑ in Greek Geography," 248-55; D. R. Dicks, "Strabo and the ΚΛΙΜΑΤΑ," *The Classical Quarterly* 6, no. 3/4 (July–October, 1956): 243-47; Marcotte, "La climatologie," 263-77; Shcheglov, "Ptolemy's system," 21-37; Dmitriy Shcheglov, "Eratosthenes' Parallel of Rhodes and the History of the System of *Climata*," *KLIO* 88, no. 2 (2006): 351-59; Shcheglov, "Hipparchus' Table of Climata and Ptolemy's Geography," *Orbis Terrarum* 9 (2003–2007): 159-92.

[30] At a minimum, Eratosthenes used the parallel of Rhodes to divide the *oikoumenē* into two halves: the "Northern Division" and the "Southern Division." He further divided these halves into sections called *plinthia* (tiles) and *sphragides* (seals) based upon shape. India thus became "Section First" of the Southern Division, Ariana (roughly, Parthia) "Section Second," and Mesopotamia and Media the "Third Section." See Strabo, *Geography* 2.1.22-27.

geographers. Whereas Aristotle divided the earth into five zones—two arctic, two temperate, and one torrid, Eratosthenes and Polybius argued in favor of additional zones. Eratosthenes suggested that a third temperate zone encircled the earth in a narrow band along the equator. Crates of Mallus, a Stoic of the second-century B.C., turned to Homer's descriptions of Ethiopia and the ocean-river Oceanus for inspiration. According to Strabo, Crates believed the Torrid Zone was "occupied" by Oceanus rather than land. Intriguingly, Crates also believed that "we must conceive that on the other side of Oceanus also there are certain Ethiopians," like those of the temperate zone.[31] Polybius, on the other hand, suggested that the equatorial zone was home to a mountain range that encircled the earth and reached its highest elevations.[32] Rainfall on the peaks of this range rendered it temperate, but Polybius did not classify the equator as a unique zone.[33] For Polybius, the equator split the Torrid Zone into two separate zones, a division which permitted an equal number of zones—three—in each hemisphere (Fig. 5).

[31] Ibid., 1.2.24, 2.3.2.

[32] Because of the physics of gravity, orbital motion, and planetary rings, equatorial mountain ranges may not be as unusual as they sound. For a comparable example within Earth's solar system, consider the Saturnine moon Iapetus. Images from Voyager II initially suggested the existence of such a mountain range. In 2004 the Cassini-Huygens mission discovered that that an "equatorial ridge," fifteen miles wide and eight miles in elevation, encircled much of the moon. Investigation of the origins of this ridge—rotation, tectonic processes, a collapsed ring—is ongoing. See Samantha Harvey and Autumn Burdic, "Iapetus: Overview," ed. Phil Davis, National Aeronautics and Space Administration, http://solarsystem.nasa.gov/planets/profile.cfm?Object=Sat_Iapetus (accessed March 23, 2013). See images and captions "PIA06156: Waning Iapetus," "PIA06169: Iapetus in 3D," and "PIA06166: Encountering Iapetus" at Jet Propulsion Laboratory, "Photojournal," California Institute of Technology, accessed March 23, 2013, http://photojournal.jpl.nasa.gov/target/Iapetus.

[33] Strabo, *Geography* 2.3.2.

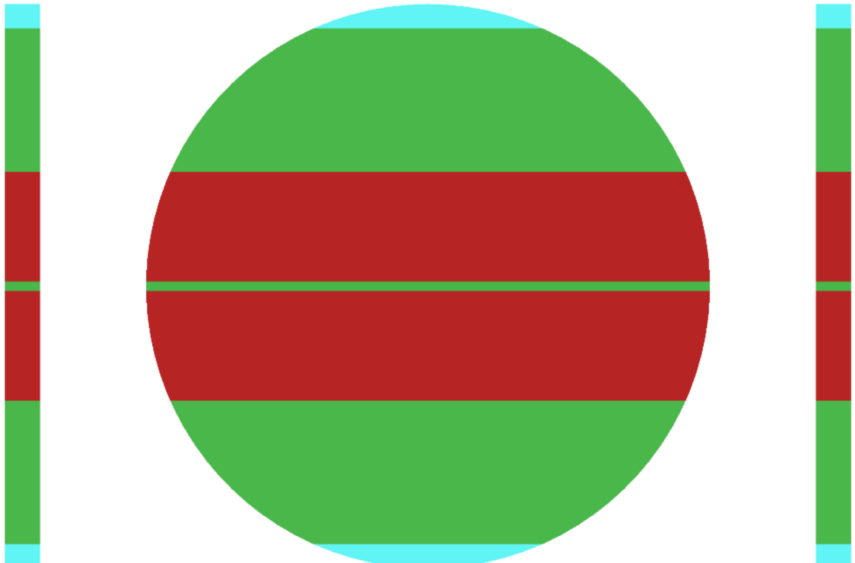

Fig. 5. *Polybius' model of habitability. The Frigid Zones are blue; the Temperate Zones are green; the Torrid Zones are red.*

Eratosthenes' geographical studies greatly influenced subsequent Hellenistic and Roman scholars. Hipparchus of Nicaea (fl. 162-126 B.C.), born around the time of Eratosthenes' death, was his primary successor in the study of geography and his most prominent critic. Although many of Hipparchus' works have been lost, fragments of one geographical treatise, *Against the 'Geography' of Eratosthenes*, are preserved in the later works of Strabo and Pliny the Elder. An astronomer and mathematician by trade, Hipparchus brought an emphasis on measurement and exactness to geography that separated him from his more theoretical colleagues. As D. R. Dicks remarks, Hipparchus "dealt only with mathematical geography, unlike Eratosthenes, who paid equal attention to descriptive geography of the type that Strabo preferred."[34]

Hipparchus' mathematical approach led to his development of a standardized coordinate-grid based on regularly-spaced *klimata*. According to Strabo, Hipparchus believed the study of geography depended on the collection of exact measurements:

> Hipparchus . . . correctly shows that is impossible for any man, whether layman or scholar, to attain the requisite knowledge of geography without the determination of the heavenly bodies and of the eclipses which have been observed; for instance, it is impossible to determine whether Alexandria in Egypt is north or south of Babylon, or how much north or south of Babylon it is, without investigation through the means of the "climata."[35]

In order to facilitate such comparisons, Hipparchus recommended the collection and tabulation of celestial data from throughout the inhabited world. Adopting the 360° circle from Babylonian geometry, Hipparchus divided the meridian passing through Meroë and Alexandria, from the Equator to the North Pole, into ninety 1° segments. Parallels of the equator intersected this meridian at 1° intervals. Hipparchus called these segments κλίματα in reference to the inclination of the celestial pole above the horizon.[36] By measuring the equinoctial day, position of the stars, and other celestial phenomena at

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[34] Hipparchus is perhaps best known for discovering that the orientation of the earth to the constellations of the celestial sphere changes over time. Today, this 26,000-year "wobble" in the earth's axis is known as the "precession of the equinoxes." See D. R. Dicks, *The Geographical Fragments of Hipparchus* (London: The Athlone Press, 1960), 31.

[35] Strabo, *Geography* 1.1.12.

[36] Ibid., 2.5.34. As an observer moves 1° of arc along a meridian of the earth, the celestial pole rises 1° above the horizon. See Dicks' commentary on fragments 39-40 of Hipparchus: Dicks, *Fragments*, 154-66.

each of the κλίματα, Hipparchus believed geographers could eventually develop accurate models of the earth's surface.

Posidonius of Apamea (*c*. 135-50 B.C.) followed Hipparchus in the study of geography, contributing to the field an influential treatise on the ocean. Fragments of this text are preserved in Strabo's *Geography*. Posidonius was not satisfied with existing definitions of the earth's zones. According to Strabo, he criticized both Parmenides and Aristotle for misrepresenting the Torrid Zone; the former, for representing it as "almost double its real breadth," and the latter, for associating it too strictly with the tropics. For Posidonius, "torrid" only applied to "the region that is uninhabitable on account of heat;" he located the beginning of the Torrid Zone in the Land of Cinnamon. Since 8,000 stadia separated Syene from the Land of Cinnamon, and 8,800 stadia separated the latter from the Equator, he suggested that a little more than half of the zone between the tropics was uninhabitable. Posidonius was also uncomfortable with using the variable "arctic circles" to delineate the polar limits of habitability. He questioned "how one could determine the limits of the temperate zones, which are non-variable, by means of the 'arctic circles,' which are neither visible among all men nor the same everywhere."[37]

Posidonius was critical of existing models of the *oikoumenē*, but his own model shared many features with those of his predecessors (Fig. 6). Like Aristotle he began with five zones and three categories, delineating the zones based on the position of the sun and the behavior of shadows. The two tropical parallels and the arctic and antarctic

[37] Strabo, *Geography* 2.2.2.

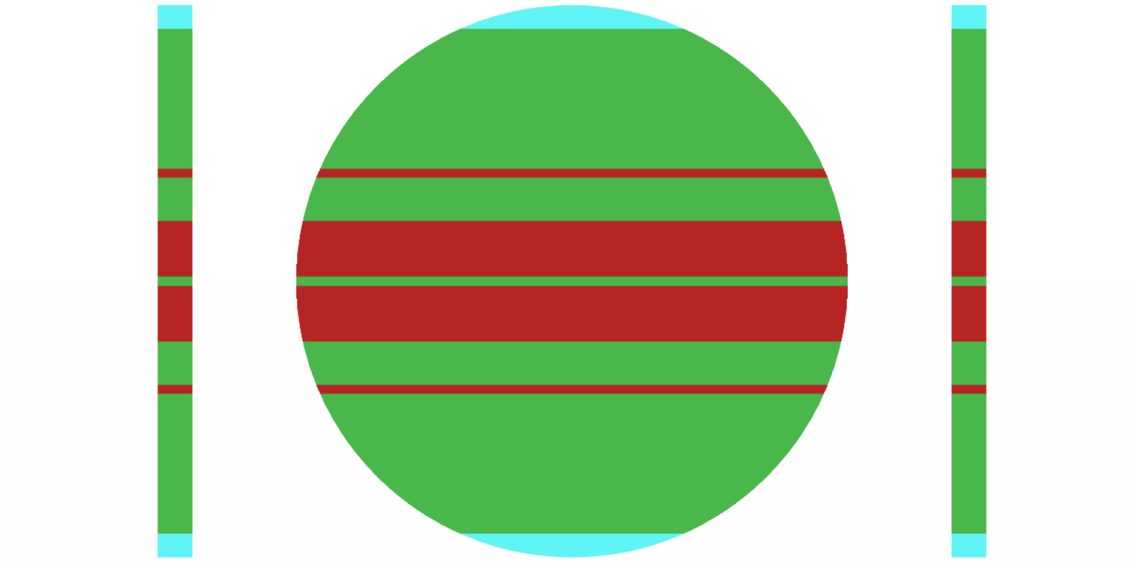

Fig. 6. *Posidonius' model of habitability. The Frigid Zones are blue; the Temperate Zones are green; the Torrid Zones are red.*

parallels divided the earth into *periscian*, *heteroscian*, and *amphiscian* zones.[38] Like Eratosthenes and Polybius, Posidonius theorized that a third temperate zone was situated along the equator. According to Strabo, though, Posidonius rejected Polybius' hypothesis that the narrow equatorial zone was a mountain range reaching the earth's greatest elevations. Still reckoning—like most classical geographers—that the earth was a perfect sphere, Posidonius suggested that "there can be no high point on a spherical surface, because the surface of a sphere is uniform all round." He suggested that the equatorial zone was instead "a plain that is approximately on a level with the surface of

[38] *Periscian* describes the circular movement of shadows across the surface of the Frigid Zone on the summer solstice, when the sun does not set. *Heteroscian* describes the noon shadows of the temperate zones, which always fall to the north in the northern hemisphere and the south in the southern hemisphere. *Amphiscian* applies to locations between the Tropics of Cancer and Capricorn, where noon shadows fall to the north for part of the year and to the south for the remainder. Ibid., 2.2.3.

the sea." According to Strabo, however, there were also passages in which Posidonius "concede[d] the view of Polybius" that a rainy, mountainous temperate zone lay along the Equator.[39]

Posidonius defined two additional, narrow zones that were characterized by their exceptional dryness: "[T]here are, in addition to these five zones, two other narrow ones that lie beneath the tropics and are divided into two parts by the tropics." Posidonius attributed their dryness to the sun, which rose to the zenith of the sky for about two weeks each year and bestowed upon the land several unique characteristics:

> These two zones . . . have a certain peculiarity, in that they are parched in the literal sense of the word, are sandy, and produce nothing except silphium [a medicinal plant] and some pungent fruits that are withered by the heat; for those regions have in their neighborhood no mountains against which the clouds may break and produce rain, nor indeed are they coursed by rivers . . . .

In the absence of an original name for these zones, historian Lloyd Brown's appellation "super-torrid" will suffice. Brown's description of their location, however, is unfortunately vague: "Some, including Poseidonius, divided the earth into seven zones, subdividing the area bounded by the tropics near the equator into two narrow zones, roughly five degrees on either side, where the sun was said to be directly overhead, or nearly so, about a half month each year."[40]

When Strabo, quoting Posidonius, wrote that the super-torrid zones were *beneath* and *divided by* the tropics, he was actually locating them on the Tropics of Cancer and Capricorn. Several points reinforce this assertion. According to Strabo, Posidonius

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[39] Ibid., 2.3.3.

[40] Ibid., 2.2.3; Brown, *Story of Maps*, 41.

believed there were people living south of the super-torrid zone: "the people who live farther south . . . have a more temperate atmosphere, and also a more fruitful, and a better-watered, country." In another passage, Strabo even adopted Posidonius' phraseology to describe the environment of the Summer Tropic: "There is still another distinctive characteristic of the regions beneath the tropic, which I have mentioned before in speaking of the zones, namely, the soil itself is very sandy, silphium-producing, and dry, whereas the regions to the south of it are well-watered and very fruitful."[41] Charting the dates and latitudes at which the sun reaches the zenith of sky provides further reinforcement. Only near the Tropics does the sun remain at approximately the same declination for an extended period of time, ascending to and returning from the zenith on consecutive days.[42]

The super-torrid zones were thus located on the Tropic of Cancer and the Tropic of Capricorn. Because Posidonius' Torrid Zone began 8,000 stadia *south* of the Tropic of Cancer in the Northern Hemisphere, the super-torrid zones actually sliced through the Temperate Zones. Depending on how one counts the subdivisions of the Temperate and Torrid Zones, Posidonius' model consisted of between eight and eleven zones: two frigid zones, two subdivided temperate zones, one subdivided torrid zone, two super-torrid zones, and one equatorial zone. According to Strabo, Posidonius used "ethnical

[41] Strabo, *Geography* 2.2.3, 2.5.37.

[42] Between the Tropic of Cancer and an imaginary line some twenty miles closer to the equator, the sun reaches the zenith of the sky twice in only two weeks. Today this narrow band passes midway between Aswan and Abu Simbel, through man-made Lake Nasser. Hellenistic geographers situated the Tropic of Cancer 50 miles north, in Syene (Aswan).

criteria” to identify some of these zones. One was the “Scythico-Celtic zone,” another the “Ethiopic zone,” and another the “intermediate zone.” Strabo did not discuss the application or justification for these titles. He suggested only that Posidonius had abandoned the “analogy of the five zones.”[43]

Strabo of Amaseia (*c*. 64-24 B.C.) was more comfortable in his role as historian than geometrician. He generally accepted the measurements of his predecessors, particularly Eratosthenes, as working hypotheses for measuring the earth. Delineating zones of habitability, however, required addressing political and ethnic borders, historical categories, flora, fauna, and the motions of the heavens. Eschewing the more complicated models of Polybius and Posidonius, Strabo settled on the traditional five-zone division because it seemed to be “in harmony with physics as well as geography.”[44] Although Strabo remained open to the idea of a narrow, mountainous temperate zone on the equator, he found too many contradictions in Polybius’ and Posidonius’ models to add an additional zone.[45]

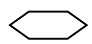
Strabo believed the five-zone model was in harmony with physics because it addressed both temperature and the motion of shadows in one model. Both of these could be divided into three categories. As Posidonius explained, shadows cast by the sun delineated three types of zones: amphiscian, periscian, or heteroscian. For Strabo

[43] Strabo, *Geography* 2.2.3, 2.3.1.

[44] Ibid., 2.3.1.

[45] Strabo found it particularly curious that geographers could defend both an all-encompassing ocean-river and an equatorial mountain range: “How, pray, can they place mountains in the centre of the ocean—unless by “mountains” they refer to certain islands?” See Ibid., 2.3.3.

this was the "best way to determine the zones." Temperature, in a loosely defined manner, could also be divided into three "very broad" categories: "excess of heat, lack of heat, and moderate heat." On a sphere the three temperatures and their corresponding shadows described five zones: two frigid, one torrid, and two temperate.[46] Like Posidonius, Strabo located the beginning of the Torrid Zone south of the Tropic of Cancer. The five-zone model harmonized with Strabo's version of geography—the study of the inhabited world—because the moderately warm, heteroscian zone in the northern hemisphere corresponded with the world of Greek trade and exploration.

For Strabo the inhabited world had two distinguishing characteristics: its shape and its diminutive size. Measurements of the known world suggested that it would fit within one quarter of the earth's surface. To define this space, Strabo divided the northern hemisphere into two quadrilaterals enclosed by the Equator, arctic circle, and a meridian passing through the north pole. The *oikoumenē*, surrounded by water, fit within one of these quadrilaterals. Existing maps suggested that it was wider at its center than at the arctic and equatorial parallels. The inhabited world thus took on the shape of a hexagonal island  with eastern and western sides that stretched to points in the surrounding seas.[47] Strabo described it as a "chlamys-shaped island," drawing a comparison between the *oikoumenē* and the mantle, an article of clothing wide at its center. Strabo estimated that the inhabited portion of the earth was about 70,000 stadia

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[46] Ibid., 2.3.1.

[47] In the West, this point corresponded with Cape St. Vincent, a promontory at the southwestern tip of present-day Portugal, 200 miles northwest of the Strait of Gibraltar.

in length and 30,000 stadia in breadth. The quadrilateral measured 126,000 stadia in length and, with the portion of the torrid zone north of the equator, 38,800 stadia in breadth.[48] The inhabited portion of the earth was thus not only smaller than the quarter of the earth it occupied, it was also smaller than the torrid and oceanic portions of that quarter. Although the temperate zone appears quite large when traced upon a sphere, the habitable world of Strabo and his contemporaries was dwarfed by its surroundings.

Strabo's methodical, geometrical description of the shape of the inhabited world veils the uncertainty with which he defined its outer limits.[49] Although reason would suggest that the entirety of the temperate zone was habitable, Strabo placed the northern extent of habitability south of the arctic circle. He found Pytheas' descriptions of Thule and the British Islands unconvincing:

> I learn nothing on the subject—neither that there exists a certain island by the name of Thule, nor whether the northern regions are inhabitable up to the point where the summer tropic becomes the arctic circle. But in my opinion the northern limit of the inhabited world is much farther to the south than where the summer tropic becomes the arctic circle. For modern scientific writers are not

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[48] Strabo, *Geography* 2.5.6; Jones, *Geography*, 436n1. Jones provides the best description of Strabo's quadrilateral:

> The large quadrilateral in question is composed of (1) the inhabited world, (2) a strip one-half the width of the torrid zone and 180° long, and (3) "the remainder." "The remainder" consists of two small quadrilaterals, one of which is east, the other west, of the inhabited world. By actual computation the strip of the torrid zone is more than half of the inhabited world, and "the remainder" is still more. Therefore the inhabited world covers less than half of the large quadrilateral in question.

[49] Strabo's methodical approach to comparing locations within the inhabited world is evident in his proposal of a coordinate system of cartography. The two axes of his system traced the inhabited world's greatest length and greatest breadth. He called these axes "elements" because they anchored a system of parallel lines that divided the known world—land and sea—into a series of measurable parallelograms. Strabo believed that his system would improve the cartographic representation of inhabited places and the klimata in which they were located. See Strabo, *Geography* 2.5.16.

> able to speak of any country north of Ierne, which lies to the north of Britain and near thereto . . . .

Strabo could accept that Ierne, or Ireland, existed; he could even accept that it was inhabited. To call the Emerald Isle habitable, however, would be too generous. Ireland, Strabo wrote, was the "home of men who are complete savages and lead a miserable existence because of the cold."[50] It was "such a wretched place to live in on account of the cold that the regions on beyond are regarded as uninhabitable."[51]

The Land of Cinnamon south of Meroë provided a precedent for redefining the geometric limits of habitability using environmental criteria. Strabo explained that, "just as it was appropriate in the case of the southern regions to fix a limit of the habitable world by proceeding three thousand stadia south of Meroë . . . so in this case too we must reckon no more than three thousand stadia north of Britain, or only a little more, say four thousand stadia." Both limits remained open to challenge. Strabo wrote parenthetically of the southern limit: "not indeed as though this were a very accurate limit, but as one that at least approximates accuracy."[52]

Strabo's description of the inhabited world was actually a description of one inhabited world upon the earth; it was not necessarily a reflection of the habitability of the earth itself. Strabo's geography focused on the known world. Beyond the limits of the known world, he admitted, there may be other habitable regions. If Polybius and Posidonius were correct that the equatorial lands were habitable, Strabo wrote, then such

[50] Ibid., 2.5.8.
[51] Ibid., 2.1.13.
[52] Ibid., 2.5.8.

regions “constitute a peculiar kind of inhabited country, stretching as a narrow strip through the centre of the country that is uninhabitable on account of the heat, and not forming a part of our inhabited world.”[53] Strabo acknowledged that the other half of the “spinning-whorl” of the northern hemisphere may too be inhabited. If such were the case, though, he warned that “it is not inhabited by men such as exist in our fourth, and we should have to regard it as another inhabited world.” This was a “plausible theory,” but it was beyond the parameters of Strabo’s geography.[54]

Strabo’s extensive research on the natural world was followed, in the first century A.D., by the elder Pliny’s *Natural History*, one of the best-documented publications of the ancient world. For the thirty-seven volume study, Pliny (A.D. 23/4-79) examined hundreds of sources about the earth, its aquatic and terrestrial regions, and their floral, faunal, and human inhabitants. Working from the universal to the regional and specific, Pliny’s *Natural History* established the form that later natural histories would follow. Its attention to meteorological phenomena, regional variations, and cultural differences make it an important source for climatic ideas.

The anchor of Pliny’s cosmology was the bountiful earth. For Pliny, the earth was much more than the center of the universe; it was “appropriated to man as the heavens are to God.” The earth was unique among the elements of nature for its absence of conceit:

> In our anger we imprecate her on those who are now no more, as if we were ignorant that she is the only being who can never be angry with man. The water passes into showers, is concreted into hail, swells into rivers, is precipitated in

[53] Ibid., 2.5.34.
[54] Ibid., 2.5.13.

> torrents; the air is condensed into clouds, rages in squalls; but the earth, kind, mild, indulgent as she is, and always ministering to the wants of mortals, how many things do we compel her to produce spontaneously![55]

Although Pliny believed the earth to be generous, he acknowledged that the heavens and the seas rendered much of her surface uninhabitable. More explicitly than Strabo, and with a thinly veiled disdain for empire, Pliny emphasized that humans could occupy very little of the earth's surface. The seas occupied about half of the earth's surface; the heavens divided the remainder into the five zones. The polar zones were characterized by "severe cold and perpetual frost," while the tropics, beneath the sun's orbit, were "parched and burned by the flame" and "consumed" by the nearness of its heat. Pliny reasoned that "the heavens take from us three parts of the earth; how much the ocean steals is uncertain."[56]

Between the poles and tropics, the two temperate zones were the natural home of humans. Pliny asserted, however, that parts of the temperate zone were uninhabitable:

> We must also take into account the extent of all the rivers and the marshes, and we must add the lakes and the pools. There are also the mountains, raised up to the heavens, with their precipitous fronts; we must also subtract the forests and the craggy valleys, the wildernesses, and the places, which, from various causes, are desert.

Tongue planted firmly in cheek, Pliny asserted: "The vast quantity which remains of the earth, or rather, as many persons have considered it, this speck of a world (for the earth is no more in regard to the universe), this is the object, the seat of our glory." The

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[55] Pliny's life came to an unfortunate end in A.D. 79 while he was rescuing victims of the eruption of Mount Vesuvius. Pliny, *Natural History*, trans. John Bostock and H.T. Riley (London: George Bell & Sons, 1890), 2.63.

[56] Ibid., 2.68.

remaining portion of the earth was, of course, by no means vast. Nevertheless, nation waged war on nation, and neighbor fenced out neighbor. “[T]he man who has most extended his boundary, and has expelled the inhabitants for ever so great a distance,” Pliny wondered, “after all, what mighty portion of the earth is he master of?”[57]

The study of *klimata* and habitability in the Greco-Roman world reached its technical apogee in the works of Claudius Ptolemy (c. 100-176 A.D.) and his contemporary, Marinos of Tyre. Although classical, Arabic, and medieval scholars would continue to investigate the known and unknown worlds, Ptolemy’s theories remained at the center of Western thought through the Copernican Revolution. Marinos was a cartographer from the province of Syria. Although Marinos’ guide to mapmaking has been lost, Ptolemy discussed it at length in the introductory chapters of his *Geography*. Like Strabo, Marinos mapped the *oikoumenē* on a graticule with *klimata* representing the latitudinal belts of the map. Meridional zones called “hour-intervals” intersected the *klimata* at right angles every 15°.[58]

One of Marinos’ most important contributions to geography was his expansion of the *oikoumenē* beyond the Land of Cinnamon and into the *antoikoumenē*, the theoretically habitable zone of the Southern Hemisphere. Like Pytheas and his successors, Marinos set the northern limit of the known world at Thule, which he located at 63° N. Unlike his predecessors, however, Marinos located the southern limit south of

[57] Ibid.

[58] The “hour-interval” takes its name from the fact that, on the equinox, noon on the eastern edge of an interval would occur one hour earlier than noon on the western edge; 15° is 1/24 of 360°. They are comparable to modern time-zones. See Berggren and Jones, *Ptolemy’s Geography*, 24.

the Equator on the Tropic of Capricorn. He based this estimate on contemporary reports of two sea voyages along the East African coast and two overland expeditions to the country of Agisymba, a client state of the Libyan king of Garamē.[59] His initial estimates, based on typical rates of travel, suggested that these expeditions had reached the unlikely latitudes of 49° S and 55° S—the icy equivalent of Scythia and Sarmatia in northern Europe and Asia.[60] Reasoning that expeditions were rarely uniform in speed or direction, Marinos arbitrarily reduced his estimate by more than half to 24° S, close to the Winter Tropic. He thus located the limit of the known world in the region of modern-day Botswana and South Africa—an unlikely location for Libyan Agisymba. According to Ptolemy, Marinos held that "the whole latitudinal dimension of the *oikoumenē* . . . amounts to approximately 87°, or 43,500 stades."[61]

Claudius Ptolemy served as a scientist and cartographer in the second century, A.D. Like Eratosthenes, much of his career was spent in and around the Egyptian city of Alexandria. Ptolemy began examining the zones of the earth in the *Almagest*, a study of astronomy that explained the eccentric motions of planetary bodies within the geocentric model of the cosmos. Berggren and Jones suggest that, at this stage in his career, Ptolemy "accepted a geographical picture of the known, inhabited world . . . that was not radically changed" from those of Eratosthenes and Hipparchus. Like Strabo, he believed

[59] Berggren and Jones locate Garamē in modern-day southwestern Libya, near the city of Jarmah (26°33' N; 13°6' E). Berggren and Jones, "Garamē," in *Ptolemy's Geography*, 172.

[60] These latitudes, in fact, correspond to locations between South Africa and Antarctica.

[61] Ptolemy, *Geography* 1.7-9.

that the *oikoumenē* occupied the center of one quarter of the earth's surface. Like Polybius and Parmenides, he respected the theory that the equator could be habitable, but he remained skeptical in the absence of evidence. Breaking from Eratosthenes and his successors, Ptolemy located the southern limit of the *oikoumenē* at Meroë (12° N), north of the Land of Cinnamon. Unlike Strabo, Ptolemy bore no hard feelings against the Irish; he located the northern limit of the *oikoumenē* at the arctic circle (66° N), north of Ireland and Thule and in the "lands of the unknown Skythians."[62]

Although Ptolemy described the *oikoumenē* in relatively familiar terms in the *Almagest*, he had already begun to conceive of an innovative way of locating its features on a globe or map. Ptolemy expanded the table of the seven traditional *klimata* and adopted a system of regularly-spaced parallels based on length-of-day. These parallels were not equally-spaced:

> The complete list of parallels starts with the equator, and proceeds north at intervals such that the duration of daylight at the summer solstice increases by quarter-hours from 12 equinoctial hours at the equator to 18 equinoctial hours at 58° N, and then by larger time-intervals (because the parallels get closer together) to 24 equinoctial hours at the arctic circle (66°8'40" N).[63]

The *Almagest*, however, was a study of astronomy. Ptolemy's most refined estimates for the *oikoumenē* are in his *Geography*. Earlier geographical works often focused on astronomy, topography, and history. Ptolemy's *Geography* emphasized the importance of accurate cartography, and his approach to the subject was undeniably

[62] Berggren and Jones, *Ptolemy's Geography*, 17-21.
[63] Ibid.

innovative.[64] By using curvilinear parallels rather than a rectilinear grid, he devised maps that were more sensitive to the curvature of the earth than those of Strabo.[65] By publishing detailed tables of locations with latitudinal and longitudinal information, Ptolemy created a system that others could replicate without the original map. By allowing land masses to spill over the borders of his maps, Ptolemy challenged the belief that the coasts of the continents and the borders of the known world were collinear. Homer had placed Ethiopia on the coast of Oceanus: "For Jove went yesterday to Oceanus, to a feast among the Ethiopians, and the other gods went with him." Strabo, in a similar way, described the known world as a chlamys-shaped island, "washed on all sides by the sea." Ptolemy, as Berggren and Jones note, was "willing to admit that the theoretically habitable land mass of the world extended indefinitely beyond the limits of knowledge of his time."[66]

In the *Almagest*, Ptolemy located the northern and southern borders of the *oikoumenē* at the arctic circle (66° N) and at the parallel through Meroë (16° N). By the time he completed the *Geography*, Ptolemy had adjusted the northern limit of the inhabited world southward to Thule, from 66°N to 63°N.[67] The location of Agisymba and the southern limit, however, remained a more difficult question. Like Marinos, Ptolemy rejected the notion that recent expeditions had reached latitudes of 49° S and

[64] "Guide to Drawing a Map of the World" is an alternate translation of its title. See Berggren and Jones, *Ptolemy's Geography*, 3-4.

[65] Ptolemy, *Geography* 1.21.

[66] Homer, *Iliad*, trans. Samuel Butler (New York: Longmans, Green, and Co., 1898), 1.423; Strabo, *Geography* 2.5.5; Berggren and Jones, *Ptolemy's Geography*, 21.

[67] Ptolemy *Geography* 1.7.

55° S, but he questioned Marinos' arbitrary location of Agisymba on the Winter Tropic. Marinos "gave not a single logical reason for reducing this amount"; he "reduces the number of stades . . . until the [southern] limit reaches the parallel that he thinks it ought to reach."[68]

Since there were no astronomical measurements to establish location, Ptolemy suggested comparing descriptions of Agisymba, the home of Ethiopians and rhinoceros, to more familiar locations north of the equator:

> This is the [evidence] of the forms and colors of the local animals, from which it would follow that the parallel through the country of Agisymba, which clearly belongs to the Aithiopians, is not as far as the Winter Tropic, but lies near the equator. For in the correspondingly situated places on our side [of the equator], that is those on the Summer Tropic, people do not yet have the color of the Aithiopians, and there are no rhinoceros and elephants . . . But in the places around Meroē people are already quite black in color, and are at last pure Aithiopians, and the habitat of the elephants and more wonderful animals is there.[69]

Because of the biological similarities of Agisymba and Meroë, Ptolemy believed the two were equidistant from the equator, though in different hemispheres. He located Agisymba about 16° S of the equator, on the parallel exactly opposite of Meroë. This

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[68] Ibid., 1.9.

[69] Ibid. Ptolemy's *Geography* is the only evidence for Agisymba. Modern attempts to determine its location use comparative methods similar to those of Ptolemy, though they locate it *on* the parallel of Meroë rather than *opposite* of Meroë. According to Berggren and Jones, Agisymba was probably located near the Aïr Mountains of Niger or the Tibesti Mountains of Chad. See Berggren and Jones, *Ptolemy's Geography*, 168; Jehan Desanges, *Recherches sur l'activité des Méditerranéens aux confins de l'Afrique (VI^e siècle avant J.-C. – IV^e siècle après J.-C.)* (Rome: École française de Rome, 1978), 197-200.

was 8° N of Marinos' estimate, and it moved the southern limit of the *oikoumenē* to modern-day Zambia and Mozambique.[70]

Ptolemy's *Geography* was the standard guide to cartography in the medieval Islamic world and Renaissance Europe. By the eighteenth century, when Chambers and d'Alembert published their encyclopedias, the term climate referred to Ptolemy's system of parallels spaced at regular intervals based on length-of-day. The creation of a system of κλίματα, however, was part of a larger process of measuring and defining the inhabited world. Natural philosophers and geographers from Parmenides to Ptolemy began with a five-zone model of the world, though differences in interpretation and the availability of new data led to numerous variations. Although the models varied, no natural force altered the essential dichotomy between habitable and uninhabitable. Such a concept would have been antithetical to the astronomical origins of the model: the heavens did not change. Environmental change, however, was an important theme of Greek and Roman natural philosophy. The catastrophic flood of Deucalion, like those of Genesis and Gilgamesh, was an important element of historical narrative. Records of drought, ruins of temples, and the discovery of aquatic fossils far from the shore all pointed toward dramatic changes of the earth's surface.

Plato's *Timaeus* and *Critias* are perhaps best known for their attention to Atlantis, the legendary rival to Athens that sank beneath waves "in a single dreadful day and night."[71] The two dialogues also provide a window into classical Greek notions of

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[70] Ptolemy, *Geography* 1.10.
[71] Plato, *Timaeus*, trans. Desmond Lee (1965; New York: Penguin, 1977), 25.

the natural world. The world Plato (*c*. 429-347 B.C.) described was not characterized by stability; it was a world of dramatic, consequential, and occasionally catastrophic environmental changes. In *Timaeus* Plato offered a sketch of the history of the natural world—its creation, constitution, order, and mechanics. Part of the dialogue, however, tells of a journey by the Greek statesman Solon (fl. 594/3 B.C.) to the Egyptian city of Saïs. While visiting the temple in Saïs, Solon learned that Egyptian priests maintained a chronology of world history more ancient than that of Athens. According to one elder priest, Athens' short memory was due to its great susceptibility to natural disaster. Of the states of the ancient world only Egypt, nourished by the Nile, had escaped this fate. "There have been and will be many different calamities to destroy mankind," the priest explained to Solon, "the greatest of them by fire and water, lesser ones by countless other means."[72]

A model for such catastrophes could be found in the legendary stories of the Greek gods. The Egyptian priest pointed to the story of Phaeton, whose failed attempt to pilot his father Helios' chariot across the heavens ended in conflagration of the Earth. According to the priest, the tale was a

> mythical version of the truth that there is at long intervals a variation in the course of the heavenly bodies and a consequent widespread destruction by fire of things on the earth. On such occasions those who live in the mountains or in high and dry places suffer more than those living by rivers or by the sea; as for us, the Nile, our own regular saviour, is freed to preserve us in this emergency. When on the other hand the gods purge the earth with a deluge, the herdsmen and shepherds in the mountains escape, but those living in the cities in your part of the world are swept into the sea by the rivers; here water never falls on the land from above either then or at any other time, but rises up naturally from below.

[72] Ibid., 22-23.

“This is the reason,” the priest confidently asserted, “why our traditions here are the oldest preserved.[73]

Plato further developed this notion of change in *Critias*, an incomplete sequel to *Timaeus*. In *Critias* Plato explored the capability of the ideal republic to wage war; ancient Athens and legendary Atlantis served as the setting for his simulation.[74] The character Critias, again repeating from Solon’s account, opened the dialogue by comparing the contemporary Greek landscape to that of the Atlantean age 9,000 years earlier. The most notable transformation had been in the distribution and fertility of the soil, once “more fertile than that of any other country.” “What proof,” Critias asked, “can we offer that it is fair to call it now a mere remnant of what it once was?” He offered this illuminating explanation:

> [T]he result of the many great floods that have taken place in the last nine thousand years . . . is that the soil washed away from the high land in these periodical catastrophes forms no alluvial deposit of consequence as in other places, but is carried out and lost in the deeps. You are left (as with little islands) with something rather like the skeleton of a body wasted by disease; the rich, soft soil has all run away leaving the land nothing but skin and bone. But in those days the damage had not taken place, the hills had high crests, the rocky plain of Phelleus was covered with rich soil, and the mountains were covered by thick woods, of which there are some traces today.

Plato’s discussion of this transformation also demonstrates an understanding of the complexity of environmental change. Critias continued his comparison by describing “second-order” consequences that some neglect even today:

> The soil benefited from an annual rainfall which did not run to waste off the bare earth as it does today, but was absorbed in large quantities and stored in retentive layers of clay, so that what was drunk down by the higher regions flowed

[73] Ibid.
[74] Ibid., 20b.

> downwards into the valleys and appeared everywhere in a multitude of rivers and springs.

Critias suggested that the remains of shrines built at dry springs were evidence of significant geographical changes.[75]

Although Plato's *Timaeus* and *Critias* offer some perspective of the scientific mindset of Classical Greece, Aristotle had a greater impact on notions of geology and environmental change. His study of meteorology was the first systematic explanation for changes at the surface of the earth. Reintroduced to Europe during the Middle Ages, Aristotle's model of the universe remained influential into the seventeenth century. Many early modern ideas about climate and environmental change were rooted in Aristotle's interpretations of cosmology and geology and in his organization of their elements.

Like many of his contemporaries, Aristotle believed the earth to be a sphere surrounded by a "spatially endless" celestial region. The celestial region consisted of one element, ether, and it was eternally in motion. The terrestrial sphere, which stretched from the center of the earth to the moon, consisted of a "kind of matter" that could be present as one of four elements or bodies: earth, water, air, fire. Each of these four bodies inhabited a "natural place," one of the nested spheres that, like an onion, together comprised the terrestrial sphere. Earth was the central sphere; water, air, and fire surrounded it. Fire is perhaps an imperfect term, for Aristotle did not mean flames, but rather a dry, flammable type of air that was easily set ablaze by the circular motion

[75] Plato, *Critias*, trans. Desmond Lee (1965; New York: Penguin, 1977), 110-11.

of the celestial region.[76] Each of the four terrestrial bodies could be categorized as hot, like air and fire, or cold, like water and earth. Each was either wet, like air and water, or dry, like fire and earth. Each also possessed one of two motions: toward the center of the terrestrial sphere or away from it. Fire always rose to the top, while earth always sought the center. Air and water occupied the space between, with air rising toward fire and water descending toward earth. When displaced, the four bodies sought to return to their natural home in the most direct route possible.

The characteristics of the four bodies were neither eternal nor inherent; they were not atoms. They could, and often did, exist in a mixed state, and they could change forms. Aristotle wrote that the four bodies were the "material cause of all sublunar events." In other words, they were the material out of which the "first cause" shaped the natural word. The celestial element, eternally circling the terrestrial sphere, was the "source of all motion" and the "first cause." This motion formed the four bodies out of matter and maintained them in a state of agitation, preventing them from settling in their natural places. Meteorology concerned the movement and interactions of these four bodies.[77]

The phenomena generated by such interactions were extraordinarily diverse in their characteristics, locations, and significance for terrestrial life. In the upper atmosphere, or sphere of fire, such phenomena included shooting stars, the aurora borealis, comets, and the Milky Way. Below, in the realm of air, were rain, clouds,

[76] Aristotle, *Meteorologica* 1.3.340b5-30, 1.4.341b5-25.
[77] Ibid., 1.2, 1.3.339a33-b5.

mists, dew, hoar-frost, snow, hail, winds, thunder, lightning, hurricanes, and whirlwinds. At the surface, meteorology addressed such phenomena as rivers, springs, coastal processes, silt, salinity, and earthquakes.[78] In each case, meteorological phenomena were the result of the displacement, movement, and interactions of the four terrestrial bodies, whose motions were ultimately caused by the celestial element.

The most important form of terrestrial displacement in Aristotelian meteorology was the exhalation, or evaporation, of earth and water into the atmosphere. The sun generated heat by rapidly moving through the celestial region, warming both earth and water. Water exhaled moist, heavy vapors that settled in the lower atmosphere, contributing to the sphere of air. Similarly, the earth exhaled a hot, dry substance comparable to smoke that accumulated beneath the limits of the celestial region as the sphere of "fire." These exhalations, effects of the eternal motion of the heavens, thus contributed to the formation of the two upper spheres.

Although Aristotle incorrectly identified an evaporation of earth (with an allowance, perhaps, for the radiation of heat), his description of the movement of water vapor closely approximates modern definitions of the hydrological cycle:

> The earth is at rest, and the moisture about it is evaporated by the sun's rays and the other heat from above and rises upwards: but when the heat which caused it to rise leaves it, some being dispersed into the upper region, some being quenched by rising so high into the air above the earth, the vapour cools and condenses again as a result of the loss of heat and height and turns from air into water: and having become water falls again onto the earth. The exhalation from water is vapour; the formation of water from air produces cloud.

[78] H. D. P. Lee, *Meteorologica* (1952; Cambridge, MA: Harvard University Press, 1987), x-xi.

Aristotle compared this cycle to a river, and he suggested that the oceanic river described by Homer might be this "river which flows in a circle round the earth."[79]

Aristotle's discussion of water vapor is particularly striking today because of its relative familiarity. Ancient and early modern readers, however, found the smoky exhalations of earth equally important. This "smoke," Aristotle argued, rose above the moist vapors of the sea and lower atmosphere and into the sphere of fire, the most flammable and easily excitable part of the terrestrial sphere.[80] Contact with the celestial region could ignite this fiery material and launch it across the sky. Such eye-catching phenomena were called "torches," "goats," and shooting stars—all forms of meteors that differed only in brilliance and size.[81] An exhalation large enough to fuel itself and compact enough to move very slowly, if at all, could become a comet.

Although meteorological phenomena were often sudden and short-lived, one chapter of the *Meteorologica* addressed the subject of long-term hydrological change. "The same parts of the earth are not always moist or dry," Aristotle wrote, "but change their character according to the appearance or failure of rivers." Likewise, "mainland and sea change places and one area does not remain earth, another sea, for all time." Aristotle did not attribute these variations to divine caprice or extraordinary causes; they were part of "an orderly cycle," much like that which controlled aging and decay in animals and plants. This process could affect neighboring regions quite differently. Due to variations in temperature, regions developed different "potentialities" for responding

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[79] Aristotle *Meteorologica* 1.9.
[80] Ibid., 1.4.341b.
[81] Ibid., 1.4.341b25-35.

to environmental change. Some would slowly dry while others would spring to life. Springs would fail, streams and rivers would shrink, and the sea would overtake deltas built by river-borne silt. Elsewhere, the reverse would compensate. Egypt, with its numerous dry depressions, suggested a region growing increasingly drier. The Greek states of Argos and Mycenae were also drier, though the alteration seemed to improve cultivation in Argos while hindering it in Mycenae.[82]

The environmental changes Aristotle described in the *Meteorologica* were neither universal nor permanent. Since the universe itself was permanent, it could neither age nor decay. Likewise, the terrestrial sphere could not fall victim to irreversible desiccation or deluge. All such changes occurred on the surface of a much larger body. Countering those who believed the sea to be drying, Aristotle asserted that "it is absurd to argue that the whole is in process of change because of small changes of brief duration like these." "Rather," he suggested, "we should suppose that the cause of all these changes is that, just as there is a winter among the yearly seasons, so at fixed intervals in some great period of time there is a great winter and excess of rains."[83]

Aristotle gave no indication of the period of such cycles, though some have suggested a relationship with the "great year" in which celestial bodies complete their circuit of the heavens. Some alterations, like the silting of a delta or the narrowing of the entrance to Lake Maeotis, could happen within one's lifetime. The hydrological variations in the *Meteorologica*, however, tended to progress slowly. They "escape our

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[82] Ibid., 1.14.351a19-b10.
[83] Ibid., 1.14.352a20-35.

observation," Aristotle wrote, "because the whole natural process of the earth's growth takes place by slow degrees and over periods of time which are vast compared to the length of our life." War, famine, and disease acted far more rapidly. Echoing Plato, Aristotle noted that the destruction wrought by such forces could break societies apart "before they can record the process from beginning to end." In a statement perhaps directed at the proud priests of Saïs, Aristotle suggested that Egypt was an example of a society whose environmental transformation had been lost in the sands of time. Environmental changes were an integral feature of Aristotelian meteorology, but they performed a carefully defined role—internal, cyclical, measured, and balanced. [84]

Aristotle's successor at the Lyceum, Theophrastus of Eresus (*c.* 372-282), completed two treatises on the weather: *On Winds* and *On Weather Signs*. A student of Aristotle and the inheritor of his library, Theophrastus was well-acquainted with Aristotle's notions of the physical world. Of the two meteorological treatises, *On Winds* is both more complete and more recognizable as an extension of the themes developed in the *Meteorologica*. *On Weather Signs* is as an organized list rather than a work of prose, but it does include a brief introduction.[85]

On Winds focused on the "forces and other conditions" that endowed the thirteen traditional winds with their unique characteristics. Theophrastus was not concerned with

[84] Ancient astronomers used a variety of definitions for the "great year," but many suggested a period of several hundred to several thousand years. As defined today, a "great year" is a complete cycle of the precession of the equinoxes. It has a period of about 25,800 years. Ibid., 1.14.351b-352a.

[85] Jasper G. Wood, *On Winds and On Weather Signs*, ed. G. J. Symons (London: Edward Stanton, 1894), 9-11.

explaining wind itself, noting in his introduction—perhaps in reference to the *Meteorologica*—that "[f]rom what elements, in what manner, and through what causes the physical constitution of the winds derives its origin has been already considered." He was instead interested in the defining characteristics of the winds: volume, temperature, turbulence, moisture, frequency, and variability. Although the treatise focused on the characteristics of individual winds, a few passages discuss Aristotelian notions of environmental change. Theophrastus suggested that each wind had a "particular place of origin" which shaped its characteristics.[86] For some winds, like the Etesian (ἐτήσιαι) or "annual" winds, these characteristics could be irregular. The Etesian winds were believed to be a consequence of summer snowmelt, which made them subject to the exhalations controlling snowfall as well as the conditions controlling melting and evaporation. As such, the Etesian winds were subject to great variability: "For at one time it is strong, and continuous; at another weaker and intermittent; and this is because the thaw is irregular."[87]

Theophrastus recognized that such meteorological irregularities could have an important impact on agriculture and settlement. As an example, he pointed to reports of historical changes in the environment of Crete. Although he was cautiously skeptical of such accounts, he did not reject them out-of-hand:

> If, then, it is true (as some and particularly the dwellers in Crete say) that the winters are more severe, and more snow falls than formerly—(as proof of which

[86] Theophrastus, *On Winds*, trans. Jasper G. Wood, ed. G. J. Symons (London: Edward Stanton, 1894), 1-2.

[87] Wood translates ἐτὴσιαι as "Monsoon" to capture the degree of seasonal variability implied by the word. Theophrastus, *On Winds* 12; Wood, O*n Winds and on Weather Signs*, 26n15.

> they allege that formerly the hills were inhabited and produced both corn and fruit, the land having been planted and cultivated for that purpose; that there are in fact on the hills of the Ida range and on others, plateaus of considerable extent of which now-a-days they cultivate not one, because they are unproductive; while formerly as has been said they not only cultivated them, but also dwelt upon them so that the Island had a large population; and that at the time showers occurred, but much snow and storm did not)—if, I repeat, this is true which they allege, it follows that the monsoon also has greater duration [now than formerly].[88]

In the brief treatise *On Weather Signs*, Theophrastus described the atmospheric and terrestrial signs that could be used to predict the weather. This early guide to "forecasting" consists of lists of signs from earth and heaven along with the weather events associated with them. A typical sign from the atmosphere reads, "Thunder in winter at dawn is a rather good sign of rain, whereas thunder in summer at midday is not, but evening thunder *is* a sign of rain." Signs could also be found in the behavior of animals: "And if birds flee from the sea they signal storm."[89] The content and organization of *On Weather Signs* demonstrate that it was intended to serve as a compendium of such examples. Theophrastus made no attempt to explain the causal relationships between sign and signified, as he did in *On Winds*. Likewise, the organization of the text precludes its use as a "desk reference" for meteorological phenomena. As editors Sider and Brunschön note, the treatise is organized by forecasted weather—rain, wind, storms, fair weather, miscellany—rather than by the signs themselves.[90]

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[88] Theophrastus, *On Winds* 13.

[89] Theophrastus, *On Weather Signs*, trans. David Sider and Carl Wolfram Brunschön (Leiden: Brill, 2007), 20, 40.

[90] David Sider and Carl Wolfram Brunschön, eds, *On Weather Signs*, 32-34.

Most of these signs referred to atmospheric phenomena of the coming hours or days—short-term events that roughly correspond to the modern notion of "weather." Some, however, applied to entire seasons: "If winter begins early it ends early and the spring is fair; if the reverse, there will be no spring." Theophrastus believed that weather changes on this scale were compensation for existing imbalances, though they could never permanently correct such imbalances. Fair weather in the fall signified a cold spring. An early winter ended early and was followed by a fair spring. A late winter ended late and permitted no spring. A cold spring and summer signified a "stifling hot and windless" late summer and fall. Rainy seasons succeeded dry seasons, and dry seasons rainy.[91]

Signs of seasonal or long-term change tended to be fixed to particular points in time; prediction required the division of time into segments with cyclical beginning and end-points. Theophrastus called these διχοτομίαι, or dichotomies. "The first point to grasp," Theophrastus explained, "is that time periods are defined by dichotomies, and so when dealing with these periods one must consider the year, the month, and the day."[92] The largest dichotomies corresponded to the rising and setting of the Pleiades in May and November, the spring and fall equinoxes, and the winter and summer solstices.[93] Months and days were divided in a similar manner, using moons, eighth and fourth days,

[91] Theophrastus, *On Weather Signs* 44, 48.

[92] Ibid., 6.

[93] The equinoxes and solstices did not necessarily define the seasons. *On Weather Signs* referenced five seasons: μετόπωρον (autumn), χειμὼν (winter), ἔαρ (spring), θέρος (summer), and ὀπώρα, a season typically comprised of August and September. See Sider and Brunschön, *On Weather Signs*, 195.

sunrises, and sunsets. Theophrastus explained how signs intersected with these points in time:

> Whatever the general state of the atmosphere is at the time of the Pleiades' setting remains this way in most cases until the next solstice; any change occurs after the solstice. And if there is no change, things remain the same until the equinox. From this point similarly until the Pleiades rise, and from thence until the summer solstice, and then until the next equinox, and from the equinox until the Pleiades set.[94]

Stated differently, weather on a seasonal or biannual scale could change in November, December, March, May, June, and September.

Aristotle and Theophrastus offered only brief remarks on long-term changes in moisture, drought, and the extent of the seas. Xanthus of Lydia, a fifth-century contemporary of Herodotus, was probably the first to provide evidence for hydrological changes through ruins, fossils, and records of drought. Although his works are lost, one fragment preserved by Eratosthenes and Strabo describes

> the opinion of Xanthus, who says that in the reign of Artaxerxes there was so great a drought that the rivers, lakes, and wells dried up; that far from the sea, in Armenia, Matienne, and Lower Phrygia, he himself had often seen, in many places, stones in the shape of a bivalve, shells of the pectin order, impressions of scallop-shells, and a salt marsh, and therefore was persuaded that these plains were once sea.

Straton of Lampascus (d. 269 B.C.), Theophrastus' successor at the Lyceum, applied similar logic to the origins of the Mediterranean and Black Seas. According to Strabo, Straton believed that the Black Sea had once been separated from the Mediterranean Sea. As tributary rivers flowed into the Black Sea, they "forced and opened a passage, and then water was discharged into the Propontis and the Hellespont." In similar

[94] Theophrastus, *On Weather Signs* 7-9.

fashion, he believed the Mediterranean, swollen by the discharge of rivers, broke through the Pillars of Heracles. Places that had “hitherto been covered with shoal-waters were left dry.” Like Xanthus, he found evidence for this in the discovery of shells far from the seashore. Straton ascribed these dramatic changes to two causes: the seas did not share the same sea-bed, and the sea-beds were of different elevations. Although the openings of the straights were catastrophic events, Straton believed that changes in sea-level were part of an ongoing process governed by the flow of rivers. The Black Sea, for example, was slowly filling with silt deposited by its tributary rivers.[95]

Eratosthenes praised Straton and Xanthus for their attention to changes in the earth’s surface, and he apparently found their arguments quite convincing. Eratosthenes believed that the earth was not a perfect sphere but rather a spherical object with “certain irregularities of surface” caused by “the action of water, fire, earthquakes, volcanic eruptions, and other similar agencies.” According to Strabo, Eratosthenes’ *Geography* attempted “to enumerate the large number of [the earth’s] successive changes in shape.”[96] Strabo reported only one of these “successive changes,” but the passage he paraphrased reveals the historical and archaeological breadth of Eratosthenes’ natural philosophy:

> Eratosthenes says further that this question in particular has presented a problem: how does it comes about that large quantities of mussel-shells, oyster-shells, scallop-shells, and also salt-marshes are found in many places in the interior at a distance of two thousand or three thousand stadia from the sea—for instance (to quote Eratosthenes) in the neighbourhood of the temple of Ammon and along the road, three thousand stadia in length, that leads to it? At that place, he says, there is a large deposit of oyster-shells, and many beds of salt are still to be found

[95] Strabo, *Geography* 1.3.4.
[96] Ibid., 1.3.3.

> there, and jets of salt-water rise to some height; besides that, they show pieces of wreckage from seafaring ships which the natives said had been cast up through a certain chasm, and on small columns dolphins are dedicated that bear the inscription: "Of Sacred Ambassadors of Cyrene."[97]

Like Xanthus and Straton, Eratosthenes provided physical evidence to support his argument. Like Aristotle, he described environmental changes within the exclusive context of natural processes.

Posidonius and Strabo shared with Eratosthenes an interest in the transformation of the earth's surface. According to Strabo, Posidonius "correctly set down in his work the fact that the earth sometimes rises and undergoes settling processes, and undergoes changes that result from earthquakes and . . . similar agencies." For Posidonius, such evidence suggested that Plato may have been right when he said that "it is possible that the story about the island of Atlantis is not a fiction."[98] Strabo, a Stoic who was wary of haphazard theories of causation, was more cautious. He worried that some might interpret changes in the surface of the earth as evidence of changes in the universe itself. Strabo warned his readers that "changes so insignificant are lost in great bodies," but he acknowledged that they had an impact on human life. In a succinct explanation of environmental variability, Strabo asserted that successive changes "produce conditions

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[97] The temple of Ammon was home to the oracle of Ammon. It was located at the oasis of Siwa (29°12'19"N, 25°32'37"E) in western Egypt. It is 25 miles east of present-day Libya, 350 miles west of the Nile River, and 150 miles from the modern coastline of the Mediterranean Sea. The Siwa area included numerous salt lakes and salt flats, several of which remain today. Ibid., 1.3.4.

[98] Ibid., 2.3.6.

in the inhabited world that are different at one time from what they are at another, and the immediate causes which produce them are different at different times."[99]

The term climate, as it is used in the twenty-first century, implies a spatially and chronologically finite habitat with familiar atmospheric and hydrological phenomena. Ancient Greek and Latin possessed no comparable word; a place or region might instead be described by its inclination, seasons, or heavens. Greek and Roman natural philosophers and geographers, however, raised questions about the natural world similar to those of modern geography and climatology. They explored methods of dividing the earth's surface into the habitable temperate zones and uninhabitable torrid and frigid zones, as well as into κλίματα. Some, like Hipparchus and Ptolemy, began compiling tables of local celestial and geographical information, each awaiting a day when data points would stretch from one end of the *oikoumenē* to the other. Through observation, historical research, and nascent archaeology, numerous scholars concluded that the earth's surface underwent significant changes. Meteorology, as defined by Aristotle and Theophrastus, provided an explanation for these phenomena that endured for two millennia.

These themes were part of a larger scientific and philosophical mission, that of describing and explaining the natural world. They were intertwined, but they were not explicitly interrelated. There were climates, and there were environmental changes. But climates did not change. Indeed, "climate change" would have implied an alteration of the heavens, the only fixed part of the universe and the first cause of all creation. There

[99] Ibid., 1.3.3.

were environmental changes, and there were environmental influences. But the environment's influence did not change. As such there was no "climate," as we would understand the term, but the pieces were there. In the wake of the Renaissance and the printing press, European scholars would have a wealth of useful, bizarre, and contradictory ideas to examine.[100] Early modern definitions of climate, like that of d'Alembert in the *Encylopedie*, are representative of this process.

[100] In 1475 Ptolemy's *Geography* became one of the first classical texts to be printed; a second edition in 1478 was among the first books to incorporate maps printed from copper plates. Over the course of two decades, Aldus Manutius published the first Greek imprints of Aristotle and Theophrastus (1495-98), Herodotus (1502), Plato (1513), and Strabo (1516). The first complete edition of Hippocrates' texts was published shortly thereafter, in 1526. See Henry N. Stevens, *Ptolemy's* Geography*: A Brief Account of All the Printed Editions Down to 1730* (London: Henry Stevens, Son & Stiles, 1908), 37-38; Sider and Brunshön, *Theophrastus of Eresus*, 50-51; Jones, *Geography*, xli.

CHAPTER III

CLIMATE AND THE *COURS ORDINAIRE*:

THEOLOGY, ASTROLOGY, AND METEOROLOGY

IN SIXTEENTH CENTURY EUROPE

Climate was the subject of the first sentence of prose printed in the English language. William Caxton, translating from Raoul Lefèvre's *Recueil des Histoires de Troye* in 1473, used climate to establish the distant origins of the French romance, when the climates of the Earth divided the children of Noah. "What tyme," Caxton recalled, "alle the Children of Noe were sprad bi the Climates. regnes and strange habitacions of the world By the general dyuysyon of tonges maad at the fondacion of the tour of babilon in tho dayes that the world was of gold?"[1] Sixteenth-century cosmographers and geographers retained the definition of climate established by their Greek and Roman predecessors; a climate was a portion of the earth between two parallels of the equator. Defined by length-of-day and the location of principal landmarks, climates did not change. To explain the evident mutability of the earth's surface and atmosphere, natural philosophers turned to theology, astrology, and Aristotelian meteorology. While these provided guidance for understanding the daily variations of weather, they presupposed a

[1] All uses of the archaic letters *wynn* and *thorn* have been rendered as "the" for purposes of legibility. The French manuscript reads, "Tous les filz de noe espars par les climatz les regnes et les estranges habitations des sieclez par la generale diuision des langue faitte a la fondation de la tour de babilonne." Raoul Lefèvre, *Le recueil des histoires de troyez* (1464), unpaginated, 1r; Lefèvre, *The recuyell of the historyes of Troye*, trans. William Caxton (1473), unpaginated, 1r.

relatively stable environment. No prevailing interpretation of weather offered a model for understanding the dramatic environmental changes of the late sixteenth century.

The first French almanac, *Le compost et kalēdrier des bergiers*, published by Guy Marchant in the 1490s, defined climate as “vne espace de terre.”[2] According to Marchant, “Bergiers [shepherds] & dautres cōe eulx diuisēt la terre habitable en sept parties quils appellent climats.” A climate was “vne espace de terre egalement large. de laquelle sa longueur est de orient en occident et sa largeur est venant du midi et de la terre bien habitable vers lequinoctial tirant a septẽtrion tant comme vng horloge nese change point.”[3] English translations of the *Kalẽdrier* retained Marchant’s definition. Parisian printer Antoine Verard published the first English edition in 1503, a Scots-English translation titled *The kalendayr of the shyppars*.[4] “Shyppars and others as they,” the author wrote, “dyuysyt the erth habytacyōs in .vii. partys the qwych they cal clymas

[2] The *Kalendrier* dates to 1491, but Marchant published several editions during the 1490s. Because the *Kalendrier* is a favorite of collectors, some early editions are in private hands. The oldest edition available at the Bibliothèque nationale de France (BnF) dates to 1493.

[3] *Icy est le compost et kalēdrier* (Paris: Guy Marchant, 1496), l5r.

[4] H. Oskar Sommer, a scholar of Arthur and Spenser, published a detailed analysis of the English translations in 1892 under the title, *The Kalender of Shepherdes*. Sommer’s three-volume study includes a photographic facsimile of the lone copy of *The Shyppars Kalender*, part of the Chatsworth House Collection held by the Duke of Devonshire. The Bodleian Library also holds a few pages of the 1503 translation. All quotations used here are from the Sommer facsimile. See *The kalendayr of the shyppars* (Paris: Antoine Verard, 1503); H. Oskar Sommer, *Photographic Facsimile of the Edition Paris 1503*, vol. 2 of *The Kalender of Shepherdes: The Edition of Paris 1503 in Photographic Facsimile, A Faithful Reprint of R. Pynson’s Edition of London 1506. Edited with a Critical Introduction and Glossary* (London: Kegan Paul, Trench, Trübner, 1892).

andnā mes thē."[5] A 1506 translation, published by London printer Richard Pinson, is more easily understood: "Shepherdys and other deuydes the erthe that is inhabyted in seuen dyuers manere of partys, the whiche that they do call clymatys and nameth theym."[6] A later translation, published in 1530 by London printer Robert Wyer, explains that "Ptholomeus & dyuers other deuyden the erth habytable in .vii. partyes / that they call Clymates." According to Wyer, a climate was "a space of the erth egally large / Wherof the length is from oryent to occydent / and the bredthe is comynge from mydday & from the erthe enhabytable toward the equynoccy all drawynge to septemtryon / as moche as an horologe or clocke chaungeth nat."[7]

Several sixteenth-century publications emphasized the importance of defining climates. Welsh lexicographer William Salesbury defined the term in the marginalia of his translation of Proclus' *The Sphere,* published in 1550 and 1553. The longest marginal note in the text—a note not found in Thomas Linacre's Latin translation—defined climate as "[a] porcion of the worlde betwene north & South where in is

[5] According to Sommer, the 1503 translation leaves much to be desired: "This translation, leaving the language and its orthography for the present aside, is a very poor piece of work. The translator evidently did not know much of his own tongue, and still less of French; in fact he must have been a person of no good education even for that time." See H. Oskar Sommer, *Prolegomena*, vol. 1 of *The Kalender of Shepherdes* (London: Kegan Paul, Trench, Trübner, 1892), 66; *The kalendayr of the shyppars*, I4v.

[6] Pinson explained in a prefatory note that copies of the 1503 edition were printed in "corrupte englysshe and nat by no englysse man," wherefore "no man coude vnderstonde them pretly." *The kalender of the Shepeherdes* (London: Printed by Richard Pinson, 1506), A2r, L4v.

[7] *Here begynneth The Compost of Ptholomeus / Prynce of Astronomye: Translated oute of Frenche in to Englysshe / for them that wolde haue knowlege of the Compost* (London: Robert Wyer, [1522]), I3v.

varyacion of tymes. &c."[8] Richard Eden, in a partial translation of Sebastian Münster's *Cosmographia*, adopted a similar definition in reference to subequatorial Africa, which "conteyneth no lesse then two clymes of the earth." The final sentence of Eden's book defined the term: "And a clyme is a porcion of the worlde betwene South and North, wherein is variacion in length of the daye, the space of halfe an houre."[9]

European expeditions to North and South America complicated attempts to neatly categorize the world's climates. Pietro Martire d'Anghiera, an Italian historian of Spain, discussed the complicated geography of the New World in a series of publications known as the *Decades*. In the sixth chapter of the first *Decade*, published in 1511, Martire examined descriptions of the Trinidadian island of Puta that were composed during Christopher Columbus' third voyage to the Caribbean. Textbook definitions of climate suggested that Puta, and its inhabitants, should resemble Ethiopia, which shares

[8] Proclus, *The Description of the Sphere or the frame of the world, ryght worthy to be red and studyed on, of all noble wyttes, specially of all those that be desyrous to attayne any perfecte knowledge in Cosmography, or true description of Reagions, Townes, or Countrees, set forth by Proclus Diadochus, and Englysshed by wyllyam Salysbury*, trans. William Salesbury (London: Robert Wyer, 1550), C2r; Proclus, *The Description of the Sphere or Frame of the worlde*, trans. William Salesbury (London: Roberty Wyer, 1553), C3r. For Linacre's 1499 Latin translation, see: Proclus, *Diadochi Sphæra, Astronomiam. Discere incipientibus utilissima, nouiter ex græco recognita*, trans. Thomas Linacre (1499; Bologna: Cynthium Achillinum, 1525).

[9] Sebastian Münster, *A treatyse of the newe India, with other new founde landes and Ilandes, aswell eastwarde as westwarde, as they are knowen and found in these oure dayes after the descripcion of Sebastian Munster in his boke of uniuersall Cosmographie: wherein the diligent reader may see the good successe and rewarde of noble and honeste enterpryses, by the which not only worldly ryches are obtayned, but also God is glorified, & the Christian fayth enlarged*, trans. Richard Eden (London: Edward Sutton, 1553), M5v.

a similar angle of solar inclination. As Richard Eden's 1555 translation of the *Decades* demonstrates, the two places were actually quite different:

> Here the Admirall consideringe with hym selfe the corporature of this people and nature of the lande, he beleaued the same to bee soo much the nerer heauen then other Regions of the same paralelle, and further remoued from the grosse vapours of the vales and maryshes, howe muche the hygheste toppes of the byggest mountaynes are distante from the deepe vales. For he ernestly affirmeth, that in all that nauigation, he neuer wente owte of the paralelles of Ethiope: So greate difference is there betwene the nature of thinhabitantes and of the soyles of dyuers Regions all vnder one clyme or paralelle as is to see betwene the people and regions being in the firme lane of Ethiope, and theym of the Ilandes vnder the same clime, hauinge the pole starre eleuate in the same degree. For the Ethiopians are all blacke, hauinge theyr heare curld more lyke wulle then heare. But these people of the Iland of *Puta* (beinge as I haue sayde vnder the clyme of Ethiope) are whyte, with longe heare, and of yelowe colour. Wherfore it is apparente, the cause of this soo greate difference, to bee rather by the disposition of the earthe, then constitucion of heauen.[10]

One could not assume that a common climate implied environmental or racial uniformity.

Although climate was an important element of sixteenth-century cosmography and geography, atmospheric phenomena garnered comparatively little attention. English chronicles, like those of historians Raphael Holinshed (c.1525–c.1580) and John Stow

[10] The 1530 edition of the *Decades*, published under the title *De orbe nouo*, explains: "Vnde discrimē hoc tantum oriri possit alias non video.terræ igitur dispositio non cœlorum flatus eam causantur varietatē." See Pietro Martire d'Anghiera, *De orbe nouo* (Alcalá de Henares, Spain: Michaele d'Eguia, 1530), B6v; Martire, *The Decades of the newe worlde or west India, Conteynyng the nauigations and conquestes of the Spanyardes, with the particular description of the moste ryche and large landes and Ilandes lately founde in the west Ocean perteynyng to the inheritaunce of the kinges of Spayne. In the which the diligent reader may not only consyder what commoditie may hereby chaunce to the hole christian world in tyme to come, but also learne many secreates touchynge the lande, the sea, and the starres, very necessarie to be knowẽn to al such as shal attempte any nauigations, or otherwise haue delite to beholde the strange and woonderfull woordkes of God and nature*, trans. Richard Eden (London: William Powell, 1555), 29v.

(1524/5-1605), demonstrate that scholars recorded and remembered weather events, but they offer little insight into the rationalization or interpretation of weather. The various editions of Stow's chronicles document more than 120 meteorological events in England's 2500-year history, almost half of which occurred during the author's lifetime (Table 1). If Stow believed that the unusual distribution of events reflected a change in the constitution of nature, rather than improved recordkeeping or preservation, such a conclusion remained beyond the scope of his chronicles.[11]

Table 1: Meteorological Entries in John Stow's *The Annales of England* (1600)

		Century						
Subject of Entry	Before 1000	11th	12th	13th	14th	15th	16th	Total
Flood	-	2	-	7	3	1	6	**19**
Tempest & Wind	-	2	-	7	4	-	6	**19**
Earthquake & Chasm	-	2	5	3	1	1	6	**18**
Marvels & Monsters	2	-	3	2	1	2	5	**15**
Pestilence & Disease	1	-	-	3	3	1	7	**15**
Scarcity & Famine	-	2	-	1	2	1	5	**11**
Meteors	2	1	1	1	-	-	4	**9**
Great Frost	-	1	-	3	1	-	3	**8**
Drought	-	-	1	-	-	1	2	**4**
Building Damage	-	-	-	-	-	-	3	**3**
Bridge Damage	-	-	-	1	-	-	2	**3**
Hot Summer	-	-	-	1	1	-	-	**2**
Early Harvest	-	-	-	-	1	-	-	**1**
Total	**5**	**10**	**10**	**29**	**17**	**7**	**49**	**127**

[11] Stow is best known for *A Survey of London*, published in 1598 and 1603. He published numerous editions of the English chronicles between 1565 and his death in 1605, including *A Summarie of Englyshe Chronicles* (1565), *The Chronicles of England* (1580), and *The Annales of England* (1592). Edmund Howes and Anthony Munday continued Stow's chronicles after his death.

Playwright John Heywood penned the first English publication dedicated exclusively to weather in 1533, a comedy titled *The Play of the Wether*. Heywood's play describes Jupiter's control of the elements and his attempt to establish weather conditions that equally benefited his subjects.[12] He collects proposals from eight representatives—a gentleman, a merchant, a ranger, a water miller, a wind miller, a gentlewoman, a laundrywoman, and a playful child. The gentleman and the merchant request fair weather, but the other petitioners sue for conditions that will benefit their professions and hobbies while undermining those of their neighbors. The ranger, who profits from the windfall of storm-damaged forests, pleas for stormy weather. The millers sue for wind and rain, respectively. The gentlewoman requests clouds to protect her complexion, while the laundrywoman demands ample sunshine. The young boy, who speaks for 100 other young boys, hopes for snow so that children can hold snowball fights and catch birds. Jupiter recognizes that any form of "contynuall" weather would "serue one" class of subjects and "destroye all the rest":

> But serue as many or as few as we thynke best
> And where or what tyme to serue moste or lest
> The dyreccyon of that doutles shall stande
> Perpetually in the power of our hande
> wherfore we wyll the hole worlde to attende
> Eche sort on suche wether as for them doth fall

[12] Scholars of Tudor literature, beginning with Kenneth Cameron in 1942, have emphasized the similarity of the play's structure to that of Lucian's *Icaromenippus*, in which Jupiter also weighs concerns about the weather. Cameron believed that Jupiter represented Henry VIII, and he suggested that the play's publication followed a series of rainy years in the 1520s. Kenneth Cameron, "The Interpretation and Dating of *Wether*" in *John Heywood's 'Play of the Wether': A Study in Early Tudor Drama* (Raleigh, NC: Thistle Press, 1941), 40-43.

> Now one now other as lyketh vs to sende
> who that hath yt ply yt and suer we shall
> So gyde the wether in course to you all
> That eche wyth other ye shall hole remayne
> In pleasure and plentyfull welth certayne.[13]

The elements would remain the domain of the gods.

Most sixteenth-century scholars agreed that meteorological phenomena were demonstrations of God's authority, but no single treatise defined a "theology of the weather." To explain weather events, clerics and lay writers relied on a small number of passages from the Old Testament, including several from Job and Psalms (Table 2). In the aftermath of the Flood, God established a covenant with the earth that guaranteed its survival and the survival of its inhabitants. "And when I shall cover the earth with a cloud, and the bow shall be seen in the cloud," Genesis 9:14-15 records, "Then will I remember my covenant which is between me and you, and between every living thing in all flesh, and there shall be no more waters of a flood to destroy all flesh." In the sixteenth century, however, the most commonly-cited verses afforded God unlimited control over the elements. "For he saith to the snow," Job 37:6 reports, "Be thou upon the earth likewise to the small rain and to the great rain of his power." Psalm 147, a hymn of praise, was particularly influential in early modern England. In the language of the 1560 Geneva Bible, the Lord "counteth the nomber of the starres, & calleth them all by their names" (147:4). "Sing vnto the Lord with praise," the Psalmist writes, "sing vpō the harpe vnto our God, Which couereth the heauē with cloudes and prepareth raine

[13] John Heywood, *The play of the wether* (London: Printed by W. Rastell, 1533), D5v.

for the earth, and maketh the grasse to growe vpon the mountaines: Which giueth to beastes their fode, and to the yong rauens that crye" (147:6-8). Winter sermons frequently cited verses 16-18, which describe the origins of snow and ice: "He giueth snow like wool, & scattereth the hoare frost like asshes. He casteth forth his yce like morsels: who can abide the colde thereof? He sendeth his worde and melteth thē: he causeth his winde to blowe, & the waters flowe."

Table 2: Biblical References to Meteorological Phenomena (1599 Geneva)

Job 37:5-11	[5]God thundereth marvelously with his voice: he worketh great things, which we know not. [6]For he saith to the snow, Be thou upon the earth likewise to the small rain and to the great rain of his power. [7]With the force thereof he shutteth up every man, that all men may know his work. [8]Then the beasts go into the den, and remain in their places. [9]The whirlwind cometh out of the South, and the cold from the North wind. [10]At the breath of God the frost is given, and the breadth of the waters is made narrow. [11]He maketh also the clouds to labor, to water the earth, and scattereth the cloud of his light.
Job 38:22-38	[22]Hast thou entered into the treasures of the snow? or hast thou seen the treasures of the hail, [23]Which I have hid against the time of trouble, against the day of war and battle? [24]By what way is the light parted, which scattereth the East wind upon the earth? [25]Who hath divided the spouts for the rain? or the way for the lightning of the thunders, [26]To cause it to rain on the earth where no man is, and in the wilderness where there is no man? [27]To fulfill the wild and waste place, and to cause the bud of the herb to spring forth? [28]Who is the father of the rain? or who hath begotten the drops of the dew? [29]Out of whose womb came the ice? who hath engendered the frost of the heaven? [30]The waters are hid as with a stone: and the face of the depth is frozen. [31]Canst thou restrain the sweet influences of the Pleiades, or loose the bands of Orion? [32]Canst though bring forth Mazzaroth in their time? canst thou also guide Arcturus with his sons? [33]Knowest thou the course of heaven, or canst thou set the rule thereof in the earth? [34]Canst thou lift up thy voice to the clouds, that the abundance of water may cover thee? [35]Canst thou send the lightnings that they may walk, and say unto thee, Lo, here we are? [36]Who hath put wisdom in the reins? or who hath given the heart understanding? [37]Who can number clouds by wisdom? or who can cause to cease the bottles of heaven, [38]When the earth groweth into hardness, and the clots are fast together?
Leviticus 26:18-20	[18]And if ye will not for these things obey me, then will I punish you seven times more, according to your sins, [19]And I will break the pride of your power, and I will make your heaven as iron, and your earth as brass: [20]And

Table 2 Continued

	your strength shall be spent in vain: neither shall your land give her increase, neither shall the trees of the land give their fruit.
Deuteronomy 28:22-24	[22]The Lord shall smite thee with a consumption, and with the fever, and with a burning ague, and with fervent heat, and with the sword, and with blasting, and with the mildew, and they shall pursue thee until thou perish. [23]And thine heaven that is over thine head, shall be brass, and the earth that is under thee, iron. [24]The Lord shall give thee for the rain of thy land, dust and ashes: even from heaven shall it come down upon thee, until thou be destroyed.
2 Chronicles 6:26-27 & 1 Kings 8:35-36	[26]When heaven shall be shut up, and there shall be no rain, because they have sinned against thee, and shall pray in this place and confess thy Name, and turn from their sin, when thou dost afflict them, [27]Then hear thou in heaven, and pardon the sin of thy servants, and of thy people Israel (when thou hast taught them the good way wherein they may walk) and give rain upon thy land, which thou hast given unto thy people for an inheritance.
Psalm 78:41-48	[41]Yea, they returned and tempted God, and limited the Holy one of Israel. [42]They remembered not his hand, nor the day when he delivered them from the enemy, [43]Nor him that set his signs in Egypt, and his wonders in the field of Zoan, [44]And turned their rivers into blood, and their floods, that they could not drink. [45]He sent a swarm of flies among them, which devoured them, and frogs, which destroyed them. [46]He gave also their fruits unto the caterpillar, and their labor unto the grasshopper. [47]He destroyed their vines with hail, and their wild fig trees with the hailstone. [48]He gave their cattle also to the hail, and their flocks to the thunderbolts.
Psalm 107:33-38	[33]He turneth the floods to a wilderness, and the springs of waters into dryness, [34]And a fruitful land into barrenness, for the wickedness of them that dwell therein. [35]Again he turneth the wilderness into pools of water, and the dry land into water springs. [36]And there he placeth the hungry, and they build a city to dwell in, [37]And sow the fields, and plant vineyards, which bring forth fruitful increase. [38]For he blesseth them, and they multiply exceedingly, and he diminisheth not their cattle.
Psalm 148:8	[7]Praise ye the Lord from the earth, ye dragons and all depths: [8]Fire and hail, snow and vapors, stormy wind, which execute his word.

London author and clergyman William Baldwin penned a richly literary expression of divine meteorology, *The Funeralles of King Edward VI*, shortly after the young king's untimely death.[14] Baldwin's elegy describes the dominion of "bytter Wynter" in early 1553, a punishment for "all vice most vile and naught" in England, a chosen land of "speciall grace."[15] When Christ intercedes, asking His Father to "stay thy wrath, haue mercy on our nede," God responds with an inventory of English sins, most of which relate to the enclosure of lands, the raising of rents, and the exploitation of the poor: "How suffer they theyr grayne to rot and hore / To make a dearth when I geue plenty store?" God extends two warnings to the English. Edward, a king "of such a godly minde, / As seldome erst he elsewhere had assinde," will take ill, then perish. If these measures fail to produce repentance, He will "powre downe plages till every one do feele."[16]

To carry out this morbid task, God calls forth his servant "Crasy cold," whom "the Icy king kept prisoner in his hold / Beneath the Poales, where vnder he doth dwell / In grysly darke like to the diepe of hell, In rockes and caves of snow [and] yse / That never thaw . . . ." The unusual character was well-named:

But forth he came this shivering crasy cold,

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[14] Baldwin flourished as a writer, editor, printer, and clergyman between 1547 and 1563. He published revels, humanist treatises, and some of the first English novels and satires, but he is best-known for editing *A Mirror for Magistrates*, a critique of government authority. According to literary scholar Stephen Gresham, Baldwin was the "literary voice of the reign of Edward VI" (1547-53). For discussion of the political nature of *A Mirror for Magistrates*, see Mike Pincombe, "William Baldwin and *A Mirror for Magistrates*," *Renaissance Studies* 27, no. 2 (2011): 183-98; John N. King, "Baldwin, William (*d.* in or before 1563)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004–), accessed September 17, 2013, http://www.oxforddnb.com; Stephen Gresham, "William Baldwin: Literary Voice of the Reign of Edward VI," *Huntington Library Quarterly* 44, no. 2 (Spring 1981): 101-16.

[15] William Baldwin, *The Funeralles of King Edward the sixt. VVherin are declared causers and causes of his death* (n.p.: 1560), A2r.

[16] Ibid., A3r-A4r.

With Ysikles bebristled like a Bore,
About his head behind and eke before.
His skin was hard, al made of glassy yse,
Ouerheard with hore frost, like gray Irishe frise,[17]
His armes and legges, to kepe him warme I trow,
Wer skaled through with flakes of frosen snowe,
And from his mouth there reekt a breth so hot,
As touched nothing that congeled not.

God instructs his servant to seek King Edward at court, “five Climates henceward to the South,” and quietly poison him there.[18]

Crazy Cold quickly traverses the climates between the North Pole and Whitehall. He sweeps into London with the North Wind, and leaves in his wake a frozen landscape that will not melt for several days:

And when he had arowsd him selfe a while,
and stretcht his ioyntes as stiffe as any stile:
Because he would his charge no longer slacke,
He got him vp on blustring Boreas backe,
And forth he went: but his horse so heauy trode,
That al the world might knowe which way he rode.
For in his way there grew no maner grene,
That could in thre dayes after wel be sene.
His breth and braying was so sharpe and shryl,
That fluds for feare hard cluddered stoode full stil.
The seas did quake and tremble in such sort,
That never a ship durst venter out of port.
The holtes, the heathes, the hilles became al hore,
The trees did shrinke, al thinges were troubled sore.
When this fel horseman with his griesly stede
Had passed Iseland, made forth such spede,
That many Skots bad: fule yle ta the Churle,[19]

[17] Frise, commonly spelled frieze, is “heavy woolen fabric with a long, rough nap.” Irish frieze has long been favored for its durability and waterproof characteristics. For a detailed description, see the entry for “frieze” in *The Standard Reference Work for the Home, School, and Library*, vol. 3 (Minneapolis: Standard Education Society, 1921).

[18] Baldwin, *Funeralles*, A4r, B1r.

[19] The phrase, “That many Skots bad ful: yle ta the Churle,” is an unusual statement, and it is not easy to decipher. With the very kind and gracious help of

> That slue their lambes and cattall with his whurles;
> He passed Yorke, and came to London strayt,
> And there alight to geve his horse a bayt.
> Where ere he had three dayes in stable stood,
> Be eat so much, the poore could get no wood,
> Except they would pay after double price,
> For Billet treble vnder common cise.

He slips into court and poisons the king's tennis refreshments, then leaves to infect others in the city with the same ailment.[20]

Edward falls ill with respiratory troubles, but his people fail to repent. As promised, God calls forth his servant Death to take from England Edward's life:

> Dispatch at ones, to *Greenwich* se thou hye,
> Where my elect, King Edward, sicke, doth lye
> In paynfull panges, wherin he hath be long,
> Not for his owne, but for his peoples wrong:
> Enforce thyne arme, and with thy cruell dart
> Cleave me in twayne his vertuous godly hart.

Though "doulful Death" grieves the assigned task, he takes on "his most cumly guyse" and visits Edward at his bed. Noble to the end, Edward prays for the kingdom he prepares to leave behind, commending to God "[h]is realme . . . for ever to defend." With this prayer, the young king breathes his last. "Wo wurth our sins," Baldwin writes, "for they, alas, have slayne, / The noblest prince that dyd, or est shall rayne."[21]

Baldwin published *The Funeralles of King Edward VI* in 1560, after the accession of Elizabeth I, a fellow Protestant. He composed the elegy shortly after

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historian Kelsey Williams, I am comfortable suggesting that the statement should be read (in modern English) as "That many Scots prayed, "Search out some harm for this clodhopper." Kelsey Williams, e-mail messages to author and Chester Dunning, September 26, 2013, and September 30, 2013.

[20] Baldwin, *Funeralles*, B1r-B1v.

[21] Ibid., B3r-B4v.

Edward's death, however, during a period of meteorological disruption in the Northern Hemisphere. The average temperature in Greenland fell 1.5°C between 1530 and 1550, plumbing depths reached only once in the preceding 200 years.[22] Rye harvest-dates in Germany and Switzerland suggest that spring and summer temperatures fell dramatically during the 1540s, perhaps by 1°C.[23] Ice break-up dates in the Baltic port of Riga suggest that 1551-52 was the first "severe" winter in more than twenty years.[24] In Zeeland and the estuary of the Western Scheldt, chroniclers recorded more high tides, storms, and storm surges in 1552 than any other year from 1400 to 1625, save 1570.[25] Two particularly strong storms struck the coastal Flemish town of Nieuwpoort in January and February, 1552, damaging the town hall and the market. Roof repairs occupied twenty-six weeks in Nieuwpoort in 1551 and 1552, more than any other two-year period for over fifty years.[26] The winter of 1549 was one of the coldest of the sixteenth century in Northern Italy, while 1553 brought a "Spring killing frost" to France.[27] In the northern

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[22] Takuro Kobashi et al., "Persistent multi-decadal Greenland temperature fluctuation through the last millennium," *Climate Change* 100 (2010): 744-49.

[23] O. Wetter and C. Pfister, "Spring-summer temperatures reconstructed for northern Switzerland and southwestern Germany from winter rye harvest dates, 1454-1970," *Climate of the Past* 7 (2011):1321.

[24] S. Jevrejeva, "Severity of winter seasons in the northern Baltic Sea between 1529 and 1990: reconstruction and analysis," *Climate Research* 17 (2001): 60.

[25] Adriaan M. J. de Kraker, "Reconstruction of Storm Frequency in the North Sea Area of the Pre-industrial Period, 1400-1625 and the Connection with Reconstructed Time Series of Temperatures," *History of Meteorology* 2 (2005): 63. For Dutch floods, see Richard S. J. Tol and Andreas Langen, "A Concise History of Dutch River Floods," *Climatic Change* 46 (2000): 357-69.

[26] de Kraker, "Storm Frequency," 57.

[27] Dario Camuffo et al., "500-year temperature reconstruction in the Mediterranean Basin by means of documentary data and instrumental observations," *Climatic Change* 101 (2010): 190.

hemisphere, temperature fluctuations of 1°C occurred three times in the 1540s and 1550s.[28]

The dramatic meteorological events of the mid-sixteenth century explain a peculiar difference between *The play of the wether* and the *Funeralles*. Winter makes only one appearance in Heywood's 1533 comedy, in the young boy's appeal for snow:

> All my pleasure is in catchynge of byrdes
> And makynge of snow ballys and throwyng the same
> For the whyche purpose to haue set in frame
> wyth my godfather god I would fayne haue spoken
> Desyrynge hym to haue sent me by some token
> where I myghte haue had great frost for my pytfallys
> And plente of snow to make my snow ballys
> This onys had / boyes lyuis be such as no man leddys
> O to se my snow ballys lyght on my felowes heddys
> And to here the byrdes how they flycker theyr wynges
> In the pytfale I say yt passeth all thynges
> Syr yf ye be goddes seruaunt or his kynsman
> I pray you helpe me in this yf ye can[29]

Heywood's "great frost" provided comic relief after a particularly pitched argument between the gentlewoman and the laundrywoman. A child pines for snow while serious adults concern themselves with wind, water, and drought. Twenty years later, Baldwin's "bytter Wynter" executed the king.[30]

The Old Testament provided a framework for understanding atmospheric phenomena, but it offered no guidance to those preparing to plant, harvest, trade, or travel. Astrologers, mathematicians, and natural philosophers developed supplemental

[28] Bo Christiansen and Fredrik Charpentier Ljungqvist, "The extra-tropical Northern Hemisphere temperature in the last two millennia: reconstructions of low-frequency variability," *Climate of the Past* 8 (2012): 776.

[29] Heywood, *The Play of the Wether*, D3r.

[30] Baldwin, *Funeralles*, A2r.

explanations of weather based on the principles of natural astrology and Aristotelian meteorology. European and English prognosticators published intricate guides to predicting daily, monthly, and seasonal atmospheric conditions. Wynken de Worde published the first English prognostication in 1498. Like Theophrastus' *On Winds*, examined in Chapter 2, the 1498 prognostication emphasized "days of alteration"—dates when one could expect the weather to deviate from the monthly norm. Eight fascicles of de Worde's prognostication have survived; six incorporate days of alteration. The entry for July is typical: "Jule shalbe temperate ynough after his nature / but about the begynnynge shalbe grete raynes & wynde with hayle thonder & lyghtnynge / & namely about the .iij. daye / dayes of alteracōn after the begynnynge shalbe .viij. x. xiii. xvi. xix. xx. xxij. xxiij. xxvij. xxix. xxx." In the final prognostication, which concerned February, the author conceded the limited accuracy of his predictions: "it is here to be noted that the days of alteracōn shall not be taken the same self day / for somtyme it shalbe in the night before or after." Almost every day in July 1498, then, could be a day of alteration. The author also warned that "it may not be lyke in all places for the dyuersyte of the clymate."[31]

[31][A prognostication for 1498] ([Westminster: Wynkyn de Worde, 1498]). Publication information for this fragment is unavailable. Textual references to Henry, Duke of York, and Princess Margaret place its publication between 1491 and 1503. It is almost certainly a translation of one (or more) of Italian astrologer William Parron's prognostications from the late 1490s, though it is not a translation of his most famous publication, the 1499 prognostication *De astrorum succincte vi fatali*. Martha Carlin, "Parron, William (*b*. before 1461, *d*. in or after 1503)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004–), accessed October 8, 2013, http://www.oxforddnb.com; C. A. J. Armstrong, "An Italian astrologer at the court of Henry VII," in *England, France and Burgundy in the fifteenth century* (London: Hambledon Press, 1983), 157–78.

Astrology offered a systematic approach to weather prognostication. In the late medieval and early modern world, divination encompassed a wide variety of practices, from the geomancy of earth to the capnomancy of smoke. Astrologers measured the movement and positioning of stars and planetary bodies and interpreted their influence on the earth and its inhabitants. Practitioners of the judicial variant of astrology used horoscopes and horary charts to foretell the characteristics or fate of an individual and to respond to specific, timely questions. According to historian P. G. Maxwell-Stuart, judicial astrology offered "an opinion." Natural astrology, on the other hand, focused on "[i]nterpreting the effect of astral influences on natural phenomena such as the weather and agriculture."[32] Since the elements and the heavens shared a system of concentric spheres, astrologers reasoned that a beam of light emitted or reflected by a planetary body would cause predictable mutations on Earth—weather. Claudius Ptolemy, who codified the western form of astrology in *Tetrabiblos*, reasoned that "a certain power, derived from the æthereal nature, is diffused over and pervades the whole atmosphere of the earth." This pervasive power transmitted the influence of the planetary bodies and fixed stars. "[T]he mutual configurations of all these heavenly bodies," Ptolemy wrote, "by commingling the influence with which each is separately invested, produce a multiplicity of changes."[33] The system of astrology described in *Tetrabiblos* provided

[32] P. G. Maxwell-Stuart, *Astrology: From Ancient Babylon to the Present* (Stroud, UK: Amberley Books, 2010), 8.

[33] Ptolemy, *Tetrabiblos*, trans. J.M. Ashmand (London: Davis and Dickson, 1822), 1.2.

the foundation for subsequent astrological practices in the Islamic world and Christian Europe.

Natural astrology weighed the influence of three primary astronomical characteristics: aspect, combustion, and sign. Aspect is a measurement of the angular distance between planetary bodies on the circle of the Zodiac. The most important measurements of aspect included conjunction, opposition, trine, quadrature, and sextile (Table 3).

Table 3: Measurements of Aspect

Aspect	Symbol	Angular Measurement
Conjunction	☌	angular distance of 1°
Opposition	☍	angular distance of 180°
Trine	△	angular distance of 120°
Quadrature	□	angular distance of 90°
Sextile	⚹	angular distance of 60°

A planet would be classified "in combustion" if the sun obscured its visibility. Each incident of aspect and combustion occurred within one or more signs of the Zodiac. Like the elements, planets, seasons, and humors, each sign possessed temperature and moisture components (Table 4).

Table 4: Seasons and the Signs of the Zodiac

Season	Signs	Signified
Spring	Aries ♈, Taurus ♉, Gemini ♊	Hot and Moist
Summer	Cancer ♋, Leo ♌, Virgo ♍	Hot and Dry
Fall	Libra ♎, Scorpio ♏, Sagittarius ♐	Cold and Dry
Winter	Capricorn ♑, Aquarius ♒, Pisces ♓	Cold and Moist

The movement of planets toward or away from other planets, in ascent or descent through the fixed houses of heaven, could exacerbate or mitigate their influence. Astrologers compared the relative influences of aspect, combustion, sign, and movement to craft meteorological prognostications.

The prognostication of weather was not a particularly important component of late medieval astrology. Italian astronomer Guido Bonatti included only a passing reference to temperature in *Liber Astronomicus*, an authoritative guide to astrology from its completion in the thirteenth century. The proem, translated by William Lilly in 1676, defined six "things that appertain to giving Judgment in Questions of Astrology." Each addressed an aspect of family life or individual experience. Only one of Bonatti's 146 astrological "considerations" addressed temperature: "The *Eleventh Consideration*, Is to take notice of the Malevolent planets, and what they signifie; for *Saturn* and *Mars* are naturally bad, *Saturn* for excess of cold, and *Mars* for excess of heat, not that either of them is really hot or cold, but virtually so."[34]

[34] William Lilly, *Anima Astrologiæ: Or, A Guide for Astrologers* (London: Printed for B. Harris, 1676), 2-3, 22.

European interest in astrology grew considerably after the fifteenth century, when Marsilio Ficino published the pseudepigrapical writings of Hermes Trismegistus, a mythical sage once believed to be a contemporary of Moses. The Hermetic Corpus, as this body of literature is known, includes extensive commentary on astrology, alchemy, and magic. Classical scholar Isaac Casaubon, writing in the early seventeenth century, demonstrated that the Hermetic Corpus dated to the first few centuries of the Christian Era rather than Mosaic Egypt. For more than a thousand years, however, historians counted Hermes Trismegistus among the most influential of philosophers. When a monk delivered a copy of the Hermetic Corpus to Cosimo de Medici in the early 1460s, the aging Florentine instructed Ficino to delay his work on Plato to sooner complete a translation of Hermes. Renaissance historian Frances Yates describes the remarkable scene:

> It is an extraordinary situation. There are the complete works of Plato, waiting, and they must wait whilst Ficino quickly translates Hermes, probably because Cosimo wants to read him before he dies. What a testimony this is to the mysterious reputation of the Thrice Great One! Cosimo and Ficino knew from the Fathers that Hermes Trismegistus was much earlier than Plato. They also knew the Latin *Asclepius* which whetted the appetite for more ancient Egyptian wisdom from the same pristine source. Egypt was before Greece; Hermes was earlier than Plato. Renaissance respect for the old, the primary, the far-away, as nearest to the divine truth, demanded that the *Corpus Hermeticum* should be translated before Plato's *Republic* or *Symposium*, and so this was in fact the first translation that Ficino made.[35]

[35] Frances A. Yates, *Giordano Bruno and the Hermetic Tradition* (1964; repr., London: Routledge, 2001), 13-14.

Alchemy, astrology, and magic assumed positions of newfound intellectual significance as the wisdom of "thrice great" Hermes spread through Europe in the sixteenth and seventeenth centuries.

Mathematicians Oronce Fine of France and Leonard Digges of England published the first influential guides to natural astrology in the early 1550s. Fine's *Ephemirides* (1551) and Digges' *Prognostication of Right Good Effect* (1555) celebrated the potential benefits of weather prognostication for agriculture and human health. Fine, a scholar at the University of Paris and an astrologer for King Henri II wrote that "la mutation de l'air . . . est vne des choses plus necessaires, tant pour les fruictz de la terre, que pour le salut du corps humain, & avec ce." For Digges, the primary benefit of prognostication was the avoidance of "the yearly care, trauailes, and peines of other, with the confusions, repugnãces, and manifold errors, partly by negligence, & ofte through ingorãce, cõmitted."[36]

Forecasts from the *Prognostication* and the *Ephemirides* include the names of the planetary bodies in question, their aspect and signs, relevant seasons, and their atmospheric consequences. Digges' entry for Saturn and Mars is typical: "The

[36] Digges published an edition of the *Prognostication* in 1553, but no known copies remain. Leonard Digges, *A Prognostication of Right Good effect, fructfully augmented, contayninge playne, briefe, pleasant, chosen rules, to iudge the wether for euer, by the Sunne, Moone, Sterres, Cometes, Raynbowe, Thunder, Cloudes, with other Extraordinarie tokens, not omitting the Aspectes of Planetes, with a brefe Iudgemente for euer, of Plentie, Lacke, Sickenes, Death, Warres &c. Openinge also many naturall causes, woorthy to be knowẽ. To these and others, now at the last are adioyned, diuers generall pleasaunte Tables: for euer manyfolde wayes profitable, to al maner men of vnderstanding* (London: Printed by Thomas Gemini, 1555), A3v; Oronce Fine, *Les canons & docvments tresamples, touchant l'usage & practique des communs Almanachz, que l'on nomme Ephemerides* (Paris: Regnaud Chaudiere, 1551), 27r.

coniunction, quadrature, or opposition, of *Saturne*, with *Mars*, in watry signes, declare in somer, rayne, often shoures, wyth hayle, thunder and lightnyng."[37] The *Prognostication* was not a translation of the lengthier *Ephemerides*, but the two used similar language. Their entries describing the conjunction, opposition, or quadrature of the Moon and Mars in hot signs are almost identical. Fine writes that "elle cause abõdance de nuées rouges & rousses," while Digges explains that "diuers coloured red cloudes are made."[38]

Digges and Fine are surprisingly useful sources for the history of weather. Although aspect and combustion have no predictive value in meteorology, the *Prognostication* and *Emphemirides* provide insight into the anticipated distribution of atmospheric conditions. Most sixteenth century descriptions of weather focused on unusual or extreme events. Fine and Digges, however, offer a much larger sample of potential phenomena. Both pondered the influence of more than 45 planetary and lunar combinations; Digges also recorded 115 incidents of combustion (Table 5). The most powerful aspect was the "Great Conjunction" of Saturn and Jupiter. In this event, which occurs every 18-20 years, Jupiter and Saturn appear to pass within one degree of each other. According to Digges, the Great Conjunction foretold "great drouthe" in hot signs; "fluddes, continuall rayne, general ouerflowynges. &c." in wet signs; and "plenty of wyndes" in airy signs.[39] Most entries, however, describe relatively typical weather. Fine placed greater emphasis on a nebulous "mutation d'air," but his prognostications were similar to those of Digges.

[37] Digges, *Prognostication*, b4v.
[38] Digges, *Prognostication*, C1r; Fine, *Ephemerides*, 26v.
[39] Digges, *Prognostication*, B4v.

Table 5: Weather Prognostications by Oronce Fine and Leonard Digges

	Oronce Fine		Leonard Digges		
	Planetary	Lunar	Planetary	Lunar	Combustion
Rain or Tempest	12	5	12	6	44
Great Rain	2	1	1	-	-
Wind	4	-	3	1	15
Great Wind	2	1	2	1	4
Drought	3	-	3	-	12
Great Drought	1	-	1	-	-
Cold	1	2	3	2	10
Snow or Frost	-	-	1	-	4
Fair Weather	1	2	2	2	15
Cloudy Weather	-	2	1	2	6
Heat	1	-	-	-	4
Great Heat	1	-	1	-	1
Mutation d'air	2	1	-	-	-
Grande mutation	2	4	-	-	-

Table 5 reveals two critical characteristics of sixteenth century prognostication: precipitation was more important than temperature, and winter was insignificant. Predictions of rain, drought, and snow outnumber those of cold and heat 18:3 and 6:2 in *Ephemerides* and 18:4, 6:2, and 60:15 in the *Prognostication*. The catastrophes associated with a Great Conjunction incorporated drought, flooding, and wind, but there were no comparable crises for winter. Additional entries warn of "great wyndes" and "great heate," but neither publication warns of "great" cold, frost, or snow. Indeed, references to winter are incidental and mild: "darke weather, hayle, rayne, thunder, and colde dayes"; "colde and rayne, principaly in moyst signs"; "snowe, or clowdie thycke weather"; "colde and myssinges [myst]."[40] Humfrey Baker translated Fine's

[40] Digges, *Prognostication*, B4v-C3r.

Emphemerides into English in 1558.[41] He altered some of Fine's prognostications, but not his treatment of winter and frost. No English prognostication from the mid-sixteenth century offered a model for understanding a catastrophe of snow and ice. Such an event remained beyond the realm of expectation, even in astrology.

The astrological interpretation of weather was not without controversy. Opponents of astrology drew on a body of literature dating to 1496, when Giovanni Francesco Pico della Mirandola posthumously published his uncle's *Disputationes contra astrologiam divinatricem*.[42] "Sometimes what they predict actually happens," the elder Pico della Mirandola wrote, "[b]ut since a good many more of their predictions do not happen, why should we not think they came true by chance?" He further subjected divination to measurement and comparison: "I have tested this frequently, a hundred times over, by constructing a geomantic figure and casting a horoscope for myself, asking the same question of each, and getting one outcome from the marks of the geomancy and another from the stars of the astrology." Pico della Mirandola acknowledged a measure of predictability for agriculture, weather, and medicine, but he ascribed this phenomenon to experience rather than divination. He humorously remarked:

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[41] Oronce Fine, *The Rules and righte ample Documentes, touchinge the vse and practise of the common Almanackes, which are named Ephemerides. A briefe and shorte Introduction vpon the Iudiciall Astrologie, for to prognosticate of thinges to come, by the helpe of the sayde Ephemerides. With a treatise added hereunto, touchinge the Coniunction of the Planets, in euery one of the .12. signes, and of their Prognostications and Reuolutions of yeres*, trans. Humfrey Baker (London: Thomas Marshe, 1558).

[42] Giovanni Pico della Mirandola, *Disputationes contra astrologiam divinatricem*, ed. Giovanni Francesco Pico della Mirandola (Bologna: 1495).

> ‘Sometimes’, said Ptolemy, ‘those who do not know astrology are deceived.’ This quite often applies to astrologers, and it turns out that astrologers have less understanding of astrology than non-astrologers. This cannot be denied. What doctors say about the sick, farmers about the corn-supply, sailors about storms, and shepherds about their flocks is worthier of belief than what astrologers predict about these same matters.[43]

Girolamo Savonarola, the notorious friar, used *Disputationes* as the basis for his own critique of astrology, *Trattato contra l’astrologia* (1497). Though hostile to judicial astrology, Savonarola acknowledged the importance of astronomy and natural astrology:

> So observational astrology is a real branch of knowledge because it seeks to recognise effects from real causes such as eclipses, the conjunctions of planets, and similar effects which always necessarily follow from their causes. Likewise, one can call ‘art’ or ‘branch of knowledge’ the astrology which seeks to recognise certain natural effects which more or less always proceed from how far or how near the sun is to us, or the conjunction, opposition, and movements of the moon. But divinatory astrology which rests entirely on effects which proceed indifferently from their causes, especially in human affairs which proceed from free will and only on rare occasions proceed from their causes, is completely worthless and cannot be called either an art or a branch of knowledge.[44]

The apperception of a natural branch of astrology permitted opponents of other forms of divination to continue interpreting weather by astrological calculation. Jean Calvin, a fierce critic of sorcery, compared the two astrological perspectives in *Advertissement contre l'astrologie judiciaire*, published in 1549. According to Calvin, “la vraye Astrologie” comprised “l’ordre naturel et disposition que Dieu a mise aux Estiolles et Planettes, pour iuger de leur office, proprieté et vertu, et reduire le tout à sa

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[43] Pico della Mirandola, *Disputationes*, 1.10 and 3.19, trans. P. G. Maxwell-Stuart, in *The Occult in Early Modern Europe: A Documentary History* (New York: St. Martin’s Press, 1999), 76-77.

[44] Girolamo Savonarola, *Trattato contra l’astrologia*, 2.3, trans. P. G. Maxwell-Stuart, in (Gloucestershire: Amberley Publishing, 2010), Kindle edition, 4150; Donald Weinstein, *Savonarola: The Rise and Fall of a Renaissance Prophet* (New Haven: Yale, 2011), 141-42.

fin et à son usage." He acknowledged an affinity between the earth and the heavens, as demonstrated by the moon's influence on oysters. "[L]es corps terrestres et en general toutes creatures inferieures," Calvin wrote, "sont subiettes à l'ordre du ciel pour en tirer quelques qualitez." Natural astrology permitted one to learn the "cours ordinaire" of nature, but it could neither predict nor preclude a particular outcome.[45] The heavens were not a primary or first cause; they were an instrument of God's will. Calvin explained:

> Or, ie confesse bien, suyvant ce que i'ay cy dessus traité, qu'entant que les corps terrestres ont convenance avec le ciel, on peut bien noter quelque cause aux astres des choses qui aviennent icy bas. Car tout ainsi que l'influence du ciel cause souvent les tempestes, tourbillions et temps dives, item les pluyes continuelles: ainsi, par consequent, elle amene bien la sterilité et les pestilences. Entant donc qu'on verra un ordre et comme une liaison du haut avec le bas, ie ne contredy pas qu'on ne cerche aux creatures celestes l'origine des accidens que on void au monde. I'entens l'origine, non pas premiere et principale, ains comme moyen inferieur à la volonté de Dieu: et mesme dont il se sert comme de preparation pour accomplir son œurve, ainsi qu'il l'a deliberé en son conseil eternel.

Natural astrology could define the seasons and perhaps explain the weather, but it could not predict famine, abundance, pestilence, health, war, or peace. This limitation distinguished "l'Astrologie naturelle" from "ceste bastarde qu'ont forgée les Magiciens."[46] Any who suggested otherwise were dabbling in sorcery.

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[45] Jean Calvin, *Advertissement contre l'astrologie qu'on appelle iudiciaire: Et autres curiositez qui regnent auiourd'huy au monde*, in *Ioannis Calvini: Tractatus theologici minores, Tomus tertius*, ed. Guilielmus Baum, Eduardus Cunitz, and Eduardus Reuss, Ioannis Calvini: Opera Quae Supersunt Omnia 7, Corpus Reformatorum 35, (Geneva: Jean Girard, 1549; repr., Brunswick: C. A. Schwetschke & Sons, 1868): 516-18.

[46] Calvin, *Advertissement*, 524-25, 529.

Goddred Gilby, elder son of the prominent Puritan Anthony Gilby, translated Calvin's *Advertissement* into English in 1561. Gilby's translation joined two additional English critiques of astrology. In *Almanach novum et perpetuumm* (1556), physician Peter Dacquet proposed excising astrology from the practice of medicine.[47] William Fulke, a barrister-in-training, found Dacquet's thesis persuasive. He rejected the appellation of "science" to astrology and advocated a return to the principles of Aristotle's *Meteorologica*. Fulke published two important studies of natural philosophy, *Antiprognosticon* (1560), which exposed the fundamental flaws of astrological reasoning, and *A Goodly Gallerye* (1563), which introduced English readers to Aristotelian meteorology.[48]

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[47] William Fulke considered Dacquet to be his most important contemporary. Jean Calvin, *An Admonicion against Astrology Ivdiciall and other curiosities, that raigne now in the world: written in the french tonge by Ihon Calvine and translated into Englishe*, trans. G[oddred] G[ylby] (London: Roulande Hall, 1561); Peter Dacquet, *Almanach novum et perpetuum, in qvo mvlti prognostarum abusus deteguntur, & vulgi deprauatæ opiniones refelluntur, & in quo ex vetrum doctrina, traditur ratio opportunè agendi ea, quæ circa corpus nostrum agenda sunt* (London: Reginald Wolfe, 1556).

[48] William Fulke, *Antiprognosticon contra invtiles astrologorvm prædictiones Nostradami, Cuninghami, Loui, Hilli, Vaghami, & reliquorum omnium* (London: Printed by Henry Sutton for Humprey Toye, 1560); William Fulke, *Antiprognosticon, that is to saye, an Inuectiue agaynst the vayne and vnprofitable predictions of the Astrologians as Nostrodame.&c. Translated out of Latine into Englishe. Wherevnto is added by the author a shorte Treatise in Englyshe, as well for the vtter subuersion of that fained arte, as also for the better vnderstanding of the common people, vnto whom the fyrst labour seemeth not sufficient*, trans. William Painter (London: Henry Sutton, 1560); William Fulke, *A goodly gallerye with a most pleasaunt prospect, into the garden of naturall contemplation, to behold the naturall causes of all kynde of meteors, as wel fyery and ayery, as watry and earthly, of whiche sort be blasing sterres, shooting starres, flames in the ayre &c. tho[n]der, lightning, earthquakes, &c. rayne dewe, snowe, cloudes, springes &c. stones, metalles, earthes &c. to the glory of God, and the profit of his creaturs* (London: William Griffith, 1563).

According to historian Richard Bauckham, Fulke developed an interest in meteorology during his term at Clifford's Inn, one of the Inns of Chancery where barristers learned to practice law. In the dedication of an unpublished manuscript, Fulke described a bout with depression during which he studied a wide variety of subjects, including poetry, geometry, meteorology, and music.[49] He published the Latin imprint of *Antiprognosticon* in August 1560, two months before his admission to the Inner Temple.[50] William Painter, a friend and fellow alumnus of St. John's College, Cambridge, translated the pamphlet into English later that fall. Fulke, who evidently hoped to address a large audience, adjoined a second treatise to the English imprint that summarized the flaws of astrology "for the better vnderstandynge of the common people, vnto whom the fyrst labour seemeth not sufficient."[51]

Antiprognosticon repudiated the fundamental classification of planetary bodies by humidity, temperature, and munificence. Fulke did not directly challenge the prevailing notion that sublunary bodies derived their characteristics from above, but he questioned whether astrologers knew enough about the heavens to measure their influence. "For by what reason are ye able to demonstrate or shewe," he asked, "that

[49] The manuscript is a translation into Latin of Thomas Littleton's *Tenures*; see Bodleian Library, MS. Rawlinson C. 673, dedication (unpaginated). For information on the dedication, see Richard Bauckham, "Science and Religion in the Writings of Dr. William Fulke," *The British Journal for the History of Science* 8, no. 1 (March 1975):17-18.

[50] Toye entered the title "antiphronosticon" in the Stationers' Register on August 30, 1560. Henry Sutton registered the English translation in December 1560 under the ironic title, "[an] almanacke and pronostication of FULKES." *Transcript of the Registers of the Company of Stationers of London, 1554-1640 A.D.*, ed. Edward Arber (London, 1875), I:150 (59v) and I:153 (61r).

[51] Fulke, *Antiprognosticon*, C8v.

Saturne is so hurtefull, malicious, and pestilent? By Induction?" He continued, "[W]e can not tell of what nature Mars is, nor thastrologians themselues, so that if they wyl proue any thyng by this argument, they must fyrst shew by what reson they call Mars whote, or Saturne colde."[52] Fulke also warned that classical astrology underestimated the importance of the sun and moon:

> But how vnjust a thynge is it, and agaynst all reason, that the Sonne it selfe, without whome thother planettes haue no more beautie then the earthe, can scarcely of them bee compted among the good & holsome starres: where as he, whiche with his heate geueth lyfe, with his shynynge lyght, and with his beholdyng, gladnes to all liuyng creatures. (If an arte of astrologie were to be inuented accordyng to reason) should haue the chiefe rule among all starres, as well planettes as fixed. Lykewise the Moone whiche gouerneth humours, shuld be seconde to the Sonne, specially in dominion of lyvyng creatures, for as muche as by these two, that is, Heate and Moisture, whereof the Sonne ruleth heate, & the Moon moistnes, all lyfe is preserued and nourished.[53]

Fulke also lamented the economic and spiritual consequences of astrological alarmism. Only one year separated the first English edition of Nostradamus' almanac, in 1559, and *Antiprognosticon*. Weighing the utility of astrology, Fulke recalled the baleful influence of Nostradamus' prophecies:

> Nay rather with how greate euyls do you burden the cytie (I speake not of the horrible wonders that you threaten to fall on them) but what a dearth of vitayles you cause in the commẽwelth, while the farmers of the countrye (as I haue good vnderstandynge) beleuyng your oracles of the imtẽperaunce of wethers do so craftily dyspose their wares, that in abundaunce of al thynges, the common people suffer a greate and greuous scarcity. What? is it to be kept in sylence, howe slowlye and coldly the people in the last yeare, seduced by the foolyshe prophesye of Nostrodamus addressed them selfe to sette vppe the true worshippynge of GOD and hys religion, good Lord what tremblynge was there? What feare? What expectation? What horror?

[52] Ibid., C7v.
[53] Ibid., B3v.

"Yea," he concluded, "thys Nostrodamus reigned here so lyke a tyrant wyth hys south saiynges, that wythout the good lucke of hys prophesies it was thought that nothyng could be broughte to effecte."[54]

Fulke focused his criticism on William Cuningham, a Norfolk physician and cosmographer. In *An Invective Epistle in Defense of Astrologers* (1560), now lost, Cuningham apparently boasted of two successful meteorological prognostications, neither by his own hand. Fulke wondered why there were so few:

> But lest we should to insolently inuey agaynste these false tellers (foretellers I wold say[ )], master Cunyngham hath geuen vs ensaumple of two yeares that chaunced accordyng to the predictions of moysture, 1524, and drynesse, 1540. But here I appeale to Cuninghams wisedom, why he bryngeth exaumple of two yeares onely, and them so longe agoe past? and why he dyd not shewe exaumple of thre yeares laste paste? yf he wyll boaste that his arte is certayne and trewe, why doothe he not declare, that the euent of euery yeare was suche, as thastrologiãs forshewed it shulde bee, whether because all menne with one voyce wold say nay: or els because of tyme longe paste he may feigne, and no manne reproue him.

Twisting the dagger, Fulke remarked: "[W]e will grant .xx. yeres sens astrol. first began, which hapned accordyng as the prognosticators fortold them: wyl you then boast that your diuinatiõ is true, because of 2000 yeares onely, twenty serue for youre pourpose."[55]

Fulke suggested that Aristotle's *Meteorologica* offered a superior explanation for the mechanics of weather. He briefly introduced the philosopher's ideas in the addendum to *Antiprognosticon*:

> [D]earthe and plentye bee caused by reasone of seasonable weather, or vnseasonable: Then yf the starres haue nothyng to doo with wether, they haue

[54] Ibid., A7v-A8r.
[55] Ibid., C8r.

> lesse to dooe with plentie or scarcity, which ar caused therby. As for clowdes whereof rayne commeth, they are drawen vp in thynne vapours, by the heate of the sonne, into the myddle region of the ayre, and there, by colde, are made grosse, then by some wyndes they ar dissipated and dryuen abroade, or elles by some resolued and drop downe. And thys is the cause for the moste part, of rayne & fayre wether, so that except the vncertayntie of the wynd may be knowen by the stars, rayne and fayre wether can neuer be foreshewed. But whereof commeth the wynd? I am sure they wyll not denye the Philosophers [Aristotle's] definition gathered oute of the seconde booke of his Meteors, which is, that the wynde is an exhalation whot and dry, drawen vp by the heate of the Sonne, and for the weight of it selfe fallyng downe, is laterally or sydelonges caried aboute the earthe.

"By this definition," he asserted, "all power of signifying starres is cleane excluded."[56]

Three years later, Fulke published the first English guide to Aristotelian meteorology, *A Goodly Gallerye*. According to its author, the lengthy pamphlet was unique, something "no wryter hetherto hath done, that we haue sene." It consists of five books, four of which form a catalog of fiery, aery, watery, and earthy meteors. Fulke borrowed the term "meteor" from Aristotle to describe any "body compounde with out lyfe naturalle." The definition encompassed all bodies "generatede in the earthe, called *Fossilia*," as well as "other *Impressiones*, named of ther height, *Meteora*." The entry "*Of Snowe*" is a representative example of the pamphlet's content:

> Snowe is a cloude congeled by greate colde, before it be prefectlye resolued from *vapors* into water.
>
> Snowe is whyght, not of the proper colour, but by recieuing the lyghte into it, in so many small partes as in some, or the whyghte of an egge beaten.
>
> Snowe is often vpon highe hilles, & lieth long there, because their toppes ar colde as they be neare to the mydle region of the ayre. For oftentimes it rayneth in the vallye when it snoweth on the hylles.
>
> Snowe melting on the high hilles, and after frosen agayne, becommeth so hard that it is a stone, & is called *Christal*. Other matters of snowe beause they ar cõmen with raine, are nedeles to be spoken of. To be shorte, sleet is generated euen as snow, but of lesse colde, or els beginneth to melte in the falling.

[56] Ibid., D6r-D6v.

> Snowe causeth thinges growing to be fruictfull, and encrease, because the cold dryueth heate vnto the rootes, and so cherysheth the plantes.[57]

The preface to the catalogue of meteors includes a guide to classification of atmospheric phenomena and an examination of their efficient causes. Drawing on a theme developed in *Antiprognosticon*, Fulke proposed an order of causes that stressed the significance of the sun. God, "principall and vniuersall cause efficiente of all naturall workes and effectes," was the first and efficient cause of all meteors. Fulke pointed to Psalm 147-48 as evidence of divine authority: "Fier, haile, snowe, yse, wynde and stones, [d]o his will and commandement, he sendeth snowe lyke woll, &c." The secondary causes of meteors included the form of heaven and the nature of warmth, both of which exercised their influence through the sun:

> The second cause efficient, is double, either remote that is to saye, farre of, or next of al. The farther cause of them as of all other natural effectes, are the same, the forme, with the other planetes and sterres, and the very heauen it selfe in which they are moued. But chiefly, the Sunne by whose heate all or at lestwyse, the mosts part of the vapors and exhalations are drawen by.
>
> The next causes efficient as the firste qualities are heate and colde, whiche cause diuers effectes in vapors and exhalations, but to returne to the heate of the Sunne, whiche is a very neare cause, it is for this purpose two wayes considered.
>
> One waye, as it is meane & temperate
> Otherwise, as it is vehemẽt & burning
>
> The meane, is by which he draweth vapors out of the water and exhalations out of the earth, and not onely draweth them out, but alse lifteth them vp very high frõ the earth, into the ayer, where they are torned into diuers kinde of *Meteores*.
>
> The burning heate of the Sunne is, by which he burneth dissipateth and consumeth the vapors, and exhalations before he draweth them vp, so that of them no *Meteors* can be generated.[58]

[57] William Fulke, *A Goodly Gallerye*, 1r, 55v-56r, mislabeled as 54r.
[58] Ibid., A3v-A4r.

The sun controlled the production of meteors by drawing vapors and exhalations from water and earth and lifting them into the spheres of air and fire where meteors form. It could also prevent the production of meteors by consuming displaced elements before they react or ignite. The characteristics of this relationship varied temporally and spatially. "These two heates," Fulke explained, "proceade from the Sunne either in respect of the place, or the tyme, but moste properly according to the casting of his beames either directly or vndirectly."[59]

In the mid-sixteenth century, scholars were only beginning to wrestle with the mechanics of atmospheric change and geological variability. There were no histories of climate or geology to match those of Theophrastus, who wondered if Cretan winters were growing more severe, or Xanthus of Lydia, who uncovered an age of great drought in Armenia and Phrygia. The interpretive methods used to rationalize and predict weather included no models of dramatic environmental change. The Old Testament demonstrated that weather and storms were instruments of God's will, but the covenant of Genesis 9 suggested that such punishment would be transitory. The forecasts of natural astrology presupposed cyclical variation, and Aristotelian meteorology depended upon equilibrium and the conservation of elemental material. The first storms of the Little Ice Age provided an opportunity for scholars to reassess their assumptions about the natural world. The *cours ordinaire* of Jean Calvin's natural philosophy became increasingly difficult to discern.

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[59] Ibid.

CHAPTER IV

CANNAE IN THE GARDENS:

THE FIRST STORMS OF THE LITTLE ICE AGE

The first storms of the Little Ice Age struck with ferocity and frequency between 1560 and 1610. These events encouraged authors and stationers to publish increasingly descriptive accounts of daily and seasonal weather. Thomas Knell, the rector of St. Nicholas Acons in London, published the first narrative of an English environmental disaster in 1570, after torrential floods devastated central England and the coastlines of the North Sea and English Channel. Subsequent phenomena in East Anglia inspired a series of meteorological publications in the 1570s and 1580s. These hewed close to the theological interpretation of weather described in Chapter 3. Few authors turned to astrology or meteorology to explain specific phenomena. The translation and publication of historical chronicles, however, encouraged authors to examine contemporary weather in its historical context. English authors Thomas Knell and Thomas Dekker and Flemish philosopher Justus Lipsius scoured the past in search of answers to a novel question: "Has the weather changed?"

In England, the first Great Frost of the Little Ice Age began on December 21, 1564, and continued through January 3. According to English antiquarian John Stow, who published the first edition of his chronicles a year later, "people went ouer the Thames on the yce, & alonge the Thames from London bridge to Westminster, and agaynward." Some Londoners "playde at the foote ball as boldly and (thankes to God) as safely as on the drye lande." On New Year's Day, and the two following days, "dyuers gentylmen, & others, set vp pricks on the Thames, and shot at the same . . . . And the people bothe men and women went on the Thames in greater numbers then in any strete in London: The costardmongers strode in dyuers places and playde at the dyce for apples on the yce." The Thames began to thaw on the evening of January 3; two days later, there was "no Ice . . . to be sene." London's attention shifted downriver, where the "sodeyn thaw caused suche great flouds and hye waters that it bare downe many bridges and houses and drowned many people."[1] Although the unusual New Year's festival lasted only a fortnight, the frozen Thames became synonymous with Great Frosts in England.

In October 1570, the River Great Ouse, England's fourth longest, descended in a torrent from Northamptonshire, overtopping its banks in the ancient market towns of Bedford, Huntingdon, St Ives, and St Neots. In Lincolnshire and southeastern England,

[1] Stow published numerous editions of his chronicles between 1565 and his death in 1605, including *A Summarie of Englyshe Chronicles* (1565), *The Chronicles of England* (1580), and *The Annales of England* (1592). The number of "Great Frosts" he identified varied somewhat among them. In *A Summarie of Englyshe Chronicles* (1565), Stowe identified ten great frosts that were distributed relatively equally between the eleventh and sixteenth centuries. In *The Annales of England* (1600), Stowe identified only eight—with a notable gap between the Great Frost of 1363 and subsequent frosts in 1564, 1572, and 1579. The quotations in this paragraph come from the 1565 edition of Stow's chronicles. John Stow, *A Summarie of Englyshe Chronicles, Conteynyng the true accompt of yeres, wherein euery Kyng of this Realme of England began theyr reigne, howe long they reigned: and what notable thynges hath bene doone durynge theyr Reygnes. Wyth also the names and yeares of all the Baylyffes, Custos, maiors, and sheriffes of the Citie of London, sens the Conqueste* (London: Thomas Marsh, 1565), 246v-247r; John Stow, *The Annales of England, Faithfully collected out of the most autenticall Authors, Records, and other Monuments of Antiquitie, lately corrected, encreased, and continued, from the first inhabitation vntill this present yeere 1600* (London: Printed by Ralfe Newbery, 1600).

wind and high tides drove the sea into coastal communities and the estuaries of the Thames and the Great Ouse. Observers in twelve English counties reported local flooding, and four additional counties probably experienced swollen rivers as well (Fig. 7). The "great wonderfull ouerflowyngs" inspired two of the first English publications concerned with reporting and explaining particular weather events. The Elizabethan actor and poet Richard Tarlton set the destruction of Bedford to verse in *A very Lamentable and woful discours of the fierce fluds*: "In Bedford town I knowe, / This many a score of yeeres: / Did neuer riuers flowe, / To bring vs in suche feares." Thomas Knell collected reports of flooding, property damage, and loss of life from around the country for a forty-page tract titled, *A declaration of such tempestious, and outragious Fluddes, as hath béen in diuers places of England*.[2]

Knell attributed the floodwaters to God's punishment of landowners who enclosed farmland for the grazing of cattle and sheep. With the righteous indignation of an Old Testament prophet, Knell warned that "if euer the Prophet Esayes [Isaiah's] woe, against them that ioygne house to house and lande to lande (till there be no more place left for the poore) coulde euer be applied it may be applied vnto them . . . which oppresse the poore and destroy the needy."[3] Such "couetous Leasemongers" and "greedy grasiers" had "cõuerted the Tillage, of much erable ground, to the grasing

[2] Richard Tarlton, *A Very Lamentable and woful discours of the fierce fluds, whiche lately flowed in Bedfordshire, in Lincolnshire, and in many other places, with the great losses of sheep and other Cattel. The v. of October. Anno Domini 1570* (London: John Allde, 1570); Thomas Knell, *A declaration of such tempestious, and outragious Fluddes, as hath béen in diuers places of England. 1570* (London: Printed by William How for John Allde and William Pickeryng, 1571).

[3] Knell, *A declaration or discourse*, A2r-A4r.

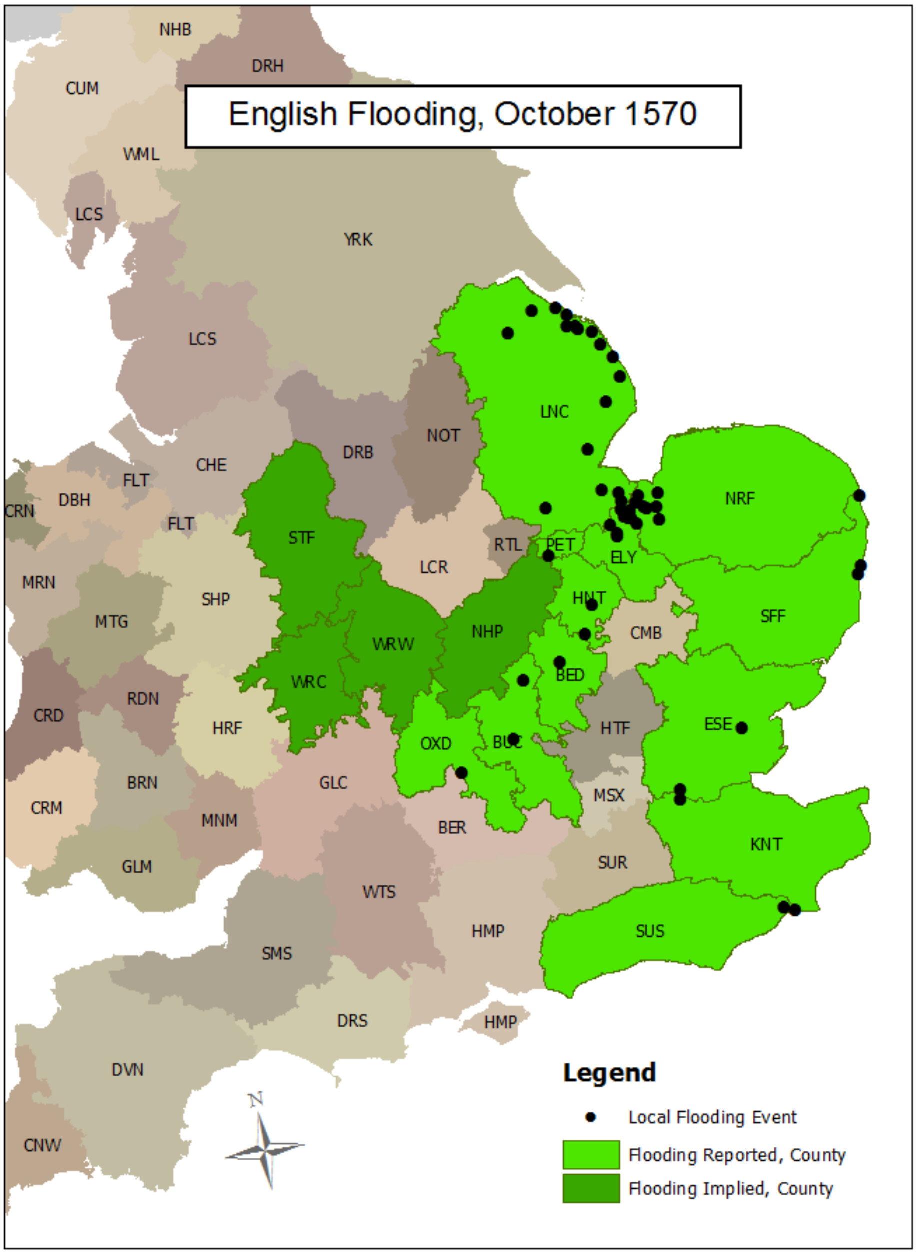

Fig. 7. *English Flooding, October 1570. Incidents of flooding as reported in Richard Tarlton's* A Very Lamentable and woful discours of the fierce fluds *and Thomas Knell's* A declaration of such tempestious, and outragious Fluddes. *This map utilizes data and shapefiles provided by the Great Britain Historic GIS Project at the University of Portsmouth and the Historic County Borders Project.*

of Shéep, and Northern Oxen, whereby they enriche them selues with the ruine and decay of thousands, round about them." "God," he exclaimed,

> seest this their vnmerciful deailing, open the cloudes, water their pastures sowne with sheep, in steede of men and Corne of all graines, geue their flocke moysture, that they may see them by thousandes swim aboue the ground, and at the fall of the waters, to lie deade vppon their watred land. Which crie God hath heard, and this is the cause of suche ruin and destruction. The Riche are so welthie, that they are without Iudgement, without mercy, and that hath caused their Heards to be wasted, their Flockes to be deminished, their Granges made pasturelesse, with the pitifull fluddes past, wherby much of their substance hath perished. For whose sakes also the Poore are made partakers of these greate losses.

Isaiah may have offered insight into the wickedness that invited God's punishment, but Genesis provided the model for the flood's mechanics. According to Knell, the floodwaters were the result of God changing "the moderate course of the vpper Fountaines; which were ordayned to water the earth, and so to make it fruitful, into immoderate, and vnseasonable Fluddes."[4]

Knell was particularly sensitive to accusations that the resumption of Protestant rule under Elizabeth I was responsible for England's troubled weather. He viciously mocked such arguments:

> [F]or then when the Masse was vp, Images of blissed holy Saints, the holy Rood, and our Lady . . . and all the trimsy trash, and peltinge paltrie, of that holy, holy, Whore of Rome, our mother holy Church, then had we a mery world, althings were plenty, wee had Uictailes and all things in abundance, and felt no yll, but synce this new fangled Religiõ, which they cal the gospel, which our Fathers neuer knewe, (and yet were led to the Deuill well inough) was Preached: wee haue had scarcitie of all things, and haue ben consumed by Sword and famine, with Fyre and water, as now al men may see by these great Fluds, which God hath sente to plague them for their Heresy.

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[4] Ibid.

Only “blind Idolaters,” Knell asserted, esteem religions “by the belly” instead of acknowledging God’s works, “which sendeth both plenty and Dearth, Raine, and drie Weather, Fluddes, and dry land, Riches, and pouerty, sycknes and health.” Despite his anti-Catholic predisposition, Knell believed Papists and Protestants shared responsibility for the 1570 flood. The “Rods of Gods correction” had fallen “on the Papists for theyr blindnesse” and “on the lose liued professours of the Gospel for their lewd conuersation.”[5]

Knell scoured English history to demonstrate that Catholic faith provided no special protection from the elements. One flood, early in the reign of Henry VIII, inundated the coastal marshes of eastern Sussex, western Kent, and the Dutch county of Zeeland, “from Armew to Dort.”[6] Knell callously reminded Catholic readers that the “Queene of Heauens Temples” and the “Alters and Pixes, with your reall Gods” were “all drowned, not beyng able to help themselues and their worshippers, but perished with

[5] Ibid., E1r-E2r, E3v.

[6] The flooded marshes of Sussex and Kent were part of the Romney Marshes and included Gylford [Guldeford], Kyte [Kite], Chaynecourt [Cheyne Court], and the Isle of Oxuene [Oxney]. They are situated along the former channels and estuaries of the River Rother. The Dutch town of Armew [Arnemuiden] is located near Middelburg on the former Walcheren Island, between the Oosterschelde and Westerschelde Rivers. Dort was the English name for Dordrecht, now part of South Holland. For a contemporary map of the Romney marshes, see John Speed, John Norden, and Jodocus Hondius II, *Sussex Described and divided into Rapes with the situation of Chichester the cheife citie thereof. And the armes of such Nobles as have bene dignified with the title of Earles since the conquest and other accidents therein observed* (London: I. S. and George Humble, 1610), Bibliothèque nationale de France GE DD-2987 (2076). For a detailed map of early modern Zeeland and the United Provinces, see Willem Blaeu and Josua van den Ende, *Novus XVII Inferioris Germaniae Provinciarum Typus de integro multis in locis emendatus* (1608), Kaartcollectie Zuid-Holland Ernsting 4.ZHPB4; Johannes Baptista Vrients and Theodoor Galle, *Inferioris Germaniae Provinciarum Nova Descriptio* (1606), Kaartcollectie Zuid-Holland Ernsting 4.ZHPB4.

bruit beasts, and the whole country, which shal neuer be recouered agayn." One storm in 1532-33 brought weeks of heavy rain and hail at harvest. "There came such Rayne," Knell wrote, "by the space of .v. weekes, with such fearful Haile that all the Wheat, Barly, Beans, Otes, & other grayne, with Apples, peares and other Fruits, were vtterly lost, neuer reaped."[7] Even the reign of Mary I, Knell suggested, failed to prevent flooding in the coastal marshes of Sandwich, Herne, and Whitstable in Kent.[8]

When "hard and sharp wether / of frost and snow" returned in 1572, the Diocese of Norwich commissioned a prayer to "craue mercye for our synnes / and release of this sore ponishment." The prayer opens with an acknowledgment of God's authority over nature as established in Genesis 1:7 and Psalm 29:5. The Lord "deuideth the waters in sonder" and "braketh the Cedar"; from God's countenance, "the elementes do . . . shrinke awaye." Like many winter prayers of the time, the Norwich prayer quoted from Psalm 147: "[A]t thy pleasure thou gyuest snow like woll / & [scatterest] the hoare frost like asshes / thou casteth forthe thy [yce] like morselles / who can abyde the cold therof / thou [sendeth] forthe thy word & meltest them agayne."[9]

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[7] According to Knell, the five-week storm episode occurred "aboute .xxxvii. yeere agon" and caused disruption in "many places of England." He further associated the event with the flooding of the Plumstead Marshes a few miles east of Greenwich in Kent: "About which time also, all Plumsted Marshes here by the Thames were drowned, which lye almost al wast til this day." Knell, *A declaration or discourse*, E3r-E3v.

[8] Ibid., E2v-E3v.

[9] Norfolk stationer and Dutch immigrant Anthony de Solempne printed the prayer, which fills three tightly-spaced columns of a single broadsheet. It is neither paginated nor divided by paragraph. The prayer is also tightly bound, obscuring a few indecipherable words on the left margin. Diocese of Norwich, *A Prayer to be sayd in the end of the mornyng prayer daily* (Norwich: Anthony de Solempne, 1572), column 1.

The Diocese of Norwich acknowledged the justice of God's punishment: "in dede [we] haue sinned / we haue committed iniquitie" and "rebelled against thy most holy will." God "iustly powred vpon vs the tokenes of [His] displeasure." Condensing Leviticus 26, 2 Chronicles 6, and Psalm 78 into one frightful list, the prayer describes the environmental consequences of sin:

> I will ponish you . . . according to your synnes / I will break [the pride] of your pour and I will make your Heauen as [iron] & your Earth as brasse / I will smyte you with [famine] / with sicknes / with heate & with cold / I will destroy [the labours] of your handes / the fruytes of the Earth / your [sheep] & cattell. According to thy threates thou hast sent [we] impenitent sinners from tyme to time thy greate & [miserable] plages / as water / fyre / sworde / pestilence / [famine] / wild beastes / cruell enemies / froggs [/] fliese / locustes [grass]hoppers / caterpillers / mildewes / blastinges / hayle . . . frost / snowe / thunder / lightninges / drought . . . heat / and cold / which all be iust rewards for sin.

The Diocese attributed the punishment to a general increase in wickedness, vanity, and disobedience. The weather reflected the coldness of men's hearts: "We haue bene colde in loue to the[e] . . . therefore the aer is now frosen vnto us."[10]

Despite its great length—over 2,000 words—the Norwich prayer offered only brief remarks about the actual characteristics of the late winter:

> Loke done O Lorde from heauen / with thy pitefull eyes / behold our lamentable estate / the deepe snow hath ouerwhelmed the Earth / the nipping frost hath consumed the fruytes therof / thou that bringest forthe herbes and grasse for the vse of man & beast / behold all is consumed and spent almost / thou that preseruest man & beast / make som prouision for both / the cattell do groue & make pitiouse complaynt / the heards do low / the flockes do bleet / the byrdes do crie to the for succour and relefe.

[10] Ibid., column 1.

Appealing for mercy through Christ's intercession, the prayer closes with a request that God "take away . . . this hard & sharpe wether / melt this snow / mitigate this frost / make bare the face of the Earth / bring forth fruytes and grasse for the vse of man & beast / gyue seasonable wether / preserue the kindes / of beast and foule / which thou has made for the seruice of man."[11]

London-born author Abraham Fleming published an account of another East Anglian weather event in 1577.[12] In *A straunge and terrible Wunder*, Fleming described an unusual thunderstorm that struck the Suffolk market town of Bungay on Sunday, August 4. Bungay and its neighboring villages on the Waveney River are uniquely vulnerable to flooding (Fig. 8). The low-lying counties of Norfolk and Suffolk are among the driest in England, despite their propensity to flood. Bungay is further enclosed within a meander of the river. Canals and other diversions have eased flooding in modern Suffolk, but they have not abolished the threat. In March 2013, prodigious rainfall in East Anglia caused widespread flooding along the River Waveney; the damage to neighboring fields and crops remained visible in July 2014.[13]

According to Fleming, who collected accounts of the 1577 storm from "them that were eye witnesses of the same," the tempest began at 9:00 a.m. with torrential rainfall, a "wonderful force . . . with no lesse violence then abundance." Lightning and thunder

[11] Ibid., column 2.

[12] Sarah C. Dodson, "Abraham Fleming, Writer and Editor," *The University of Texas Studies in English* 34 (1955): 51.

[13] Aerial photographs captured after the storm reveal the extent of the flooding. "Flooding in the Waveney valley – from the air," ITV, last modified March 13, 2013, http://www.itv.com/news/anglia/story/2013-03-10/floods-cause-problems-in-east/.

Fig. 8. *The River Waveney at Beccles. View North. Photographed from the bell tower at St. Michael's Church. Photo by author (2014).*

accompanied the rain, "the dashing of the one wherof was so rare and vehement, and the roaring noise of the other so forceable and violent" that it disturbed both man and beast. The townspeople were gathered in St. Mary's Church for Sunday services (Fig. 9). Plunged into darkness, the gray stone church offered little comfort—spiritual or otherwise. Its walls were "witnesses of the straungenes, the rarenesse and sodenesse of the storm, consisting of raine violently falling, fearful flashes of lightning, and terrible cracks of thūder." The storm came "with such vnwonted force and power, that to the

Fig. 9. *The East Wall and Nave of St. Mary's Church in Bungay, Suffolk. Photos by author (2014).*

perceiuing of the people . . . the Church did as it were quake and stagger, which struck into the harts of those that were present, such a sore and sodain feare, that they were in a manner robbed of their right wits."[14]

Absent their wits, the parishioners' terror multiplied. "[T]here appéered in a moste horrible similitude and likeness to the congregation," Fleming recorded, "a dog as they might discerne it, of a black colour." The apparation, "togither with the fearful flashes of fire which then were séene, moued such admiration in the mindes of the assemblie, that they thought doomes day was already come." The beast cleaved two parishioners kneeling in prayer, and "wrung the necks of them bothe at one instant clene backward." Both died on their knees. It passed another man in church and "gaue him such a gripe on the back, that therwithall he was presently drawen togither and shrunk vp, as it were a peece of lether scorched in a hot fire: or as the mouth of a purse or bag, drawen togither with a string." He survived. Outside, a clerk toiled on the lower eaves of the church, twenty feet above the ground, in a belated attempt to clear the gutters. With a "violent clap of thunder," he was "smitten downe." Remarkably, he escaped unharmed.[15]

[14] Abraham Fleming, *A straunge and terrible Wunder wrought very late in the parish Church of Bongay, a Tovvn of no great distance from the citie of Norwich, namely the fourth of this August, in y^e yeere of our Lord 1577,in a great tempest of violent raine, lighting, and thunder, the like whereof hath been seldom seene. With the appearance of an horrible shaped thing, sensibly perceiued of the people then and there assembled. Drawn into a plain method according to the written copye* (London: Printed by Franncis Godly, 1577), A4r, B3v.

[15] Ibid., A4r.

The nature of the injuries and damage suggest that lightning was the most likely culprit, but the morning of August 4 remains shrouded in mystery. The devilish apparition was probably a figment of terrified imaginations, but it could have been a frightened animal seeking shelter. Twelve miles south of Bungay, however, parishioners in the village of Blythburg reported an eerily similar Sunday morning. A creature of the "same shape and similitude" settled itself in the beams of the church and, swinging down, "slew two men and a lad, and burned the hand of another person that was there among the rest of the company, of whom diuers were blasted." East Anglian folklore tells of a devilish dog, the Black Shuck, that roams the shores of the North Sea. Witnesses in Bungay and Blythburg may have drawn upon such traditions to make sense of the unusual August morning.[16]

A 1586 conflagration in Beccles, seven miles below Bungay on the River Waveney, provides two additional illustrations of East Anglian meteorological literature. On St. Andrew's Eve (November 29), wind and early frost transformed a domestic fire into a town-wide catastrophe. Two black-letter accounts of the "lamentation of Beccles" have survived: Thomas Deloney's *A proper new sonet declaring the lamentation of Beckles* and D[aniel] Sterri's *A brief sonet declaring the lamentation of Beckles*. According to the sonnets, the fire began in the chimney of a "rude felowe," a "carelesse wretch most rude in life." Strong winds spread the flames throughout the town. "The

[16] Fleming's tale remains a source of great pride in Bungay. St. Mary's Church boasts an extensive exhibit on the tale, and the town's weathervane is capped by a dog running across a lightning bolt. Bungay's coat-of-arms includes similar symbols. For the Black Shuck, see Iain Bamforth, "Notes for a Dog Philosophy," *Quadrant* 51, no. 5 (2007): 63-68.

flame whereof increasing stil the blustering windes did blowe," Deloney wrote, "And into diuers buildings by disperst it to and fro." The meandering river offered little aid; Suffolk was in the grip of an unusually deep freeze for November 29 [December 9 NS]. "The Riuer," Deloney explained, "was frozen so no water they could come by." The damage was profound; the fire consumed the parish church, the town market, and eighty private homes. Both sonnets estimate a loss in value of twenty thousand pounds.[17]

Deloney and Sterri both believed that the fire was a demonstration of God's displeasure with greed and discord, particularly in matters of law. Deloney warned his readers to learn from Beccles' "sodaine fall": "Liue not in strife and enuious hate to breed each other thrall / Seeke not your neighbors lasting spoyle by greedy sute in Lawe / Liue not in discord and debate which doth destruction draw." For Deloney, the "carelesse wretch" who started the fire was merely an "Instrument . . . of Gods most heauie ire." Sterri was more direct, asserting that "sinne hath consumed pore Beckles

[17] Nicholas Colman, a Norwich surgeon, commissioned London printer Robert Robinson to publish both sonnets. In the Stationer's Register, both were entered to N. Colman on December 13, 1586—a mere two weeks after the fire. The English Short Title Catalog does not include "Market Towne" in the bracketed segment of Deloney's title. Based on the length of the first line of Deloney's title, and its similarity to Sterri's title, the words "Market Towne" should be considered part of the original title. T[homas] D[eloney], *A proper newe sonet declaring the lamentation of Beckles [a Market Towne in] Suffolke, which was in the great winde upon S. Andrewes eve last, past most pittifully burned with fire, to the losse by estimation of twentie thousande pound and vpwarde, and to the number of foure score dwelling houses. 1586. To Wilsons tune* (London: Imprinted by Robert Robinson for Nicholas Colman, [1586]); D[aniel] Sterri, *A briefe sonet declaring the lamentation of Beckles, a Market Towne in Suffolke which was in the great winde upon S. Andrewes eve pitifully burned with fire to the value by estimation of tweentie thousande pounds. And to the number of fourescore dwelling houses, besides a great number of other houses. 1586. To the tune of Labandalashotte* (London: Imprinted by Robert Robinson for Nicholas Colman, [1586]).

with Fire." Like Deloney, he beseeched his readers to "[b]e all one as Christians, not liue in debate, / With wrapping and trapping, each other in thrall, / With watching, and pryeng at each others fall, / With houing, and shouing, and striuing in Lawe." Sterri, however, rejected the notion that one's behavior determined their fate in a catastrophe. Paraphrasing Luke 13:4, Sterri warned, "Let none thinke there liuing is cause they scape free, / But let them remember, how Christ once did tell, / Their sinnes were not greater, on whom the wall [of Siloam] fell."[18]

The last decade of the sixteenth century brought particularly sharp environmental challenges to northern Europe. Contributors to Peter Clark's *European Crisis of the 1590s* determined that frosts, dramatic swings in precipitation, and coastal and riverine flooding contributed to property loss, famine, and the spread of disease in the Netherlands, Germany, and Italy.[19] In England, the price of grain more than doubled, and probably tripled, in the last three years of the century. John Stow recorded frosts in December 1598 and Spring 1600. "In the moneth of December," Stow wrote, "great frosts, the Thamis nigh ouer frozen at London bridge, but thawed about one wéeke before Christmas." Frost returned on December 27, and snow the following day, "so that the Thamis was againe nigh frozen as before, but on New yeeres day it thawed."[20] The next year, on December 23, 1599, a "winde west and by south, boysterous and

[18] Ibid.

[19] Leo Noordegraaf, "Death . . . Sixteenth Century," in *The European Crisis of the 1590s*, ed. Peter Clark (London: George Allen & Unwin, 1985), 74-75; Heinz Schilling, "The European Crisis . . . German Towns," in Clarke, *European Crisis*, 137; Nicholas Davidson, "Northern . . . 1590s," in Clarke, *European Crisis*, 160; David Souden, "Demographic . . . 1590s," in Clarke, *European Crisis*, 232-33.

[20] Stow, *Annales*, 1303.

great" lashed the city of London, "wherethrough the toppes of many chimneies were ouerthrowne, lead blowne off churches, trées, and barnes blowne downe, with also a tiltboate from London towardes Grauesend, lost against Woolwich, with 30. persons, men and women, whereof eleuen were saued." One month later, there began such a frost "that within one seuen night the after riuer of Thamis was nigh ouer frozen at London bridge." In 1600, it snowed on March 23, March 30, and April 4. April and May were "cold and drie, with frosts euerie morning, except some three daies little raine." The weather triggered a brief panic in the grain market:

> [The] coldnes of the spring, and drinesse of the ground, made men doubtfull of any good haruest to succéede, whereupon, and by means of some late transporting ouer the seas, procured by the Justices of the shires, but more by vnconscionable farmers hoording vp their corne, badgers, and other corne-mongers, kéeping the same from the markets, or extorting what price they listed, euen vpon a sodaine, namely, wheate was raised from thrée shillings to sixe, seuen, and eight shillings the bushell, still increasing their prices. Untill the Quéenes most excellent Maiestie, perceiuing how bitter a thing the scarcitie of uictualls is to the poorer sort of her people, published by proclamation that her Maiesty had, not only recommended precisely to her councell and other principall ministers, that all maner of graine might bee kept within the Realme, but likewise directed them to punish such ingrocers, and forestallers of corne as by greedinesse laboured to racke things vp to vnreasonable prices, &c.

According to Stow, the price of grain declined after the Queen's intervention.[21]

In 1601, Flemish scholar and stoic philosopher Justus Lipsius reported similar conditions in the Spanish Netherlands, where he served as a professor at the Catholic University of Leuven.[22] In a series of heretofore untranslated letters to Nicolao de

[21] Ibid., 1305-06.

[22] Born into Catholicism, Lipsius lived much of his life as a Protestant, lecturing in a variety of northern European universities. He was the most prominent advocate of Stoicism in sixteenth-century Europe, and his scholarship largely reflects this orientation. Lipsius' contributions to early modern literature include *De Constantia Libri*

Weerdt, a kinsman and attorney in Brussels, Lipsius described the damage the weather wrought in his beloved garden. "About the garden which you mention as a pleasant and agreeable thing," Lipsius wrote in a letter dated April 11, "indeed it was, but it was . . . . [W]hat a ruin was caused by that winter!"[23] He compared the damage to his garden to the Battle of Cannae, where Hannibal and the Carthaginians surrounded and destroyed the army of Rome in 216 BC: "The calamity of Cannae is, so to speak, in my garden: the flowers have been laid low and slaughtered, and scarcely a third of the troops remain."[24] De Weerdt's response has been lost, but he apparently replied with further remarks on the unusual weather. In a letter dated June 2, Lipsius agreed that the weather remained quite severe: "This obstinacy of the sky [is] remarkable, it is to be admitted: for more than four months it hardly rained, and dew did not fall unless lightly. Meanwhile [there was] very hot weather and an unusual drought." "To what extent our

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Duo (1584), *Politicorum sive Civilis Doctrinae Libri Sex* (1589), two studies of Stoicism, and commentaries on Tacitus, Seneca, and Polybius. His publications were widely translated; both *De Constantia Libri Duo* and *Politicorum sive Civilis Doctrinae Libri Sex* were available in English by 1594. Justus Lipsius, *Tvvo bookes of constancie. Containing, principallie, a comfortable conference, in common calamites. And will serue for a singular consolation to all that are priuately distressed, or afflicted, either in body or mind*, trans. John Stradling (London: Richard Johnes, 1594); Justus Lipsius, *Sixe bookes of politickes or ciuil doctrine, which doe especially concerne principalitie*, trans. William Jones (London: Printed by Richard Field for William Ponsonby, 1594); John Sellars, "Justus Lipsius's *De Constantia:* A Stoic Spiritual Exercise," *Poetics Today* 28, no. 3 (Fall 2007): 340-41.

[23] Although Flemish printer Jan Moretus and the Officina Plantiniani began publishing collections of Lipsius' letters during his lifetime, few have been translated. The two letters described in this chapter were published in Latin in 1605. Professional translation assistance was procured through Tomedes; see http://www.tomedes.com. Justus Lipsius, "Epistola LXXXIII," *Epistolarvm selectarvm centvria secvnda ad Belgas* (Antwerp: Officina Plantiniana, 1605), 85.

[24] Translation mine; originally: *Clades Cannensis est,vt sic dicam, in meo horto: flores prostrati, occisi, & vix tertia pars superest copiarum.*

little vegetable gardens are suffering?" Lipsius mused, "And I with them, as this climate is so unfavorable to me?"[25]

Despite his personal discomfort, Lipsius rejected the notion that the late frosts and drought were anomalous for Europe or the Low Countries. "[I]t is not too unusual or novel," he wrote, "even if it looks so to us." Using ancient and medieval chronicles, he identified six historical events characterized by great heat or drought. Livy described droughts in 431 BC and 182 BC, but Lipsius warned that these happened "under another sky and in another land: what about ours?" In the Alsatian chronicles of Colmar, he found evidence for great warmth or drought in 1228, 1268, 1303, and 1351 AD[26] "[T]hese [events are] not exactly extraordinary," he wrote, "just as it [is] not [extraordinary] even the cold, the excessive [cold] which now has blown over us for two years." Lipsius identified eight historical frosts comparable to that of 1599-1600 (Table 6).

[25] Justus Lipsius, "Epistola XCI," *Epistolarvm selectarvm centvria secvnda ad Belgas* (Antwerp: Officina Plantiniana, 1605), 90-92.

[26] Lipsius did not identify the "Germanici Annales," but three quotations in his letter correspond to entries in the Chronicles of Colmar: 1228, 1268, and 1304 (rather than 1303). Lipsius did not include a quotation for 1351. See *Annales Colmarienses minores*, ed. Phillip Jaffé, in *Monumenta Germaniae Historica, Scriptores*, vol. 17, ed. George Heinrich Pertz (Hannover: Hahn, 1861), 189; *Annales Basileenses*, ed. Phillip Jaffé, in Pertz, *Scriptores* 17, 193; *Annales Colmarienses maiores*, ed. Phillip Jaffé, in Pertz, *Scriptores* 17, 230.

Table 6: Great Frosts in Justus Lipsius' *Epistolarvm Selectarvm Centvria* (1605)

Year	Location of Frost	Source
399 BC	Tiber River	Livy[27]
(undated)	Chrysopolis & the Bosporus	John Zonaras[28]
800 AD	Black Sea	Marianus Scotus[29]
821 AD	Rhine, Danube, & Seine Rivers	Royal Frankish Annals[30]
1063 AD	(unspecified)	Berthold of Reichenau[31]
1076 AD	Rhine River	Lambert of Aschaffenburg[32]
1125 AD	Brabant	Robert de Monte[33]
1234 AD	Adriatic Sea	Chronicle of St. Peter's, Erfurt[34]

[27] Livy, *The History of Rome*, trans. Benjamin Oliver Foster (London: William Heinemann, 1924), 5.13.1-4.

[28] The great frost occurred during the reign of Constantine V (r. 741-775). See John Zonaras, *Annales*, 15.7, in *Patrologia Graeca*, vol. 134, ed. Jacques-Paul Migne (Paris: Jacques-Paul Migne, 1864), column 1334.

[29] For the winter of 800, Lipsius cites Marianus Scotus (ca. 1028-1082), an Irish-born chronicler. The quoted passage appears a 1559 edition of his chronicle. See Marianus Scotus, *Chronicon*, 3.6 (Basel: Johannes Oporinus, 1559), column 401.

[30] Lipsius does not identify his source for the winter of 821, but he quotes from the anonymously-compiled Royal Frankish Annals. See *Annales regni Francorum*, in *Annales regni Francorum inde ab a. 741. usque ad a. 829. qui dicuntur Annales Laurissenses maiores et Einhardi*, ed. Fridericus Kurze (Hannover: Hahn, 1895), 157.

[31] For the winter of 1063, Lipsius cites Hermann the Lame, who died in 1054. The reference actually comes from Berthold of Reichenau (d. ca. 1088), who continued his mentor's chronicle. See Berthold, *Annales*, in Pertz, *Scriptores* 5, 272.

[32] Lambert of Aschaffenburg is better known as Lambert of Hersfeld (ca.1024-1077). See Lambert, *Annales*, ed. Ludwig Friedrich Hesse, in Pertz, *Scriptores* 5, 255.

[33] For the winter of 1125, Lipsius cites Robert de Monte (ca. 1110-1186), the abbot of Mont St. Michel, who completed several editions of an earlier chronicle by Sigebert of Gembloux (ca.1035-1112). The passage Lipsius quotes actually comes from an earlier expansion of Sigebert's chronicle by Anselm, the abbot of Gembloux (fl. 1115-1136). In Anselm's chronicle, the quoted passage describes 1124 rather than 1125. For the original chronicle and Anselm's additions, see Anselmi Gemblacensis, *Continuatio*, ed. D. Ludowicus Conradus Bethmann, in Pertz, *MGHS* 6, 379.

[34] Lipsius does not identify his source for the winter of 1234, but he quotes from the Chronicle of St. Peter's Abbey in Erfurt, Thuringia. See *Cronica S. Petri Erfordensis Moderna*, in *Monumenta Erphesfurtensia saec. XII. XIII. XIV.*, ed. Oswald Holder-Egger (Hannover: Hahn, 1899), 231.

Lipsius' interest in weather developed as an extension of the Stoic notion of "constancy." As a resident of the Low Countries during the Eighty Years' War, Lipsius was well acquainted with social and political upheaval. For the better part of two decades, he lived alternately as a Lutheran and a Calvinist in the universities of Jena, Cologne, and Leiden. Lipsius wrote the dialogue *De Constantia libri duo* as an attempt to make sense of the tumultuous 1570s, during which Spanish soldiers looted his property on two occasions.[35] *De Constantia* describes a philosophy of constancy, "a right and immouable strength of the minde, neither lifted vp, nor pressed downe with externall or casual accidentes." Lipsius explored the geological implications of constancy in a discussion of "providence" and "necessity." Providence implied a "gouerning facultie" that insinuated itself in all parts of the whole. The "selfsame fore-seeing intelligence which turneth about the heauen dayly," Lipsius wrote, "produceth all these calamities and changes which thou so much maruellest and mutterest at."[36]

Necessity was the property of creation through which providence exerted its authority. The necessity of decay was an important element of Lipsius' philosophy of constancy:

> [I]t is a natural propertie to all things created, to fall into mutability and alteration: As vnto Iron cleaueth naturally a consuming rust: to wood a gnawing worme, and so a wasting rottenness. Euen so to liuing creatures, citties and kingdoms, there bee certaine inward causes of their own decay. Looke vpon all things high and lowe, great and small, made with hand, or composed by the minde, they alwayes haue decayed, and euer shal. And as the riuers with a

[35] Soldiers looted Lipsius' property in Leuven in 1572 and 1579. Sellars, "A Stoic Spiritual Exercise," 340-41.

[36] Lipsius, *Tvvo bookes of constancie*, 9, 33.

> contiual swift course runne into the sea: So all humaine thinges thorough this conduit of wastings and calamities slyde to the marke of their desolation.[37]

The “nova stella” of 1572, famously observed by Tycho Brahe, encouraged Lipsius to extend the “necessity” of decay to the heavenly bodies:

> Seest thou the Sun? He fainteth. The Moone? She laboureth and languisheth. The S[t]arres? They faile and fall. And howsoeuer the wit of man cloaketh and excuseth these matters, yet there haue happened and daily do in that celestiall bodie such things as confound both the rules and wittes of the Mathematicians. I omit Cometes strange in forme, scituation and motion, which al the vniuersities shal neuer perswade me to be in the aire, or of the aire. But beholde our Astrologers were sore troubled of late with strange motions, and new starres. This very yeare there arose a star whose encreasing and decreasing was plainly marked, and we saw (a matter hardly to be credited) euen in the heauen it self, a thing to haue beginning and end againe.[38]

Lipsius pointed to the ruins of once-great cities as evidence of the historical significance of necessity. Floods destroyed Atlantis, Helice, and Bura. Earthquakes buried twelve towns in Asia Minor and Campania during the reigns of Tiberius and Constantine. Attila destroyed more than one hundred towns in a single war. Thebes, Crete, Carthage, Numantia, and Corinth lay in ruins. Athens and Sparta were “vnworthy relickes.” The great cities of the sixteenth century, Lipsius warned, were subject to the same fate: “Seest thou that noble *Byzantium* being proude with the seate of two Empires? *Venice* lifted vp with the stablenesse of a thousande yeares continuance? Their day shall come at length. And thou also our *Antwerpe*, the beautie of citties, in time shalt come to nothing.” The old world entered its “dotage” as a new world rose on the horizon:

[37] Ibid., 36-37.
[38] Ibid.

> I haue spoken yet of townes and cities: Countries likewise and kingdomes runne the verie same race. Once the East flourished: *Assyria*, *Egypt*, and *Iewrie* excelled in warre and peace. That glorie was transferred into *Europe*, which now (like a diseased bodie) seemeth vnto me to be shaken, and to haue a feeling of her great confusion nigh at hande. Yea, and that which is more (and neuer ynough) to bee maruelled at, this world hauing now bene inhabited these fiue thousand and fiue hundred yeares, is at length come to his dotage: And that we may now approoue againe the fables of *Anaxarchus* in old time hissed at, behold how there ariseth els wher new people, & a new world: O the law of Necessity, woonderfull, and not to be comprehended: All things run into this fatall whirle poole of ebbing and flowing: And some things in the world are long lasting, but not euerlasting.

"Am I deceiued?," Lipsius asked in conclusion, "or els do I see the sunne of another new Empire arising in the West?"[39]

Despite Lipsius' apparent interest in the mutability of nature, his letters to Nicolao de Weerdt offered neither examination nor explanation for the unusual frosts and drought of 1599-1601. Historical chronicles from throughout Europe demonstrated that such similar weather events had happened on several occasions in the past. In the letter of June 2, 1601, Lipsius explained the philosophical importance of historical comparisons:

> In order that it may be banished that false belief of unusualness, which flatters [us] badly in every suffering and complaint. There was never [such a thing], it never happened to anyone; trifles, and idle talks: which are confuted by Histories, and [when] carefully read, [the Histories] also bring forth the fruit of steadfastness. Let us do this, my kinsman, and we will save both the body and the soul.[40]

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[39] Ibid., 38-41.

[40] Lipsius, "Epistola XCI," 92.

The philosophy of "constancy" required one to acknowledge the volatility of creation. Like Strabo, a fellow Stoic, Lipsius was not inclined to exaggerate the uniqueness of natural phenomena.

Lipsius' ideas about weather history were first published in a 1605 collection of letters. Despite their relative obscurity, Lipsius' epistles dramatically influenced seventeenth-century ideas about weather. As Chapter 5 will demonstrate, English theologian George Hakewill borrowed liberally from "Epistola XCI" for *An Apologie of the Povver and Providence of God in the Government of the World* (1627), a denunciation of several theories of universal decay and climatic change. Scots-Polish natural philosopher Jan Jonston cited Lipsius as an authority on weather in *Naturæ constantia* (1632) and reused many of his historical examples. In 1657, London stationer John Streater published an English translation of *Naturæ Constantia* titled *An History of the Constancy of Nature*.[41]

The Great Frost of 1607-1608 provided another opportunity to reflect on the history of weather. According to Edmund Howes, who continued John Stow's chronicles after the his death, the frost began on December 8, 1607:

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[41] George Hakewill, *An Apologie of the Povver and Providence of God in the Government of the World. Or an Examination and Censvre of the Common Errovr Tovching Natvres Perpetvall and Vniversall Decay, Divided into Fovre Bookes* (Oxford: Printed by John Lichfield and William Turner, 1627); Jan Jonston, *Naturæ Constantia* (Amsterdam: Printed by William Blaeu, 1632); Jan Jonston, *An History of the Constancy of Nature. Wherein, By comparing the latter Age with the former, it is maintained that the World doth not decay universally, in [re]spect of it Self, or the Heavens, Elements, Mixt Bodies, Meteors, Minerals, Plants, Animals, nor Man in his Age, Stature, Strength, or Faculties of his Minde, as relating to all Arts and Science* (London: Printed for John Streater, 1657).

> The 8. of December began a hard frost, and continued until the 15. of the same, then thawed : and the 22. of December it began againe to freeze violently, so as diuers persons went halfe way ouer the Thames vpon the Ice : and the 20. of December, at euery ebbe many people went quite ouer the Thames in diuers places, and so continued from that day untill the third of January : the people past daily betweene London and the Bankside at euery halfe ebbe, for the floud remoued the Ice, and forced the people daily to tread new paths, except onely beweene Lambeth and the ferry at Westminster, the which by incessant treading, became very firme and frée passage until the great thaw.

The frost peaked during the week of January 10, when conditions "grew extreame, so as the Ice became firme, and remoued not, and then all sorts of men, women, and children, went boldly vpon the Ice in most parts." The Thames took on the appearance of a fair, where "some shot at prickes, others bowled and danced, with other variable pastimes; by reason of which concourse of people, there were many that set vp boothes and standings vpon the Ice, as Fruit-sellers, Uictuallers, that sold beere and wine, Shoomakers, & a Barbers tend, &c." "Euery of them," Howes remarked with no little surprise, "had fire néere their beings."[42]

The Thames began to thaw on January 15, 1607/8, and continued to do so for four days. The melting smoothed the ice, and the countenance of the river reminded Howes of the Great Frost of 1564. "The great Ice vpon the Thames," he wrote, "held firme & passable, and became somewhat smooth, like as in the last great frost in the yeare 1564. Which till then were very craggy and vncertaine." In late January 1607/8, the frost "violently" returned and remained through February 1, when the ice began to

[42] Edmund Howes, *The Abridgement of the English Chronicle, First collected by M.* Iohn Stow, *and after him augmented with very many memorable Antiquities, and continued with matters forreine and domesticall, vnto the end of the yeare 1610* (London: Printed for the Company of Stationers, 1611), 481-82.

break “little by little.” By the following afternoon, no evidence of the ice remained—except for “spoiled” bridges, dead fowl, and frozen artichoke gardens. Howes warned, however, that the frost had been “more grieuous in France then in England.”[43]

Contemporary accounts of the Great Frost of 1607-1608 offered similar observations to those found in Howes’ *Chronicle*. The letters of Dudley Carleton, an English diplomat, and John Chamberlain, London’s most celebrated letter-writer, describe the “bytter weather” of a “colde frosty season.” Carleton passed the holidays at Knebworth House in Hertfordshire, the home of Rowland Litton (1562-1615), a Member of Parliament. In a letter dated December 31, 1607, Carleton inquired about the rumors of a frozen River Thames. “If we see you not (which I am loth to make a supposition),” Carleton wrote of the holiday season, “you will let vs heare at lest how the world goes at London. and if it be true (as was told vs this day) that the Thames is frosen ouer to make up the number of miracles of owr kings raigne.”[44] “Touching the freesing of the Thames,” Chamberlain replied on January 5, “yt was, and was not.” He elaborated: “for on wensday, thursday, and friday at lowe water the yce cluttering together, diuers [scrambled] ouer, and some fell in, but when the tide came yt scattered those ylands of yce all ouer so that boates passed vp and downe: and from that time for ought I can discerne there is more water to be seen then yce.”[45] Three days later, Chamberlain delighted in sharing tales of the frost, which apparently returned by January 6, 1607/8:

[43] Edmund Howes, *Abridgement*, 481-82.

[44] John Chamberlain to Dudley Carleton, London, 30 December 1607. SP 14/28/128; Dudley Carleton to John Chamberlain, Knebworth House, 31 December 1607. SP 14/28/129.

[45] John Chamberlain to Dudley Carleton, London, 5 January 1608. SP 14/31/1.

> [A]boue westminster the Thames is quite frosen ouer and the Archbishop came from Lambeth [across the Thames] on twelfth day ouer the yce to the court. many fantasticall experiments are dayly put in practise, as certaine youths burnt a gallon of wine vpon the yce and made all the passengers partakers, but the best is of an honest woman (they say) that had a great longing to haue her husband get her with child vpon the Thames.[46]

Chamberlain, a skillful newsgatherer, was well equipped to respond to enquiries about the Thames: he lived quite close to the river, where St. Paul's Cathedral now stands.

Zorzi Giustinian, the Venetian ambassador to England, noted in a letter dated January 10, 1607/8, that ice on the Thames was preventing the ship *Husband* from offloading its cargo, valued at 30,000 crowns.[47] One week later, Giustianan remarked, "The cold is intenser [than] any within the memory of man. The Thames is frozen and the City is, as it were, in a state of seige. All the posts are delayed and that is why we have heard only this week that the states of Holland have consented to treat for peace, and that the Congress is being pushed forward."[48] Rowland Whyte, postmaster of the court and a newsagent for Gilbert Talbot, the Earl of Shrewsbury, described the frost in similar terms in a letter dated January 26, 1607/08:

> The frost continues here in a very strange manner; the Thames so hardly frozen that it is made a beaten highway to all places of the city, but all bridges are in

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[46] John Chamberlain to Dudley Carleton, London, 8 January 1608. SP 14/31/4.

[47] Zorzi Giustinian to the Doge and Senate, London, 10 January 1608, in *Calendar of State Papers and Manuscripts, Relating to English Affairs, Existing in the Archives and Collections of Venice, and in Other Libraries of Northern Italy*, ed. Horatio F. Brown, vol. 11 (London: HMSO, 1904), no. 146.

[48] The Armistice of 1607 began in April. Giustinian's remarks may refer to a later expansion of the terms of the Armistice to forbid hostilities at sea. See Randall Lesaffer, Erik-Jan Broers, and Johanna Waelkens, "From Antwerp to Munster (1609/1648): Truce and Peace under the Law of Nations," in *The Twelve Years' Truce (1609): Peace, Truce, War, and Law in the Low Countries at the Turn of the 17th Century* (Leiden: Brill, 2014): 234-35; Zorzi Giustinian to the Doge and Senate, London, 10 January 1608, *English Affairs*, no. 148.

great danger upon a thaw. We at Baynard Castle [in London] watch and ward to preserve ours, that was but newly built. A great part of Kingston Bridge is down. All the merchants that dwell upon London Bridge have removed their goods of value, fearing they know not what.[49]

London bookseller Henry Gosson, who maintained a shop at London Bridge, published the lengthiest description of the frozen river, *The Great Frost. Cold Doings in London*.[50] Catalogers have long attributed the authorship of the anonymous pamphlet to playwright Thomas Dekker. *The Great Frost* (1608) was the first substantial examination of contemporary and historical weather published in England since Thomas Knell's *Declaration of such tempestious, and outragious Fluddes* (1570). Though written in a deceptively entertaining format—the dialogue of a city-dweller and a traveler from the country, *The Great Frost* is a complex pamphlet that addresses the physical, economic, and social consequences of the long freeze. The pamphlet's table of contents—in a dialogue that lacked formal chapters—reveals an ambitious approach to meteorological writing:

A Table of the most speciall matters of note contained in this short Discourse.
1. A description, of the Thames being frozen ouer.
2. The daungers that hath happened to some persons passing vpon the Thames.
3. The harmes that this Frost hath done to the Citie.
4. The miserie that the Country people are driuen into by the meanes of this Frost.
5. The Frosts in other Kings times compared vvith this.

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[49] Rowland Whyte to Gilbert Talbot, London, 26 January 1608, in *Illustrations of British History, Biography, and Manners, in the Reigns of Henry VIII, Edward VI, Mary, Elizabeth, & James I, Exhibited in a Series of Original Papers, Selected from the MSS. of the Noble Familes of Howard, Talbot, and Cecil*, 2nd ed., vol. 3, ed. Edmund Lodge (London: John Chidley, 1838), no. 93.

[50] Thomas Dekker, *The Great Frost. Cold Doings in London, except it be at the Lotterie. With Newes out of the Country. A familiar talke betwene a Country-man and a Citizen touching this terrible Frost and the great Lotterie, and the effects of them. The Description of the Thames frozen over* (London: Henry Gosson, 1608).

6. A description of the Lottery.

Like Knell and Lipsius, Dekker compared the late frost to those recorded in historical chronicles.[51]

The Great Frost is comprised of a dialogue between an aging Londoner and a vigorous octogenarian from Yorkshire. Winter had interrupted their typical duties, and both citizen and countryman sought news of the other's home. "[B]lessed be God, we haue now too many idle howres against our will," the citizen complained. Tales of the frozen river drew the countryman into town:

> Marry Sir I will tell you, euen that drew me to London, which drawes you out of your houses: that which makes you cry out in London, *Wee haue cold doings*, and to leaue your shops to catch you heate in the stréetes, nay to leaue your new beautifull walks in Moore-fields . . . and to make newer and larger walkes (though not so safe) upon a field of glasse as it were. That slippery world which I beheld (as I remember) in the fift yeare of the raigne of Quéene *Elizabeth* . . . doe I come thus far to behold againe in the fift yeare of our good King Iames & that is (in a few cold words) the thames frozen ouer.

The Yorkshire traveler hoped to confirm the tales for himself, rather than trust in the wild speculation of the countryside—"a thousand tales in lesse then seuen daies." "[B]ecause this world is like our Millers in the Country, knauish and hard to be trusted," he explained, "I had rather giue credite to mine eyes."[52]

Their discussion of London focused on the frozen river. According to the citizen's account, "Cakes of Ise" began to appear in "great quantitie, and in great numbers," a few weeks before the surface of the river froze in late December 1607. "You shall vnderstand," he explained, "that the *Thames* began to put on his *Freeze-coote*

[51] Ibid., A1v.
[52] Ibid., A2v-A3r.

(which yet he weares) about the weeke before *Christmas*, and hath kept it on till now this latter end of *Ianuarij*." The river remained frozen for much of January, as there were "[o]nely thrée dayes, or foure at the most," of inconsequential thaw. The Thames initially froze along London Bridge, where the wide starlings that protected the piers of bridge funneled the river through narrow passages that trapped rafts of debris and ice. The citizen's account describes "winter castles of yce" collecting in heaps, "justling against the arches of the Bridge, and striuing (like an unruly Drunkard at a gate of the Citie in the night time) to passe through." One rumor held that "all the arches of [the] famous London Bridge" were "so damd vp with yce, that the flakes shew like so many frozen gates, shut vp close . . . that a man cannot look through them as he had wont."[53] The citizen dismissed this as exaggeration.

The winter castles congealed in icy imitation of their limestone neighbor, forming a bridge between Cold-Harbour in London and Bankside in Southwark. "[W]ylde youthes and boyes" were first to explore the "new found Fréezeland," but these "Marchant-venturers" were soon joined by their elders. The citizen's account describes the narrow bridge and its wandering patrons:

> [T]here was as it were an artificiall bridge of yce reaching from one side of the Riuer to the other, uppon which infinite numbers of people passed too and fro, iustling one an other in crowdes, when the current of the water ran (in sight) more than halfe the breadth of the Thames, on eyther side of that ycecy bridge, the bridge itself being not aboue fiue yardes broad, (if so much.).[54]

[53] Ibid., A3v-A4r.
[54] Ibid., B1r.

The first crossings of the Thames were a public spectacle—the "Age of Exploration" writ small, and performed by the community itself:

> [N]o danger could nip their bloods with feare; but ouer some wēt in shoals when thousands stood gazing on and swore, they would not follow their steppes in that waterie wildernesse for many thousands of pounds: nay, euen many of those that were the discouerers, and did first venture ouer, would neuer vndertake the second voyage, but protested when they were halfe way, they would haue lost much to haue bin againe on shore.[55]

Curiosity overcame caution, however, as the frozen domain of the river grew in size and stability. "The frost hath made a floore vpon it," the citizen explained, "which shows like grey marble roughly hewen out: it is a very pauement of glasse, but that it is more strong." According to *The Great Frost*, thick ice stretched from London Bridge to Westminster, two miles upriver. At Queenhithe, where the Millennium Footbridge now connects Southwark to the City of London, unemployed watermen cut a channel "by maine labour . . . with axes, and such like instruments" to reopen their trade (Fig. 10).[56] The closure of the city's coal wharves suggests that the Thames froze below London Bridge, as well.

[55] Ibid.

[56] The channel would have been located within 200 yards of the London Millennium Footbridge, which stretches from Queenhithe in London to Bankside in Southwark, and very close to the reconstructed Globe Theatre. Dekker, *The Great Frost*, A3v, A4v-B1r.

Fig. 10. *The River Thames at Queenhithe. Looking East. From left, Queenhithe harbor, Southwark Bridge, the Shard, and Bankside. Tower Bridge is visible on the horizon. The medieval London Bridge was located between Queenhithe and the Tower of London, not far from the Shard skyscraper. Photo by author (2014).*

The novelty of the ice drew a crowd of remarkable diversity to the frosty commons. It facilitated free transportation between the banks, and it apparently fostered an atmosphere of lowered inhibitions:

> [B]oth men, women, and children walked ouer, and vp and downe in such companies, that I verily beléeue, and I dare almost sweare it, the one halfe (if not thrée parts) of the people in the Citie, haue béene séene going on the Thames. The Riuer shewed not now (neither shewes it yet) like a Riuer, but like a field where Archers shoote at prickes, whilst others play at foote-ball. It is a place of maisterie, where some wrestle, and some runne, and he that does best is aptest to take a fall. It is an Alley to walke vpon without dread, albeit vnder it be most assured daunger. The Gentlewomen that trembles to passe ouer a Bridge in the field, doth here walke boldly: the Citizens wife that lookes pale when she sits in a boate for feare of drowning, thinks that here shee treades as safe now as in her Parlour. Of all ages, of all sexes, of all professions this is the common path: it is

> the roade way betwéene London and Westminister, and bewéene South-warke and London.[57]

The frozen river was a source for fantastical rumors—to the great disappointment of the countryman. One rumor held that a person could "drink a pinte of sack in the Tavern that runs vpon whéels," while another described a system of transportation in which "the Westerne Barges come downe vpon certaine artificiall pullies and engines, sliding on the yce; to serue [the] Citie with fewell."[58]

Commerce followed traffic, though, and London's newest intersection quickly became a bustling tavern, marketplace, and tourist destination. With all the skill of a modern publicist, Dekker's "citizen" touted Freezeland's available foods, drinks, and services:

> Thirst you for Béere, Ale, Usquibath, &c. or for victualls? there you may buy it, because you may tell an other day how you dined vppon the Thames. Are you colde with going ouer? you shall ere you come to the midst of the Riuer, spie some ready with pannes of coales to warme your fingers. If you want fruite after you haue dined, there stands Costermongers to serue you at your call.[59]

Two barbershops established temporary locations on the ice, and these were among the most popular of the river's destinations:

> [T]here were two Barbers shops (in the fashion of Boothes with signes and other properties of that trade belonging to them) fixed on the yce: to which many numbers of people resorted, and (albeit they wanted no shauing) yet would they here be trimmed, because an other day they might report, that they lost their haire betweene the banke side and London. Both these shoppes werr still so full, that the workemen thought every day had beene Saturday: neuer had they more barbarous doinges for the time.[60]

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[57] Ibid., B1r-B1v.
[58] Ibid., A4r.
[59] Ibid., B1v.
[60] Ibid., D1r.

Freezeland exercised a magnetic pull on the population of London. “[P]eople leaue their houses and the stréetes,” *The Great Frost* reported, “turning the goodliest Riuer in the whole Kingdome, into the broadest stréete to walke in.”[61]

Most Londoners, however, did not share the good fortune of the barbers. Exposure, thin ice, and drowning were responsible for several deaths, and the frozen river disrupted trade, commerce, and their supporting industries. The city was “cut off from all comerce”; it was “The dead Vacation, The frozen Vacation, The cold Vacation.” “If it be a Gentlemans life to liue idlely, and doe nothing,” Dekker’s citizen pondered, “how many poore Artificers and Trades-men haue béene made Gentlemen then by this Frost?” Food and fuel were in particularly short supply. According to *The Great Frost*, the frozen river severed London from upriver sources of wood and downriver sources of coal, via the Newcastle trade, which led to the “vnconscionable and vnmercifull raising of the prices of fewell by Chandlers, Wood-mongers, &c.” Difficult roads impeded the shipment of food from some parts of the countryside, as well, bringing “victuall itselfe . . . into a scarcitie.” The intervention of the city’s aldermen, under senior alderman John Spencer, prevented catastrophe. The city fathers established relief stations “about the outer bounds of the Citie, where pouertie most inhabiteth[,] by storing them before hand with Seacoale and other fiering at a reasonable rate.”[62]

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[61] Ibid., B1v.

[62] Ibid., B2v-B3r.

The Great Frost dedicates only a few passages to conditions outside of London, but these suggest widespread hardship. "It goes as hard with vs as it doeth with you," Dekker's countryman explained, and "[t]he same colde hand of Winter is thrust into our bosomes, the same sharpe ayre strikes woundes into our bodies: the same Sunne shines vppon vs, but the same Sunne doeth not heate vs no more then it doeth you." Humans, animals, and crops shared the bitter cup of winter's wrath: "The ground is bare, and not worth a poore handfull of grasse. The earth séemes barren, and beares nothing, or if shee doeth, most vnnaturally she kills it presently, or suffers it through cold to perish." Dekker seemed well-aware that a dramatic frost like that of 1607-08 could do long-term damage to agricultural households:

> The poore Cottager that hath but a Cowe to liue vpon, must feed vpon hungry meales (God knows) when the beast her selfe hath but a bare Commons. He that is not able to bid all his Cattle home, and to feast them with Fodder out of his Barnes, will scarce haue Cattell at the end of Sommer to fetch home his Haruest. Which charge of feeding so many beastly mouthes, is able to eate vp a Country-mans estate, if his prouidence before time hath not bin the greater to meet and preuent such stormes. Of necessity our Sheep Oxen &c. must be in danger of famishing, (hauing nothing but what our old drandam the earth will alowe them to liue vpon) of necessitie must they pyne, scithence all the fruits that had wont to spring out of her fertile womb, are now nipt in their birth, and likely neuer to prosper.[63]

The fate of the humble leek was evidence of the winter's unusual harshness. Though it often survived storms of hail, snow, frost, and rain with little difficulty, it was "nowe by the violence and cruelty of this Weather, beaten into the earth, being rotted, dead, disgraced and trode vpon."[64]

[63] Dekker, *The Great Frost*, B4r-B4v
[64] Ibid.

The Great Frost of 1607-08 was an extraordinary meteorological event, but it was not without precedent. Like Thomas Knell and Justus Lipsius, Dekker recognized the value of comparing weather conditions across time and space. The countryman, a budding historian, concluded his account of the weather with a discussion of nine similar frosts from England's past. During the fifth year (1091-92) of William II's reign, several English rivers froze solidly enough to permit the passage of heavy carts. A second great frost occurred in the sixth year (1205) of King John's reign; it so devastated wheat stores that the cost of a wheat increased thirteen-fold. The Thames froze again in the fifty-third year (1268-69) of Henry III's reign, during a frost lasting from November 30 to February 2. Thirteen years later, during the tenth year (1281-82) of Edward I's reign, ice rafts swept away several bridges, including five arches of an earlier London Bridge. Severe frosts occurred in 1363-64, 1407-08, and 1464-65, and the Thames froze in the ninth year (1517-18) of Henry VIII's reign and again in 1564.[65]

Reports from abroad suggested that all of Christendom shared in the "cold breakfast" of 1607-08. "[V]pon my conference with some Merchantes my friendes here in London," Dekker's citizen recalled, "and vpon view of Letters from seuerall factors out of other Countries beyond the Seas[,] I adde this further report, that this frost hath not onely continued in this extremitie here in England, but all or the greatest part of all the Kingdomes in Christendome, haue beene pinched by the same." Among those affected were "those Countries Northward (as Russia, Muscouia, &c, which at these

[65] There are no citations in *The Great Frost*, but Dekker appears to have drawn his examples from Stow's chronicles, which describe the frosts in similar terms. Ibid., C1v-C2r.

times of the yeare are commonly subject to sharpe, bitter and violent Frosts)." These were "more extreamely, and more extraordinarily afflicted, then vsually they haue beene in many yeares before." In the citizen's opinion, England escaped the worst of the winter. "[T]he calamities that haue falne vpon vs by this crueltie of the weather, are so much to be endured with the greater patience, and with more thankesgiuing to God," he advised, "because his hand hath punished neighbors and other Nations as heauily (if not more seuerely) then he hath vs."[66] No formal networks of meteorologists recorded the earliest phases of the Little Ice Age. Dekker's *Great Frost*, however, demonstrates that weather was an important element of merchant and trade correspondence.

The first English pamphlets about contemporary weather date to the beginning of the Little Ice Age, when cold and stormy conditions coincided with the expansion of publishing in England. Many accounts hailed from the environmentally marginal counties of Norfolk and Suffolk, where slight variations of weather and climate dramatically affected agriculture and transportation—and continue to do so today. Thomas Knell, Richard Tarlton, the Diocese of Norwich, Abraham Fleming, Thomas Deloney, and Daniel Sterri all interpreted weather within a theological framework. None made reference to the popular astrological texts of 1550s and 1560s, and none drew deeply from the well of Aristotelian meteorology. Historical chronicles, however, transformed the study of weather during this period. Thomas Knell relied on historical records to establish some separation between church and weather. Justus Lipsius and

[66] Ibid., D1r-D1v.

Thomas Dekker further demonstrated that weather could be a subject of secular, historical examination rather than theological speculation. They were hesitant to suggest that the great storms of the late sixteenth and early seventeenth centuries were unusual. The "Windie Year" of 1612 would challenge that supposition.

CHAPTER V

A CIRCLE OF MISERY: THE "WINDIE YEARE" AND THE FIRST THEORY OF CLIMATE CHANGE

Five years after the "Great Frost," in autumn 1612, powerful tempests battered farms and communities from Devonshire to Lincolnshire and upended ships from Cornwall to Calais. By January, weather had become a matter of profound public interest. English stationers published nine weather-related titles in 1613—an unprecedented number for the early seventeenth century. Between 1600 and 1650, English stationers typically published one or two such publications, at most, each year. Only in 1613 did this number exceed five. The authors of these publications cautiously explored the implications of unusual weather; a few even suggested that some fundamental alteration of the heavens, the earth, or both had taken place. In 1616, three years after the winds subsided, English theologian Godfrey Goodman proposed the first theory of climatic change. He suggested that unusual weather was a symptom of "universal decay," a progressive decay that would continue until purifying fire consumed the fallen world.

London booksellers registered six anonymous books about weather during the first two weeks of 1613.[1] Four of these have survived: William Barley's *Lamentable*

[1] On January 5, William Barley entered in the Stationers' Register "a booke shewinge *the wonderful delyuerance of master EDWARD PETT. Master of A ship, dwellinge in Sethinge Lane in London neere Barkinge churche* with *other thinges lately happened concerninge this great Wynde and tempestuous weather bothe at Sea, and Land*." On January 7, Thomas Bushell and John Wright entered a book titled *lamentable*

Newes, Arthur Johnson's *The VVindie Yeare*, and Joseph Hunt's *The VVonders of this windie winter* and *The last terrible Tempestious windes and weather*.[2] According to the four pamphlets, England's weather turned foul in September 1612, after which "long continuing windes and tempests" were a "daily calamity."[3] Reports of the wind's wrath flowed into London by way of travelers, carriers, and personal letters. Farmers in Lincolnshire reported that wind had driven their flocks and herds into fenny marshes or

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reportes of this wyndy Wynter in the iiij last monethes and parte of this January." On January 7, Joseph Hunt and Henry Gosson entered two publications, a book titled *a brief relacon of the great Losses by Sea. by reason of the Late great tempestes this present yere 1612* and a ballad "of the said *Losses by these tempestes*." On January 12, Arthur Johnson entered a book titled *The wyndy wynter shewinge certayne straunge accydentes happening by the late terrible tempestes of wynd and weather*, and William Barley entered a ballad titled *the Wonderfull deliuerance of master PETT sayler in these last tempestes*. See Edward Arber, ed., *A Transcript of the Registers of the Company of Stationers of London: 1554-1640 A.D.*, 5 vols. (London: Privately Printed, 1875–94), 232v-233r.

[2] The two ballads have been lost. *Lamentable Newes, Shewing the wonderfull deliuerance of Maister Edmond Pet Sayler, and Maister of a Ship, dwelling in Seething Lane in London, neere Barking Church. With other strange things lately hapned concerning these great windes and tempestuous weather, both at Sea and Lande* (London: Printed by T[homas] C[reede] for William Barley, 1613); *The Windie Yeare. Shewing Many strange Accidents that happened, both on the Land, and at Sea, by reason of the winde and weather. With A particular relation of that which happened at Great Chart in Kent. And Also how a Woman was found in the water, with a sucking Child at her brest, with the nipple in it mouth, both drowned; with many other lamentable things worthy to be read, and remembered* (London: Printed by G[eorge] Eld for Arthur Johnson, 1613); *The VVonders of this windie winter. By terrible stormes and tempests, to the losse of liues and goods of many thousands of men, women and children. The like by Sea and Land, hath not beene seene, nor heard of in this age of the World* (London: Printed for Joseph Hunt, 1613); *The last terrible Tempestious windes and weather. Truely Relating many Lamentable Ship-wracks, with drowning of many people, on the Coasts of England, Scotland, France and Ireland: with the Iles of Wight, Garsey & Iarsey. Shewing also, many great mis-fortunes, that haue lately hapned on Land, by reason of the windes and rayne, in diuers places of this Kingdome* (London: Printed for Joseph Hunt, 1613).

[3] *The VVonders of this windie winter*, A3v.

the sea. Reports from Gloucestershire, Wiltshire, Berkshire, Bedfordshire, and Oxfordshire described travelers who perished when “the fierceness of the wind” drove them off bridges, into flooded pits, or into unsafe structures. Two shopkeepers, two scholars, a clothier, and a tanner perished in the storms. Farmers in Warwickshire, Leicestershire, and Northamptonshire reported collapsed barns, stables, and homes. Damaged ricks of hay and peas crushed animals and threatened the winter feedstock. The wind destroyed windmills in Bedfordshire and Northamptonshire. Wind-whipped flames threatened cities from Tiverton in Devonshire to Bury St Edmunds in Suffolk. Coastal and riverine flooding damaged numerous locations, including Sutton-on-Trent and Marshland (western Norfolk). In Essex and London, the wind tore lead roofs from buildings and felled trees that had survived “all winds & weathers safe and sound for these two hundred yéers past.” Stationer Henry Gosson knew better than any the danger of the wind: A falling chimney crushed his London home on Catherine Wheel Alley, near Spitalfields. According to Hunt, who collaborated with Gosson on at least one pamphlet, the chimney “fell with such a violence in the night, that it beat through the roofe and a garret, and into a middle chamber: but God be praised it hurt no body.”[4]

The greatest loss of life and property, however, occurred at sea. According to Hunt, the winter’s dangerous weather was a subject of frequent discussion in the merchant community:

> It is with sorrow remembered, and with griefe reported in the Citie of London, euen vpon the roiall Exchange, the honourable and worthy meeting place of Merchants; that within these three forepassed Moneths of October, Nouember,

[4] The examples in this paragraph represent a cross-section of the four accounts; the quotation is from *The Last terrible Tempestious windes*, C2v-C3r.

> and December, the deuouring gulfes of the sea hath swallowed vp aboue two hundred saile of ships, as well of our owne Countrey, as of neighbouring Nations, with great store of passengers, sea-fairing men, and owners of the same.

Winter tempests endangered passage to Cornwall in the West, Newcastle in the North, Marseilles in the South, and Picardy in the East. Joseph Hunt recorded six confirmed shipwrecks in *The last terrible Tempestious windes and weather* (Table 7).

Table 7: Shipwrecks recorded in the *The last terrible Tempestious windes and weather* (1613)

Ship	Cargo	Passage	Wreck Location	Wreck Date
Mary of Albrogh Master Edmunds	Wine, 120 tons	Bordeaux – London	Picardy, France	Dec 1612
Dartmouth	Oils and Cotton	Marseilles – London	Picardy, France	Dec 1612
[Illegible] Master John Love		London – Bordeaux	Shoeburyness, Essex	24 Dec 1612
Hermit Master Goodlad Master Wolfe	140 tons	London – Cornwall		
[Unknown ship]	Salt fish, 60 tons	Out of Looe, Cornwall	Isles of Scilly	26 Dec 1612
[Unknown barque]		Out of Falmouth, Cornwall	Isle of Wight	26 Dec 1612

One particularly devastating accident occurred in October 1612, when fourteen ships sailing from Newcastle to London, “laden with sea-coale and other commodities of those parts,” were “violently cast into the Oceans wombe.” One hundred forty sailors perished, along with an unknown number of passengers. According to Hunt, it was “certified for a truth, to some of the greatest statesmen of the Land,” that more than

7,000 passengers and sailors drowned at sea between Michaelmas (August 29) and Christmas.[5]

Stationer William Barley preserved one particularly vivid account of the winter tempests in *Lamentable Newes, Shewing the wonderfull deliuerance of Maister Edmond Pet*. The brief pamphlet describes the harrowing shipwreck and rescue of Captain Edmund Pet, who faced dangerous weather soon after departing from Newcastle.[6] According to Barley, strong wind caused "the Seas to be outragious and boysterous, and the waues thereof to be so great, and to arise so hie, that many times they were readie to ouerwhelme the ship." Pet safely steered the vessel around Norfolk, but the storm worsened as he neared Yarmouth and Harwich. The ship began to take on water, and its exhausted crewmen resigned themselves to God's mercy. As his ship slipped beneath the waves, Pet lashed himself to the mast, which remained above water. He was the only survivor. Pet remained at sea for two days, until a Dutch man-of-war rescued him and carried him to Harwich. He was "so beaten with wind and weather that his body was swolne as big as two bodies, and every lim and part of him was so disfigured . . . that he was altogether unknowne of any: nay his owne wife knew him not."[7]

Barley did not address the mechanics of the tempests, except to state that they were "for our sinnes."[8] The two pamphlets published by Joseph Hunt in January 1613 offer some insight into this "peccatogenic" interpretation of weather. *The last terrible*

[5] *The Last terrible Tempestious windes*, A4r-Arv, B1v, B3v-C1v.
[6] Pet lived on Seething Lane, near Tower Hill and the ancient church of Barking.
[7] *Lamentable Newes*, A2r, C1v-C2r.
[8] Ibid., A4r.

Tempestious windes and weather attributed the storms to "Atheisme, Epicurisme, and so many sundry sorts of hydra-headed scisme." "[W]ith millions of varieties of transgressions," the author wrote, "we seem to batter the glorious frame of heauen, with thundering shot of our abhominable hell hatchd impieties." These provoked God to "powre forth the consuming vials of his incensed heauie Indignation," including fire, wind, water, earth, plague, and pestilence.[9] According to *The VVonders of this Windie Winter*, foul weather became more frequent as the earth neared redemption. "In this old, and last age of the World," the author wrote, "we yeerly behold the strange alterations of times & seasons, and therein, wee are put in minde of Gods anger purposed against vs, by many variable and vnusiall accidents . . . to mooue sinful mankind to repentance and newnesse of life." The pamphlet suggested that the harsh winter was part of a larger environmental crisis:

> We haue within these few yeers, as well within this our natiue countrey of England as in forraine nations, béene most grieuously stroken with the bitter blasts of powerfull greatnes, one while with the darts of death, as by plagues & pestilence, continuing long amongst vs; another time by drie summers, and parching heates, droughts, & sweating sulphers drying vp the moystures of the earth, to cause barrennesse with scarcety, then fréezing and cold winters in more then vsuall extremity to ano[y] vs; another time by floods and ouerflowings of waters breaking from the boundes of the Seas, in which the mercilesse element many hundreds haue perished and haue lost both life and goods, as the west parts of England, in the yeere of our Lord, 1607. can sufficiently witnesse: Fierie losses, by the lamentable burning of many Townes: strange sicknesses, by corruption of ayre: deare yeers, by scarcety of victuall, and such like; all which be the consuming plagues of heauen, laid vpon the shoulders of the sinfull world.[10]

[9] Ibid., A1v-A2r.
[10] *The VVonders of this windie winter*, A3r-A3v.

The VVonders of this windie winter was the first publication to describe a discrete "climate change" event that united meteorological phenomena across time and space. This was a departure from the interpretations of Justus Lipsius and Thomas Dekker, who found no evidence of progressive environmental change in the historical record.

On January 12, Stationer Arthur Johnson published the final pamphlet about the winter of 1612-13, *The VVindie Yeare*. The anonymous pamphlet summarized several of the accounts Barley and Hunt first published, including that of Edmund Pet's shipwreck. Johnson also included the most extensive explanation of the mechanics and historical context of the winter storms. Like *The VVonders of this windie winter*, the pamphlet suggested that the world was in the midst of intense environmental upheaval—a "circle of misery, which hath for many yeeres been drawne about vs." The circle of misery was elemental:

> The elements of Earth, Water, Ayre, and Fire haue seuerally commenced warre against vs. The Ayre hath breathed forth contagious, and pestiferous fumes to choake vs: She hath burst open the cloudes of infection, and poured plagues and sicknesses vpon our heads. . . . The Water hath (like Egyptian Grashopers) couered our corne-fields, and eaten vp the fruits of the earth: whilest the Earth by that misery hath closed vp the wombe, and promised nothing (that hath alwaies beene so plentifull to her children) but barrennesse, and infertillitie. . . . The Fire hath had his seuerall daies of triumph to increase our sorrow in vs, as it hath had in other countries, as in burning Constantinople by the descending thereof from the Element in the time of Arcadius: and destroying a great part of Rome walls, and many parts of the same City and other places by sodaine fires. So that al that is aboue vs, and all that is vnder our feet haue conspired to work our ouerthrow.[11]

In *The Play of the Wether*, John Heywood imagined a parliament of gods with authority over the elements. The author of the *The VVindie Yeere* used similar language to

[11] *The Windie Yeare*, A4r.

describe the late weather: "Those creatures, which in the first & great parliament of our creation, were appointed to bee our comforters, are now set forth, and armed with weapons from heauen to bee our destroyers."[12]

The VVindie Yeere traced the upheaval in the elements to two causes: sinfulness and planetary decay. "The causes of this celestiall quarrell with vs," he wrote, "are writ vpon euery mans forehead: the defiance is in our lips, the maintenance of it is in our hearts, the end of it will be dangerous wounds in our soules." Like most peccatogenic texts, the pamphlet did not associate foul weather with particular sins; it referenced only the "bad and base company of vgly and detestable sinnes, that hang vpon euerie one of vs." *The Windie Yeere* also delved into Aristotelian notions of planetary age and material decay. Whereas *The VVonders of this windie winter* hinted that the earth had grown old, *The Windie Yeere* described a dying planet: "The world (as a Tree) hath beene manie thousand yeeres in growing, it hath had many summers to flourish in, & many winters to make it wither." The earth had grown "less fruitful," and it was losing "the fresh ayre, and sun-beams of heauen." Though apparently burdened with sin, England was an exception to global decay; the "two imperiall grafts of this our great Iland of Brittaine, doe now grow proper in one Stem, and make one of the fairest and fardest-spreading branches to this tall and stately Cedar (the world)." The world-tree itself, however, shuddered under the assault of storms, "earth-quakes of the deep," and the "axe of [God's] indignation."[13]

[12] Ibid.
[13] Ibid., A4v-B1r.

The author of *The VVindie Yeare* also included a short narrative of the operation of the elements in history. Comparing England's afflictions to those of the past and of foreign lands, he concluded that "we haue iust cause to account them but as fauorable and fatherly corrections." Evidence of "earthly" justice could be found in reports of ancient earthquakes, including the one that swallowed the Achaean city of Boura in 373 B.C. Storms, tempests, thunder, lightning, and disease represented justice by air, while the floods of Noah, Ogyges, and Deucalion exemplified punishment by water. For the wrath of fire, the pamphlet pointed to the burning of Ager Galenus in Campania and the eruptions of Mount Etna in Sicily. Uniquely, *The VVindie Yeare* included incidents of frost among its discussion of the elements:

> And to passe from heat to colde (besides the extreamity of great frosts, wherewith these parts haue beene lately pinched) wee read that fowre thousand souldiers, who at the siege of Asculum fled from *Pompeius*, were vpon the top of a Mountaine frozen so stiffe that standing there in the Sunne, with their eyes open and their teeth bare, no man could otherwise perceiue they were dead, but only by want of motion.[14]

According to *The Windie Yeare*, England's freedom from such "prodigious and fearefull" phenomena was a testament to "Gods singular mercy towards vs."[15]

The four meteorological pamphlets published in January 1613 share a broadly theological interpretation of weather. *The VVonders of this windie winter*, however, suggests that some Londoners—perhaps those who suffered losses—rejected the peccatogenic explanation of the late storms. The pamphlet bitterly chastised such "temporizing naturallists":

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[14] Ibid., C4r, D2r.
[15] Ibid.

> Looke vpon the dwellings of many worthy Cittizens of this City, & we shal see that God is angry, by the vnloosing of these powerfull windes, and by suffering them terribly, to vncouer their stately Archytectures, vntopping their peiring pinickles, blowing down whole sides of houses, yet for all this many of them are merciles, regarding nothing at all the strangeness of these accidents, nor the fearefulnesse of these times and seasons, but accounts them natural, common, and vsuall, more like vnto Atheists, then Christians, but, oh you temporizing naturallists except you repent, full vials of Gods wrath wil be powred downe vpon your heads, and all your temporal purposes brought to nothing.[16]

The storms of 1607-1613 piqued English writers' and stationers' interests in meteorological phenomena, including those occurring on the Continent. In August 1613, stationer Thomas Archer published a chronicle of German storms and floods from May and June, as well as a letter describing a major fire in Constantinople. According to the author, these events were evidence that "the great and fearefull day of the Lords terrible and last Iudgement to be giuen vpon this wicked world" was "at hand."[17] Later that fall, stationer John Trundle registered a book concerning the November flooding of Lincolnshire. The pamphlet, which Trundle published in early 1614, compared the late inundations to those of 1607: "Let vs call to minde the like mishap some sixe yeares since in the West parts of England, where the waters of the Sea were violently driuen

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[16] *The VVonders of this windie winter*, B2r-B2v.

[17] *A Wonderfull and most Lamentable Declaration of the great hurt done, and mighty losse sustained by Fire that hapned; and mighty stormes of Winde, Thunder, Lightning, Haile, and Raine, with Inundations of Water, that fell in the Towne of Erfford and Weinmar; and in the Country of Wurtenburgh, as namely in the Townes of Nagolt, Hernburg, Rotenburch, Tubingen, Issingen, Elwang, and Duncken-spiel, as also in many other places of Germany, to the great destruction of thousands of Men, Women, and Children; Houses, Cattle, Corne, Money, Houshold-stuffe, and many other things: In the Month of May, but much more in the Month of Iune last past, Anno, 1613. With a briefe Relation of a great fire, which vpon the fourteenth of Iune hapned in the Citty of Constantinople, and burnt fiue thousand houses. Written to moue all good Christians to pitty and compassion, and to stirre vp their hearts to pray vnto God to convert his Ire from vs* (London: Printed for Thomas Archer, 1613), A3r.

ouer their Bankes by a South west wind, as these were opposite to them with a Northeast, where likewise many a wealthy village sustained much hurt, hardly recouered at this day."[18]

Memorably cold weather returned to England in late 1614. The winter of 1614-15 was not quite as extreme as that of 1607-08; the Thames, for example, did not freeze in London. Nevertheless, the season's snow and cold encouraged new meteorological publications. In 1615, stationer Thomas Langley published *The Cold Yeare. 1614. A deepe Snow: In which Men and Cattell haue perished*. The twenty-four page pamphlet borrowed liberally from *The Great Frost* (1608); Thomas Dekker, in fact, may have written both pamphlets.[19] Like its predecessor, *The Cold Yeare* uses a dialogue between

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[18] Trundle published the Lincolnshire pamphlet as an addendum to an account of miraculous possessions and prophesies, though it retained a separate title page. See *Lamentable Newes out of* Lincoln-shire *of the ouerflowing of waters, breaking from the Seas, which drowned 5. Villages with all their goods and cattell, with other places of the Land, this present month of Nouember: 1613. to the great hurt of many people there dwelling* (London: Printed for John Trundle, 1614), in *A Miracle, of Miracles. As fearefull as euer was seene or heard of in the memorie of MAN. Which Lately happened at* Dichet *in Sommersetshire, and sent by diuers credible witnesses to be published in* LONDON. *Also a Prophesie reuealed by a poore Countrey Maide, who being dead the first of October last, 1613. 24. houres, reuiued againe, and lay fiue dayes weeping, and continued prophesying of strange euents to come, and so died the 5. day following. Witnessed by M.* Nicholas Faber, *Parson of the Towne, and diuers worthy Gentlemen of the same countrey. 1613, Withall, Lincolnshire Teares. For a great deluge, in which fiue Villages were lamentably drowned this present month* (London: Printed for John Trundle, 1614), D3r-D3v.

[19] Langley did not register any meteorological pamphlets in the Stationers' Register in 1615, and there is no entry for *The cold year*. On March 12, 1615, John Trundle registered a book entitled *the cold winter* "to be printed at his owne perrill without further authoritie." This may correspond to Langley's pamphlet, or it may be an entirely different publication. See Arber, *Register*, 259v. *The Cold Yeare. 1614. A deepe Snow: In which Men and Cattell haue perished, To the generall losse of Farmers, Grasiers, Husbandmen, and all sorts of people in the Countries; and no lesse hurtfull to Citizens. Written Dialogue-wise, in a plaine familiar talke betweene a London Shop-*

a London shopkeeper and a traveler from the country to explore the consequences of extreme snow and cold. It does not, however, include any reference to historical frosts, frost fairs, or the 1607 lottery.

Langley's countryman relished the wintry weather, which he associated with transformation and birth:

> I haue been an old Brier, and stood many a Northerly Storme: the Windes haue often blowne bitterly in my Face, Frostes haue nipped my Blood, Ysicles (you see) hang at my Beard, and a hill of Snow couers my head. I am the Sonne of Winter, and so like the Father, that as hee does, I loue to be seene in all places. I had as lesse walke vp to the knees in Snow, as to tread vpon Turkie Carpets: And therefore my Jorney to see London once more ere I die, is as merry to mee, as if I were a Woman and went a Gossipping; For the Earth shewes now, as if shee lay inne, (All in White).[20]

As in 1607, rumors exaggerated the season's characteristics. One country rumor held that "all the Youth of the Cittie" had mustered upon the frozen Thames for battle. "I would haue ambled on my bare ten-Toes a brace of hundred Miles," the countryman admitted, "to haue seene such a triumph." Unfortunately for him, the report was false. The shopkeeper described London's experience of winter:

> But neither hath the Riuer been this yeare (for all the vehement cold) so hard-hearted, as to haue such a glassy crusted floare; neither haue our Youth been vp in Armes in so dangerous a Fielde: Yet true it is, that the Thames began to play a few cold Christmas Gambols; and that very Children (in good Array) great numbers, and with War-like furniture of Drummes, Cullours, Pikes, and Gunnes, (fit to their handling) haue sundry times mette Armie against Armie, in most of the Fieldes about the Cittie; to the great reioycing of their Parents, and numbers of beholders.

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keeper, and a North-Country-man. In which, the Reader shall finde many thinges for his profit (London: Printed by W.W. for Thomas Langley, 1615).

[20] *The Cold Yeare*, A3r.

One rumor in the country reported snow of "such abundance" in London that no one could enter or leave the city. Another held that arctic beasts, like those of Russia, terrorized the city. "I remember when I traueld into Russia," the countryman explained, "I haue there seene white Beares, and white Foxes: But some credulous fooles would needes sweare vs downe, that your Cittie was full of such Monsters; and that they ran aliue in the Strees, and deuowred people."[21]

Like the pamphlets of 1613, *The Cold Yeare* suggested that England was in the grip of a lengthy and complex meteorological event. In one passage, the shopkeeper explains that "an Arme from Heauen hath for seuerall yeares one after another, shaken Whips ouer our Land," scourging it with "strange Inundations of Flouds," "mercilesse Fires, destroying whole townes," "intolerable and killing Frostes, nipping the Fruites of the earth," the "scarcitie of Victuals," and, "last of all, with deepe and most dangerous Snowes."[22]

According to Langley's countryman, harsh winters had become the norm in northern England: "the Countries of *Cumberland*, *Northumberland*, *Yorkshire, Lancashire*, and all those adioyning, haue been so hid in Snow, that a man would haue thought, there was no more possibly to be found in the world." Their conversation suggests that the winter of 1613-14 was particularly disruptive:

> *Citt*. So then you must conclude, that the heapes of Snow in those former times, being this yeare doubled and trebled, the miserie that falles with it, must by consequence, be multiplyed.
>
> *Nor*. Multiplyed! I haue met with some that haue come from the *Peake* in *Darbyshire*, others (since my comming to Towne) that haue been in *Nottingham*,

[21] Ibid., A4v-B1r.

[22] *The Cold Yeare*, B1r.

> *Cambridge-shire*, and the *Ile of Ely*; who verily beleeue (vpon the daily cryes of poore people, not onely there, but in many other Countries besides) that neuer any Calamitie did happen to them so full of terrour, and so sodainely to vndoe them, their Wiues and Children, as this Snow.
>
> *Citt*. It is lamentable.
>
> *Nor*. Mine Eyes are witnesses (bad though they be) that some Countries which stand high, shew for all the world, like the *Alpyne* Hilles parting *France* and *Italie*: (I thanke God, in younger dayes I haue trauelled that way, and therefore know what I speake) for the heads of those Hilles are couered with these white Winter-lockes in the hottest dayes of Sommer. And it is to be feared, that in some of our farre Countries, Sommer will haue made his progresse a good way into our Land, before the Earth will disgest these cold Pellets off from her stomacke.[23]

The transformation was so dramatic that some in the countryside wondered if the planet's geography or orientation to the sun had changed:

> *Nor*. Why I will tell you Sir, if you saw some places by which I haue passed but within these three weeks, you would verily thinke, that *Freezland* were come ouer Sea, swimming on a cake of Ice, and that it was lodged in *England*. Nay you would, if you dwelt as coldly and miserably, as some poore people of our owne Nation doe, you would almost sweare, that those partes of *England* lay under the *Frozen Zone*, and scarce remember there were a Sunne in Heaven, so seldome doe his fyres cast any heate vpon them.[24]

Several religious scholars were inclined to agree that major geological changes were afoot. Godfrey Goodman (1583-1656), the vicar of Stapleford Abbots in Essex, attributed the inclement conditions of the early seventeenth century to the corruption of nature. In a sermon published as *The Fall of Man, or the Corrvption of Natvre, proved by the light of our naturall Reason* (1616), Goodman asserted that nature was irreparably corrupt and, without God's intervention, would decay until it ceased to exist. "[A]s nature was made of nothing," he wrote, "so it should haue a power to returne againe to

[23] *The Cold Yeare*, A4v-B2r.
[24] Ibid.

the same nothing." According to Goodman, decay was universal and progressive. The heavens conspired against the elements. The elements conspired against themselves and the mixed bodies. Creature conspired against creature. Antipathy was the law of nature.[25]

Theories of universal decay date to the scholars of the ancient world who wondered at the ruins of lost cities and the aquatic fossils of contemporary deserts. French philosopher Jean Bodin introduced the theory to a new generation of scholars in the late sixteenth century before later abandoning it. Bodin discussed the frame of the theory in *Method for the East Comprehension of History* (1583):

> Pliny, Book VII, reported that all writers complained that the race of men cannot be compared with the ancients in number, size, or strength. Wherefore it happens that it seems fabulous to our generals when they hear of the countless armies of Xerxes or that Alexander or Caesar defeated sometimes three hundred or even four hundred thousand men in one battle; yet this is in keeping with the Holy Scriptures. Crete, indeed, which was called by Homer "hundred-citied" . . . in this age can hardly boast of three. Moreover, Diodorus wrote in Egypt eighteen thousand famous cities were once mentioned in their sacred books. Later, at the time of Ptolemy Lagi, three thousand existed. Indeed, in this age in Egypt and Asia together hardly that number are said to be standing.[26]

For Bodin the most striking change involved the orientation of the sun and earth:

> But of all things nothing is more wonderful than that, for the recollection of posterity forever, Copernicus in the books *About the Motion of the Heavenly Bodies*, then [Erasmus] Reinhold, and afterwards [Johannes] Stadius, well-known

[25] Godfrey Goodman, *The Fall of Man, or the Corrvption of Natvre, Proved by the light of our naturall Reason. Which being the first grovnd and occasion of our Christian Faith and Religion, may likewise serue for the first step and degree of the naturall mans conuersion. First preached in a sermon, since enlarged, reduced to the forme of a treatise, and dedicated to the Queenes most excellent Maiestie* (London: Printed by Felix Kyngston, 1616), 14-20, 271.

[26] Jean Bodin, *Method for the Easy Comprehension of History*, trans. Beatrice Reynolds (New York: Columbia University Press, 1945; New York: W. W. Norton, 1969), 317-19.

> mathematicians, showed with clear demonstrations that the apsis of the sun was nearer to the earth than it was in the age of Ptolemy (for he lived when Hadrian was emperor) by twelve degrees, that is, thirty-one semi-diameters of the earth, or as the Germans measure, 26,660 miles German, which is said to be twice as much in French miles. When Philip Melancthon verified their theory by frequent experiments and tried demonstration, he thought it ought to be attributed to the wasting nature of celestial and terrestrial bodies, so that these elements may be warmed more comfortably by the heat of the sun.[27]

Significantly, Melancthon's interpretation of decay suggests that no change in temperature or habitability would be sensible on Earth. The nearer sun warmed a weaker earth, preventing it from cooling. Bodin initially found some merit in the theory of universal decay, and he chided scholars like Joseph Scaliger of France, who were ignorant of its implications. Scaliger "thought people who wrote such things were worthy of the lash," Bodin wrote, but "[h]e himself was not worthy of the lash, because from ignorance of these matters he erred often and indeed childishly."[28]

Godfrey Goodman measured the influence of universal decay by comparing the present fruitfulness of the earth and sea to that of the past. He was a creative scholar, and he attempted to make use of limited economic data while adjusting for technological changes and the devaluation of currency. Goodman concluded that the elements were "much decaied in their wonted perfection." He wrote of the seas:

> [O]ur seas are growne fruitlesse and barraine, as it appeares vpon records in our Hauen townes, that a farre greater quantitie of fish hath formerly been taken and brought into this land, then there is in these daies. If you answer me, that it proceeds from the loosenes of these times, as neglecting all fasts, I doe easily confesse our abuse; yet I think it not sufficient to cause this scarcitie; for our sailes at this time are more in number then euer they were, our skill is much better, our wants and necessities are farre greater, and so our labour and industrie

[27] Ibid.
[28] Ibid.

> should bee proportioned accordingly. I rather thinke it proceeds from the decay of the elements; or indeed doe esteeme it as a punishment of God vpon vs.[29]

The soil presented similar challenges. Focusing on England, Goodman wrote that "it is not only the complaint of all old men, and our own experiēce, but likewise many reasons drawne from husbandrie . . . doe vndoubtedly perswade me, that our land is growne barraine, and yeelds not that profit, which formerly it did, in the daies of our forefathers."[30]

Goodman compared historical descriptions of wine and honey to the modern distribution of apiculture and viticulture—the former arguing "the sweetnesse of the grasse or the pasture," the latter, "the goodnesse and depth of the mould." References to beekeeping, honeyed drinks, and beeswax (for lighting) seemed more common in the past, which suggested decline in the fertility of the pasture. "[A]ssuredly," Goodman wrote, "our countrey at this day cannot affoord the one halfe of that which formerly it did, it is apparent." The absence of English wine provided a much more compelling argument:

> Secondly, it is very credibly reported, that in this our Northerne climate we haue had heretofore a vintage in Wostershire; and it appeares vpon record, that tith hath bin paid for wine pressed out of grapes, growing in the little Parke at Winsor, in the time & being then in the possessiō of King *Edw*. I [r. 1272-1307]. But at this time, whether thorough the cold mould of the earth, or thorough the weaknesse and swift declining of the sun, as being not able to bring our grapes to ripenesse and perfection (the grapes being a very lateward fruit, containing a great naturall heate, which appeares by the strength of our wines, and their long continuance, and therfore require a hot soyle); yet at this time it is thought to be a work impossible: the like may bee said for Wales, and the North parts of this kingdome in many places, where fruits and saffron did anciently growe, (the places still carrying the names of those fruits), within these late yeeres, triall

[29] Godfrey Goodman, *The Fall of Man*, 365-67.
[30] Ibid.

> being made, and all possible diligence and good husbandry obserued, yet they faild in their purposes.[31]

Goodman described the early seventeenth century as a time of "continuall famine." He acknowledged that scarcity had a long history, but he believed modern famines were defined by a uniquely natural origin. Ancient societies "haue had as great famins as we haue," he confessed, "but I suppose not so vsually; and commonly these famins did not arise from any vnseasonable weather, or barrennesse of the earth, but rather from ciuill warres within themselues, making hauocke and waste of natures blessings, and of poore mens labours."[32] Although Goodman addressed the influence of population growth, inflation, eating habits, and new economic practices, he attributed modern scarcity to unseasonable weather and barren soil.

Goodman believed that "fruitfulnesse" and "barrennesse" proceeded "from the influence and disposition of the heauens," which were "guiltie, conspiring, and together ioyntly tending to corruption." He pointed to Psalm 102 for scriptural support, noting that "the heauens shall waxe old as doth a garment." The supernova of 1572, recorded in Tycho Brahe's *De Stella Nova* (1573), demonstrated the variability of the heavens. "[W]ithin our memorie," Goodman recalled, "in the yeere 1572. a true Comet did appeare in the eighth Heauen, which as it had a time of beginning, so had it a period, and time of dissoluing." Careful observation of the moon revealed "spots and shadowes" on its surface, suggesting that it was an imperfect body, as well. Even the sun appeared subject to corruption. As Melancthon discovered, the comparison of ancient and modern

[31] Ibid., 368-69.
[32] Ibid.

measurements suggested that its inclination was variable or declining. "[C]ertaine it is," Goodman asserted, "that the Sunne hath descended much lower by many degrees, then he was in the time of King *Ptolemis*; the same Mathematicall instruments, which agree together in all other dimensions, doe vndoubtedly proue the diuersities."[33]

Goodman concluded, somewhat circuitously, that natural corruption tempered the extremes of temperature, weakened the sun, and generally cooled the earth. The disappearance of the torrid, uninhabitable zones of ancient literature were evidence of such alteration. "[L]et vs compare times with times," Goodman wrote, "and so it shall better appeare":

> [T]he hot Zones heretofore adiudged by all the Ancients to be vnhabitable, we know that now they are habitable, and furnisht with people; let vs thinke reuerently of the Ancients, they were very wise, and as I suppose far exceeding vs. Can we conceiue them to be such simple men, so fondly mistaken at their owne homes, being neighbours, and bordering vpon these hot climates, where a few daies sayling, would discouer the truth? a truth so manifest and palpable, as that they could not pretend any grosse ignorance; let vs doe them no wrong, but so esteeme of them, as we desire our posteritie may regarde vs.[34]

Goodman pointed to the "great burning" recorded in the "fabulous historie" of Phaeton as evidence of nature's former warmth. At present, however, the sun and the constellations were "defective" in their power:

> [I]n these daies we neuer found the heate of the sunne to be such . . . nay rather we haue iust cause to complaine of the sunnes weakenesse, and that he is defectiue in heate: notwithstanding that in this time of his olde age, God hath appoynted that the sunne should enter into the hot signes, yet both sunne and signes are defective in their power, and cannot ripen our fruites in that manner, which formerly the sunne alone did in the waterie constellations.[35]

[33] Ibid., 378-79.
[34] Ibid., 379.
[35] Ibid., 381.

"What a strange difference appeares in our season," Goodman concluded, "more then in ancient times; we can not promise vnto our selues the like certaintie, neither in our feede time, nor in our haruest, nor in the whole course of the yeere, which they did."[36]

Goodman attributed these changes to natural corruption and the progressive decay of nature. He considered himself to be an Aristotelian, but his notion of universal decay described a fundamental transformation of nature at odds with traditional science. In Aristotelian thought, corruption and generation were parallel processes. The growth of one part of nature complemented the decay of another. The flowing water of a flood carries away forests, towns, soil, and rock, but its sediment forms new land in the delta. There is no progressive decay, only a cyclical process of dissolution and composition. The theory of universal decay posited that nature was irreparably corrupt and would decay until it ceased to exist—unless God determined to renew it, likely through fire.

Goodman believed that corruption began reshaping the earth after the Genesis Flood. The world seemed to "goe backward," he wrote, "and to returne to the first nothing." Goodman offered a creative exegesis of Genesis to explain his point of view:

> Hence began a great alteration in nature, and all things were changed to the worst; the earth did decay in plenty and goodnes of fruits, for immediatly after the deluge, God did enlarge *Noahs* commission, and gaue him free power to feed on the flesh of the creatures; the water likewise lost her naturall propertie of goodnesse, and therefore *Noah* immediately began to plant a vine-yard; the ayre was more subiect to vapours, foggy mists, and darke clouds; the fire with hot fumes and exhalations ascending and turning to meteors, was made more imperfect and impure; the heauens themselues haue not freely escaped, though these sublunary contagions could not infect the stars, yet were they able much to hinder the goodnes of their actions and operations, as likewise to eclipse and obscure their beauty.[37]

[36] Ibid., 379-81.
[37] Ibid., 281.

The “generall deluge,” Goodman asserted, was “the death of nature”:

> [T]his generall deluge was indeed the generall confusion of nature; and as it was the death of nature, so nature herself could neither hinder nor hasten her owne death; and being once fallen, she could not raise herself by her own naturall power, for howsoeuer the God of nature might well vse naturall meanes (the watery constellations) for the effecting of his good will and purpose; yet surely these in themselves were no[t] sufficient . . . for certaine it is, that there was the like coniunction of stars, within our memory, in the yeeres 1524. and 1588.[38]

Goodman was uncertain of the flood’s mechanics. Perhaps, he suggested, the earth’s surface had been more level. Perhaps the water flowed from some transmutation of the earth, or from the rarefaction of the watery sphere. He even outlined a rudimentary, if Aristotelian, greenhouse theory: “[T]he bordering region of the ayre, might be condensed and thickned, that it might serue instead of choking waters, and these might be raised and puft vp with hot fumes, proceeding from the bowels of the earth, which might make the boyling or scalding seas to swell aboue measure.”[39]

Bolstered by foul weather, the Thirty Years’ War, and peccatogenic sermons like those of Goodman, the notion of decay and decline took root in seventeenth-century England. According to George Hakewill (1578-1649), Archdeacon of Surrey, the theory of universal decay was a “common error”: “The opinion of the Worlds decay is so generally receiued, not onely among the Vulgar, but of the Learned both Diuines and others, that the very commonnes of it, makes it currant with many, without any further examination.”[40] Hakewill published the most complete examination of the “Controversy

[38] Ibid., 281-82.

[39] Ibid., 282-83.

[40] George Hakewill, *An Apologie of the Power and Providence of God in the Government of the World* (Oxford: John Lichfield and William Turner, 1627), 1.

touching the worlds decay" in *An Apologie of the Power and Providence of God in the Government of the World* (1627).[41] Some theories of decay emphasized deterioration in the substance, motion, light, warmth, or influence of the heavenly bodies. Others identified decay in the temperature, constitution, and fruitfulness of the elements. Still others described decay in the strength, stature, wits, and manners of humans and other living creatures. Hakewill assessed each of these theories, but he found them incapable of explaining the evident mutability of the earth's surface and atmosphere.

Hakewill's philosophy exemplified the humanist optimism of the Renaissance and the coming Enlightenment. "I doe not beleeue that all Regions of the World, or all ages in the same Region afford wits alwayes alike," he wrote in the introductory remarks of *Apologie*, "but this I think . . . that the witts of these latter ages being manured by industry, directed by precepts, regulated by methode, tempered by dyet, refreshed by excercise, and incouraged by rewardes, may bee as capable of deepe speculations . . . as any of the ancienter times haue done." Hakewill wholly rejected the principles of universal decay and decline:

> If then we come short of our *Auncestors* in *knowledge*, let vs not cast it vpon the deficiencie of our wits in regard of the *Worlds decay*, but vpon our own *sloth*; if we come short of them in *vertue*, let us not impute it to the *declination of the World*, but to the malice and faintnese of our *owne wills;* if we feele the scourges of God vpon our Land by mortality, famine, vnseasonable weather, or the like, let vs not teach the people that they are occasioned by the *Worlds old age*, and

[41] Hakewill served as Archdeacon of Surrey from 1617 to 1649 and as Rector of Exeter College, Oxford, from 1642 to 1649. He briefly served as a spiritual advisor to the future king of England, Charles I, but he ran afoul of the crown when he secretly advised against marriage to the Infanta Maria Anna of Spain. P. E. McCullough, "Hakewill, George (*bap*. 1578, *d.* 1645)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004–), accessed March 13, 2015, http://www. oxforddnb.com.

> thereby call into question the *prouidence*, or *power,* or *wisedome*, or *iustice*, or *goodnes* of the Maker thereof; but by their and our *sins*, which is doubtles both the truer & more profitable doctrine, & withall more consonant to the Sermons of *Christ* & his *Apostles,* & the *Prophets of God* in the like cases.[42]

Hakewill acknowledged that the "present face of things both at home and abroad" challenged his optimism, and he questioned whether "those faire hopes I sometime had" were little more than "false perspective glasses." Nevertheless, he refused to accept that the challenges of seventeenth-century Europe were typical of the world or representative of decay. In a bracingly "modern" statement, Hakewill challenged his readers to take a "larger view" and examine local crises within a global and historical context:

> [W]hen againe I abstracted and raised my thoughts to an higher pitch, and as from a vantage ground tooke a larger view, comparing time with time, and thing with thing, and place with place, and considered my selfe as a member of the *Vniverse*, and a *Citizen of the World*, I found that what was lost to one part, was gained to another; and what was lost in one time, was to the same part recouered in another; and so the ballance by the divine providence over-ruling all, kept vpright.

To discern the works of God, Hakewill wrote, one must "study the great Volume of the *Creature*, and the *Histories* not onely of our owne, but of forraigne Countreyes, and those not onely of the present, but more auncient times."[43]

Hakewill held philosophical, practical, and factual objections to the theory of universal decay. He wrote the *Apologie* to "redee[m] . . . a captivated truth" and vindicate the Creator's honor, wisdom, justice, goodness, and power—all "impeached and blemished" by the theory. Resignation to universal decay encouraged a fatalist

[42] Ibid., B2v-B4r.
[43] Ibid., C1v- C2r.

perspective of the world and the intervention of God therein; it seemed "not a little to rebate and blunt the edge of mens vertuous endeavours." It further blunted the "exhortations and threatnings" of religious leaders, Hakewill wrote, "when men are perswaded that famines and pestilences, and vnseasonalbe weather, and the like, are not the scourges of God for sinne, but rather the diseases of wasted & decrepit Nature, not procured so much by the vices of men, as by the old age and weakenesse of the world." Civil society could only suffer:

> For when they consider how many thousand yeares *nature* hath now beene as it were in a fever *Hectique*, daily consuming and wasting away by degrees; they inferre that in reason shee cannot hold out long, and therefore it were to as little purpose to plant trees, or to erect lasting buildings, either for *Civill*, *Charitable*, or *Pious* vses, as to provide new apparell for a sicke man, that lies at deaths dore, and hath already one foote in the graue.[44]

Hakewill's final reason for penning the treatise was the "weake grounds which the contrary opinion of the Worlds decay is founded vpon." He traced the theory to "the *fictions* of *Poets*"—Homer, Virgil, Juvenal, and Horace and to "that *pretty invention* of the *foure Ages* of the World" which reduced historical eras to gold, silver, brass, and iron. The comparison "hath wrought such an impression in mens mindes," Hakewill lamented, "that it can hardly bee rooted out." He attributed the theory's longevity to "the *morosity* and crooked disposition of old men, alwayes complaining of the hardnesse of the present times, together with an excessiue admiration of *Antiquity*." Hakewill explained that such admiration was

> in a manner naturall and inbred in vs, *vetera extollimus*, *recentium incuriosi*, The ancient we extoll being carelles of our owne times. For the former of these, old men for the most part being much changed from that they were in their youth in

[44] Ibid., 14-16, 19.

> complexion and temperature, they are fill'd with sad melancholy thoughts, which makes them thinke the World is changed, whereas in truth the change is in themselues.

"Themselues being launched into the deepe, the trees and houses seeme to go backward," Hakewill wrote, "whereas in truth the motion is in themselues, the houses and the trees still standing where they were.[45]

Hakewill acknowledged that alteration was a characteristic of creation. "It is then agreed on all hands," he wrote, "that all subcoelestiall bodies, *indiuiduals*, I meane, vnder the circle of the moone, are subiect not onely to *alteration*, but to *diminution* and decay." Metals, oaks, and the pyramids of Egypt had long apparent lifespans, but all nevertheless had "a time of *groweth* and increase, of *ripenesse* and perfection, and then of *declination* and decrease, which brings them at last to a finall and totall *dissolution*." He rejected the "poeticall fiction" that time was responsible for such alteration, since time was passive, a "branch of *Quantity*" and a "measure of motion." "It is then either some *inward* conflict, or *outward* assault which is wrought *in time* that eates them out," Hakewill explained, "*Time* it selfe without these is toothlesse, and can neuer doe it."[46]

The four elements of which the "mixed bodies" of nature were composed also experienced such alteration. "Of these," Hakewill wrote of the elements, "it is certaine that they decay in their *parts*, but so as by a *reciprocall compensation* they both loose and gaine, sometime loosing what they had gotten, and then again getting what they had formerly lost." The discovery of sea fossils in dry regions demonstrated that sea and

[45] Ibid., 22-23.
[46] Ibid., 27-28.

land were not fixed categories, historically speaking, as did the pairing of mountains and valleys, peninsulas and bays, and islands and lakes:

> The ordinary depth of the sea is cōmonly answerable to the ordinary hight of the main land aboue the water: and the whirlepooles & extraordinary depths answerable to the hight of mountains aboue the ordinary hight of the Earth. The *Promontories* and necklands which butt into the Sea, what are they but *solide creekes*, and the *creekes* which thrust forth their arms into the Land, but *fleeting promontories*. The *Ilands* what are they but *solide lakes*, and the *lakes* againe but *fleeting Ilands*.

According to Hakewill, the heart of the controversy about elemental decay concerned quality rather than quantity or dimension—"whether the *aire* and *water* be so *pure* and *wholsome*, and the *earth* so *fertile* and *fruitfull* as it was some hundreths or thousands of yeares since." [47]

Hakewill did not believe that universal decay was responsible for such changes. He acknowledged that all living creatures were subject to "*declination* and *dissolution*," but he suspected that, in general, plant and animal life remained as vigorous as it had ever been. Weather responded to similar patterns. [T]he *ayre* and *earth* and *water* and diverse seasons," Hakewill explained, are "diversely affected sometime for the better, sometime for the worse, and that either by some speciall *favour* or *judgement* of *God*, or by some *cause in nature, secret or apparent*." He quoted Justus Lipsius, "The circle and ring of things returning alwayes to their principles will neuer cease as long as the world lasts."[48]

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[47] Ibid., 28-29, 31.
[48] Ibid., 37.

The habitability of the Torrid Zone raised pointed questions about the relative strength of the sun in present and former ages. "[S]ome haue not doubted to attribute the present habitablenesse of the *Torride Zone*," Hakewill wrote, "to the weaknesse and old age of the *Heauens*." He suggested that proponents of the theory should remember "that the *Cold Zones* should thereby haue become more inhabitable by cold." Hakewill brilliantly turned the theory upon itself by explaining that universal decay in *all* creation would leave humans "as ill able to indure the present heate, as the men of former ages were, to indure that of the same times wherein they liued, the proportion being alike betweene the *weaknes*, as between the *strength* of the one and the other."[49]

Hakewill was a careful reader of Jean Bodin, and he was well-aware of contemporary theories about the orientation of the sun and earth. "That which touches neerer to the quick, & strikes indeed at the very throat of the cause," he wrote "is an opinion of very *many*, and those very *learned* men, that the *Body* of the *Sunne* is drawne nearer the Earth by many degrees then it was in former ages . . . which some ascribe to a deficiencie of strength in the *Earth*, others in the *Sun*, most in *both*." Hakewill saw little reason to fear such hypothetical alteration. "[I]f the *terrestrial* depend vpon the *coelestiall*," he wrote, "then what is wanting in the wonted *vigour* of the *coelestiall*, being supplied by the *appraoch* thereof, the *terrestrial* should still without any decay remain vnimpaired in their condition." In other words, a cooler but proportionally closer sun would impart equal warmth.[50]

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[49] Ibid., 92-93.
[50] Ibid., 93.

Hakewill remained suspicious of such a dramatic realignment of the heavens, however, and he turned to “both the learned *Professours* in the *Mathematicks* at *Oxford*” for guidance. The two professors—probably John Bainbridge and Henry Briggs, Savilian Professors of Astronomy and Geometry—found little merit in Bodin’s and Melancthon’s theories. Hakewill wrote that the professors “jointly agree, that this assertion of the *Sunnes continuall declination*; or neerer approach to the Earth, is rather an *idle dreame*, then a *sound position*, grounded rather vpon the difference among *Astronomers*, arising from the difficulty of their *observations*, then vpon any certain & infallible *conclusions*.”[51]

Another solar theory suggested that the apparent “diminution in the Heauenly warmth” could be ascribed to the “removall” of the Sun “more Southerly then in former ages.” Hakewill again turned to his “worthy friend” Doctor Bainbridge for guidance, and he published the professor’s response in the *Apologie*. “It is the generall opinion of *Moderne Astronomers*,” Bainbridge wrote, “that the *Sun* in our time goeth not so far *Southernly* from vs in Winter, as it did in the time of *Ptolomy* and *Hipparchus*, neither in Summer commeth so much Northernly towards vs, as then.” Bainbridge compared several historical measurements for the inclination of the sun, but he doubted that universal decay was responsible for any apparent differences.[52] He explained:

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[51] Ibid., 93-94.

[52] Hipparchus and Ptolemy found the greatest declination to be 23° 51′ 20″. The Syrian Albategnius and several Arabian scholars measured 23° 35′ but found nothing remarkable about the difference. The Spanish Moor Arzachel observed a maximum declination of 23° 33′ 30″ and hypothesized “that the Sunnes greatest declination was mutable.” Copernicus, building on the observations of German astronomer Regiomontanus and Austrian astronomer Georg von Peuerbach, determined that the

> But to speake freely, I cannot so easily bee drawn into this opinion, but rather thinke the greatest declination of the Sunne, to be . . . immutable, and for ever the same; For the little difference of a few minutes betwixt vs, and *Ptolomy* may very well arise (as I formerly said) from the errour of observations by the Ancients.[53]

Hakewill found Bainbridge's argument compelling and concluded that changes in the sun's inclination were highly unlikely.

Hakewill applied similar reasoning to the controversy over the diminished temper of the air. "That the *ayre* is not distempered, more then in former ages," he explained, "will as I conceiue appeare by this":

> that vnseasonable weather, for excessiue *heate* and *cold*, or immoderate *drought* and *raine*, *thunder* and *lightning*, *frost* and *snow*, *haile* & *windes*, yea & *contagious sicknesses*, *pestilentiall*, *Epidemicall diseases*, arising from the *infection* of the *ayre*, by noysome mistes and vapoures, to which we may adde, *earthquakes*, *burning* in the *bowels* of the *earth*, *blazing Comets*, & the like, were as frequent, if not more, in former ages, then in latter times, as will easily appeare to such who please to looke either into the *Generall history* of the world at large, or the severall *Cronicles* of particular nations.

Hakewill identified Justus Lipsius as an unlikely authority on the subject. "To like purpose," he wrote, "I remember *Iustus Lypsius* a man rather partiall for *Antiquity* then for the present age, hath written an *Epistle* vpon occasion of a great *drought* which happened in the yeare one thousand six hundred and one, and lasted by the space of aboue foure months." "It is no new or vnusall thing," he quoted Lipsius, "though to vs so it seeme." Hakewill described the historical incidents of heat, drought, and

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maximum inclination of the sun was 23° 28′ 30″. He also "renewed the *Hypothesis* of *Arzachel*," suggesting that the sun's greatest declination varied between 23° 28′ and 23° 52′. John Bainbridge to George Hakewill, undated, in Hakewill, *Apologie*, 94-96.

[53] Ibid.

"immoderate cold" listed in Epistle XCI and included a translation of Lipsius' concluding remarks.[54]

To extend Lipsius' conclusions to England, Hakewill turned to John Stow. "[F]or excessiue and vnseasonable *frosts*, *raine, snow, haile, windes* & the like," Hakewill wrote, "our stories are full, specially *Stowes Chronicles:* & many of them were so immoderate, as wee haue had none of latter times comparable therevnto." Islands like Britain, he argued, were already "subject to such vncertainety of weather" that "many times wee can hardly distinguish *Christmas* from *Mid-summer*, but onely by the length of daies." England also received more precipitation than the Continent, a characteristic for which Hakewill suggested the title, "*Matulam Planetarum*"—the "Vrinall of the Planets." He correctly attributed Britain's weather to its geographic situation; it was "environed by the *Sea*" and "farre to the *Northwest*." England's location, of course, remained the same. "Since it is still situate where it was," Hakewill wrote, "it is likely that the *aire* was heere for the most part, tempered or distempered in *former ages*, as now it is."[55]

Like Goodman, Hakewill had heard rumors that the North Sea fishery was in decline. It was a point Hakewill could "neither affirme nor deny, hauing not searched into it." He wondered, though, whether the "intrusion" of Dutch fisherman had reduced the available store of fish, and he suggested comparing the local fishery to its global counterparts. "[I]f we should a little enlarge our view, & cast our eyes abroad,

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[54] Hakewill, *Apologie*, 110-11.
[55] Ibid., 112.

comparing one part of the world with another," he wrote, "we shall easily discerne, that though our Coast faile in that abundance . . . others still abound in a most plentifull manner, as is by experience found vpon the Coast of *Virginia* at this present."[56]

Although many believed the constitution of nature had changed, Hakewill found the notion unconvincing. "I know the complaint is common," he wrote, "that our summers by reason of cold and moist, are not so kindely as they haue beene." Perhaps, he reasoned, God had a "quarrell to vs for our sinnes." He doubted that such complaints reflected reality, though:

> But what is this to the vniversall decay of Nature? doubtlesse the same complaint hath still beene in the times of our *Fathers,* & *Grandfathers*, and *Great Grandfathers*, and so vpward in regard of the *Generations* before them. . . . For my selfe then, mine opinion is, that men for the most part, being most affected with the present, more sensible of punishments then of blessings, & growing in worldly cares, & consequently in discontent, as they grow in yeares and experience, they are thereby more apt to apprehend crosses then comforts, to repine & murmurre for the one, then to returne thankes for the other. Whence it comes to passe that vnseasonable weather, & the like crosse accidents, are printed in our memories, as it were with red letters in an Almanacke: but for seasonable & faire, there stands nothing but a blanke.

"The one is graven in brasse," Hakewill wrote, "the other written in water."[57]

Hakewill's *Apologie* collected numerous accolades in the seventeenth century. Seven of twelve chaired professors at Oxford endorsed his work.[58] Samuel Pepys, a naval official with good access to information, once turned to Hakewill to ease his mind after a dinnertime discussion of Nostradamus and the Great Fire of London. "I fell to

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[56] Ibid., 125-26.

[57] Ibid., 113.

[58] George Hakewill, *An Apologie or Declaration of the Power and Providence of God in the Gouernment of the World*, 3 ed. (London: Printed for Robert Allott, 1635), B5v- C1v.

read a little in Hakewill's Apology," he wrote on February 3, 1667, "and did satisfy myself mighty fair in the truth of the saying that the world do not grow old at all, but is in as good condition in all respects as ever it was as to nature."[59] Although Goodman's publications about universal decay remained in press for several decades, it appeared that Hakewill's interpretation of weather and environmental change had won the day. The Global Crisis of the Seventeenth Century, however, would reopen the debate over the unusual weather of the Little Ice Age.

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[59] Pepys "continued reading this book with great pleasure" until supper. Samuel Pepys, *The Diary of Samuel Pepys*, vol. 6, bk. 1, *Oct. 1, 1666 – Feb. 26, 1667*, ed. Henry B. Wheatley (1896; repr., New York: Croscup & Sterling Company, 1900), 150-52.

CHAPTER VI

OLD ALMANACS AND NEW:

WEATHER IN THE AGE OF SCIENTIFIC REVOLUTION

George Hakewill's critique of the catastrophic prognostications of Universal Decay was well-timed. After 1630, foul weather, failing harvests, and demographic crises contributed to an era of tremendous social and political unrest, often dubbed the "Crisis of the Seventeenth Century."[1] According to historian Geoffrey Parker, "the mid-seventeenth century saw more cases of simultaneous state breakdown around the globe than any previous or subsequent age." Between 1635 and 1666, some 49 major revolts and revolutions shook the foundations of states and empires on five continents. Ming China and Poland-Lithuania fell victim to the tumult—as did Sultan Ibrahim in Istanbul and Charles I in London. In Paris, a young Louis XIV fled the Fronde, vowing never

[1] For several perspectives of mid-seventeenth century crises, see: Hugh Trevor-Roper, *The Crisis of the Seventeenth Century: Religion, The Reformation, and Social Change* (New York: Harper & Row, 1967); Geoffrey Parker and Lesley M. Smith, *The General Crisis of the Seventeenth Century* (London: Routledge, 1978); Jack A. Goldstone, *Revolution and Rebellion in the Early Modern World* (Berkeley: University of California Press, 1991); Chester S. L. Dunning, "Does Jack Goldstone's Model of Early Modern State Crises Apply to Russia," *Comparative Studies in Society and History* 39, no. 3 (July 1997): 572-92; Geoffrey Parker and Lesley M. Smith, *The General Crisis of the Seventeenth Century*, 2 ed. (London: Routledge, 1997); Chester S. L. Dunning, *Russia's First Civil War: The Time of Troubles and the Founding of the Romanov Dynasty* (University Park, PA: Pennsylvania State University Press, 2001); Geoffrey Parker, "Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered," *American Historical Review* 113, no. 4 (October 2008): 1053-79; Geoffrey Parker, *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (New Haven: Yale University Press, 2013).

again to be so helpless. According to Parker, seventeenth-century conflicts lasted seventy-five percent longer than those of the sixteenth century, and 350 percent longer than those of the famously "violent" twentieth century.[2] By the end of the Thirty Years' War, Germany was bereft of at least twenty percent of its population. Parts of China fared even worse, with losses exceeding sixty percent. The Four Horseman trode heavily upon the fertile plains of Europe and Asia in the seventeenth century, and many thoughtful folks feared that the End was nigh.

In England the war between Charles I and Parliament coincided with a wave of publications attributing floods and other phenomena to the sins of the English people. The theological interpretation of weather remained alive and well. On December 9, 1646, London clergyman Francis Roberts (1609-1675) delivered a sermon on "the great judgment of rain and waters" before a gathering of the House of Lords in Westminster Abbey. Roberts served as minister to St Augustine's Church on Watling Street, a hotbed of Presbyterian thought in London.[3] "This day we are come together to afflict our souls and mourn before the Lord," he explained, "because the heavens have now for divers moneths together so sadly mourned upon the Land in extraordinary dearth-threatning shours." According to Roberts, the "immoderate rain" threatened famine, "hindering seed-time with some" and "washing seed sowne out of the ground with others."

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[2] Parker, "Crisis and Catastrophe," 1053-57.

[3] Nicholas Keene, "Roberts, Francis (1609-1675)," *Oxford Dictionary of National Biography* (Oxford: Oxford University Press: 2004–), accessed April 3, 2015, http://www.oxforddnb.com.

Credible reports suggested that murrain was spreading among cattle and horses, as well. In a personal message to the Peers, Roberts warned that "God hath brought Two of his Four sore Judgements upon the Land; *viz.* Sword, and Pestilence; and a Third of Famine may overtake us ere we be aware."[4]

Using the language of Aristotelian meteorology, Roberts attributed the showers to the "poysonfull vapours of our sins, and the sins of the Land, that have ascended and been multiplyed before the Lord." The lengthy sermon exhorted the audience to emulate the Israelites of Ezra 10:9, who trembled before the rain. "This is the judgment of God that hath of late been most extraordinarily inflicted upon this Land," Roberts wrote, "for which we are here trembling before the Lord this day." He continued: "[W]e have great cause to tremble, not onely at the plague of water it self and the sad consequences of scarcity and dearth which may follow, but much more at the wrath of God that appears therein, and the sins of England the procuring cause thereof."[5]

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[4] Francis Roberts, *A broken Spirit, Gods Sacrifices. Or, The Gratefulnesse of a Broken Spirit unto God. Represented in a Sermon, before The right Honourable House of Peeres, in K. Henry the Seventh's Chappell in the Abbey Westminster, upon Wednesday Decemb .9. 1646. Being a Day of publike Humiliation for removing of the great judgment of Rain and Waters then upon the Kingdome, &c.* (London: Printed for George Calvert, 1647), A2v, 1, 37-38.

[5] Roberts was perhaps more concerned with reformation than rainfall: "But yet both Church and State still cry out for further Reformation,—how doth the *Commonwealth* groane under wofull oppression, injustice, and all manner of violence and wrong, as much, if not more then ever?—O hasten to save the poore Kingdome from these destructive evills! But how doth the *Church of God*, not onely groane, but even languish, faint and dye continually under those cursed diseases of error, heresie, blasphemy, licentiousness, divisions, disorder and confusion, horrid Atheisme, and all manner of prophanness? Ministers may preach, people may petition, and both may pray: but if you sit still . . . where shall we have healing?" Ibid., 1, 31-35.

Although Roberts offered no explicit identification of the sin or sins responsible for the 1646 floods, many Puritans were inclined to pin the blame on Charles I and his supporters. John Bryan, the vicar of Holy Trinity in Coventry, delivered such a sermon on December 23, 1646, as part of a day of public fasting and humiliation for the late floods.[6] Bryan attributed the "Great Iudgement of Rain and Waters" to "Our discontentment with our present Government, and Inordinate Desire of our King." He doubted that prayer alone would lift God's judgment if the responsible sins remained unaddressed: "to lye under the Sin, and to pray against the Judgement was but lost labor." Rather than focus on the sins that typically invited famine—"Unthankfulness for, and abuse of Plenty, neglect of Gods House and Ministers, &c.," Bryan applied himself to "what I heard, and saw everywhere practised, but no where so much as conceived to be a Sin, . . . viz. To censure and judge the present Parliament, and inordinately to desire the Kings return upon any terms."[7]

Bryan compared the English to the Israelites in the age of Samuel, whose wicked desire for a king invited punishment by thunder and rain (1 Samuel 12:17).[8] "Our discontentment with the present Government of the States in Parliament," he wrote, "is

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[6] C. D. Gilbert, "Bryan, John (*d.* 1676)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004–), accessed April 3, 2015, http://www.oxforddnb.com.

[7] John Bryan, *A Discovery of the Probable Sin Causing this great Iudgement of Rain and Waters: viz. Our discontentment with our present Government, and Inordinate Desire of our King* (London: Printed for Richard Best, 1647), A2r-A2v.

[8] 1 Samuel 12:17 (KJV) records: "Is it not wheat harvest to day? I will call unto the Lord, and he shall send Thunder and Rain, that ye may perceive and see that your wickedness is great which ye have done in the sight of the Lord, in asking you a King."

no less then theirs." "We are displeased," Bryan explained, "and murmur at Taxes and Impositions, whereat we should not quarrel, seeing we enjoy our Lives, Liberties, Priviledges, Estates and Religion (all which were at stake and almost lost)." England's inordinate desire for a king, he reasoned, threatened re-imposition of arbitrary rule and Catholic superstition—including the celebration of Christmas. "And as the sin, so the punishment runs parallel," Bryan explained, "an immoderate rain in an unseasonable time, destroying as part of their Harvest, so no small part of ours, and not that only, but our seeds time also, dashing and almost drowning our hopes of the insuing year."[9]

The 1648 pamphlet *Strange and Terrible Newes from the North* suggests that fear of famine—real and superstitious—was quite strong in northern England. A letter from "R. S." in Berwick-upon-Tweed, dated April 16, describes eyewitness accounts of an extremely unusual Yorkshire storm:

> [O]n the 24. day of this last *March*, in the afternoon, arose a great storm, beginning first with Rain, which was powred downe in great abundance; aftes which instantly succeeded a mighty showr of Hayl being powred down with such an extraordinary force & violence, that it brake many glasse windows, kil'd Geese, Ducks, and other such feeble creatures as wanted shelter. After the haile was over, their issued out of the Aire a great showr of wheat; so that in some places it covered the ground, & it was in all respects like unto the common wheat whereof bread is made, both for colour & form, but that it was something more sad or darke colour then our ordinary wheat.[10]

The poor folks of Shereborn gathered the grain and apparently succeeded in fashioning it into bread, which they compared favorably to rye. According to the letter, the local

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[9] Bryan, *A Discovery*, 3, 11.

[10] *Strange and Terrible Nevves from the North* (London: Printed for R. G., 1648), unpaginated.

population was "very much amazed" at the event, which some thought "to be a sign of a famine" and others thought "to be a signe that Bread-corn, or Wheat, or Rye, or the like, in Harvest shall be destroyed, by some extraordinary storm of Haile or Raine, or some such accident, but none can assuredly tell what it prognosticates." R. S. concluded, though, that "surely, such strange and unusual things, are signes of some great alterations."[11]

London stationer John Wright reaffirmed God's control over weather in a 1649 "Question and Answer" guide to precipitation titled *The Way to get Rain*. The anonymous pamphlet examined "the true Cause both of too much want, and too much abundance" of rain. It attributed responsibility to God: "*Question.* Who hath the disposing of the raine and showers? *Ans.* The Lord only." "[I]f the Lord alone have the disposing of the Raine," the author explained, "then we [should not] expect it from the Plannets, nor from the Clouds, though the skie be over spread with them, no nor yet from the winde, though it be in the South, for all such things are but the vanities of the Gentiles." Two "especiall" sins invited an overabundance of rain: "the sin of unequall and ungodly marriages" and "the soothing up of wicked men in their sinnes." Drought, on the other hand, was the consequence of "five speciall sins": idolatry, disobedience of the commandments, failure to bear fruit "answerable to the meanes and mercies bestowed" by God, oppression of the poor, and neglect of worship. Only through the prescriptions of 2 Chronicles 7:14—humility, prayer, and the rejection of evil—would

[11] Ibid.

Fig. 11. *The Rupture of St. Anthony's Dike at Houtewael. Willem Schellinks*, De doorbraak van de St. Antonisdijk bij Houtewael*, 1651, oil on canvas, Amsterdam Museum, Amsterdam.*

the land be healed. Uniquely, the pamphlet included a model prayer for use in times of flood and drought.[12]

The North Sea floods of 1651, the worst in eighty years, provided ample opportunity for prayer. During "St. Peter's Flood" in the Netherlands, floodwaters inundated Holland, Friesland, and dozens of settlements on the Rhine River. The

[12] *The Way to get Rain: By way of Question and Answer. Shewing the true Cause both of too much want, and too much abundance of Raine. With the onely remedy and means to remove either of these iudgements when they are upon us. As also shewing what we must do upon the removall of either of these Judgements* (London: Printed for John Wright, 1649), 1, 4, 6-10.

dramatic failure of St. Anthony's Dike spared the city of Amsterdam but devastated the surrounding countryside (Fig. 11).[13] Stationer Robert Wood published a collection of letters from Amsterdam and Yarmouth, in East Anglia, describing the 1651 floods. Two of the three letters attributed the devastation to God's judgment. Peter Malbone of Amsterdam wrote of the Rhine that the "water overflowed with such violence, that it sunk 60 Parish Churches" and of Friesland that "there cannot be less then one hundred thousand people drowned." The flood was "the great judgment of the Lord against this Nation." A letter from Yarmouth reported that "the Sea broke into the Marshes at Soal (a place not far from this Town) with such violence, that it hath drowned a great part of the Country, and many Cattle." It attributed the flooding to God, who was "pleased once more to chastise us (as we may justly attribute it) for stubborness and disobedience in walking contrary to his Laws and Ordinances, and refusing to be humbled for our sins, and to return praise and thanks to him for . . . the last year, when the Sea made inundations in divers places, and yet did not much harm."[14]

[13] Several artists captured the breach of St. Anthony's Dike in sketches, engravings, and paintings, including Jan Asselijn, Jan van Goyen, Roelant Roghman, Loodewijck Spillebout, Pieter Nolpe, and Willem Schellinks (Fig. 11). Willem Schellinks, *De doorbraak van de St. Antonisdijk bij Houtewael*, 1651, oil on canvas, Amsterdam Museum, Amsterdam, Public Domain.

[14] *Strange and Terrible News, from Holland, and Yarmouth. Being, A Perfect Relation, concerning the Inundation of the South Sea; And of its drowning the rich and populous City of Amsterdam; with divers other places in Friesland, Holland, Brabant, and Flanders, and the names of them. Also, The Over-flowing of the River of Rhine, and sinking 60 Parish Churches, and drowning 100000 men, women and children; and how they row in Boats near Amsterdam, over the tops of houses. Together, With the Breaking in of the Sea at Soal (near Yarmouth) drowning a great part of the Country and many*

When it benefited him, Oliver Cromwell encouraged theological interpretations of weather. In 1654 he promulgated a declaration naming May 23 a "publique day of thanksgiving" for peace with the United Provinces and for "the late seasonable rain." Cromwell described the peace accords as "another Link" in God's "golden Chain of loving kindness," but he placed special emphasis on recent changes in weather:

> And let us not forget our other Mercies, was not the Earth lately so unusually parcht up, that it threatned Famin, and did cause the Beast of the field to mourn for want of food, and water to sustain it? And hath not the Lord so watered the Earth that he hath turned those fears into the expectation of the greatest plenty that ever was seen by any now living in this Nation?

The Heavens "thus declared the glory of God," with the Earth "answering thereunto in its fruitfulness."[15]

Cromwell's celebration was premature. One year later, London stationer Arthur Reynolds published *The Sad and Dismal Year. Or, England's great and lamentable Flood*, an account of devastating flooding along the Trent, Dove, and Severn rivers. As in 1570, coastal and riverine flooding combined to dismal effect. Reports from Liverpool, Lancashire, and the surrounding regions described a "great Inundation of the sea," but precipitation had the greatest impact. "[I]n the Northern parts, they had not three fair dayes, these six weeks last past," Reynolds wrote; "many have lost their hay,

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Cattle; Also casting many Ships upon the Land, and forcing others to Sea in that storm (London: Printed by Robert Wood, 1651), 4-6.

[15] Oliver Cromwell, *A Declaration of his Highness, Setting apart Tuesday the 23. of this present May for a publique day of Thankgiving, for the Peace concluded between his Commonwealth, and that of the United Provinces, and for the late seasonable Rain* (London: Printed by William du-Gard and Henry Hills, 1654), 1.

that lived neer the Rivers, the rest rotten, which makes hay to be dear, and in many places a death of Beasts." According to his sources in Derbyshire, Leicestershire, and Nottinghamshire, 230 people drowned in the River Trent. Contemporaneous flooding on the Continent suggested an elemental assault on Christendom itself: "This great Deluge extends to most parts of Europe, and France hath . . . lost the greatest part of their Vintage."[16]

The "great Deluge" remained a powerful image in seventeenth-century Europe. Robert Gell, rector of St Mary Aldermary, delivered a sermon titled "Noah's Flood Returning" before the Lord Mayor of London and the Worshipful Company of Drapers in August 1655.[17] Gell's approach to weather prognostication was strongly influenced by notions of numerology and chronological symmetry. He noted with interest that the period of time between the birth of the "second" Adam—Christ—and the present would soon match that between the "first" Adam and the Genesis Flood: 1,656 years. "[M]any believe that the next year will bring with it a notable change in the world," Gell wrote, "yea, many place the end of the world in that year." Likewise, he found the "same

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[16] *The Sad and Dismal Year. Or, England's great and lamentable Flood; Being A true, but woful Relation, of the mighty Rains, and overflowings of the stately Rivers of Trent, Dove, and Severn, in several parts of this Nation, and the number of men, women, and children, that perished by the force of this Inundation. Likewise, the hideous noise and shrieks of poor sucking Babes and Infants, that lay floting up and down the waters in their Cradles, and the getting up of divers people to the tops of houses to save their lives. Together with the carying away of great store of Hay, Pease, and Beans, by the merciless streams; and the great loss and ruine of many Cowes, Horses, Sheep, and Oxen* (London: Printed for Arthur Reynolds, 1655), 4-5.

[17] St Mary Aldermary is located at the intersection of Watling Street and Bow Lane, two blocks east of St Paul's Cathedral.

Chronological number of years, 1657" in the capitalized letters of "MVnDI ConfLagratIo," Latin for the long-anticipated destruction of the Earth by fire.[18]

The death of Oliver Cromwell in 1658 unleashed another wave of meteorological musings, in no small part because a great storm struck England as the Lord Protector breathed his last. Several famous poems expressed the spectrum of sentiments about the late sovereign, and they did so using the language of weather. John Dryden wrote of his demise, "But first, the Ocean, as a Tribute, sent / That Giant-Prince of all her Watry Herd; / And th'Isle, when her protecting *Genius* went, / Upon his Obsequies loud Sighs conferr'd."[19] Poet Edmund Waller adopted similar language:

> We must resigne; Heaven His great Soul do's claime
> In stormes as loud, as His *Immortal Fame*;
> His dying *groanes*, his last *Breath* shakes our Isle,
> And Trees uncut fall for His *Funerall Pile*,
> About his Pallace their broad roots are tost . . . .
> *Nature* her selfe tooke notice of His Death,
> And, *sighing*, swel'd the Sea, with such a breath
> That to remotest shores, her Billowes rould,
> Th'approaching Fate of her *great Ruler* told.[20]

Royalists, like Sidney Godolophin, were more sanguine about the storm:

> 'TIS well he's gone, (O had he never been!)
> Hurry'd in *Storms* loud as his crying Sin:

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[18] Robert Gell, *Noah's Flood Returning: or, A Sermon Preached August the 7th 1655. before the Right Honourable Christopher Pack, Lord Major of the Honourable Citie of London, And the Right Worshipfull, the Company of Drapers* (London, Printed by F. L., 1655), 17.

[19] John Dryden, *A Poem upon the Death of His Late Highness, Oliver, Lord Protector of England, Scotland, & Ireland* (London: Printed for William Wilson, 1659), 12.

[20] Edmund Waller, *Upon the Late Storme, and of the Death of His Highnesse Ensuing the same* (London: Printed for H.H., 1659), 1.

The *Pines* and *Oaks* fell prostrate to his *Urn*,
That with his *Soul* his Body too might burn.
Winds pluck up *Roots*, and fixed *Cedars* move,
Roaring for Vengeance to the *Heavens* above . . . .
Nature her self rejoyced at his Death,
And on the *Halter* sung with such a Breath,
As made the *Sea* dance higher than before,
While her glad *Waves* came dancing to the shore.[21]

Poet and wit George Wither also wrote a response to Waller's elegy, but he was more interested in the civil storms to come. Two English governments had fallen. Would a third follow? "*Black Clouds*," he wrote, "are now ascending o're these *Lands*." Such clouds, however, had been gathering for some time, a consequence of England's sin and division. Wither briefly summarized the foul weather of the preceding decade:

GOD, hath made known unto us, in some measure,
By every *Element*, his just Displeasure:
Those things, without which, nothing is enjoy'd,
Have all our late *Enjoyments* much destroy'd.
By *sudden Fires*, our dwellings are consum'd,
And, into smoak, our *pretious things* are fum'd.
The *Waters*, in their Wombs, have swallow'd up
No little *Portion* of the *Merchants* hope,
And, overflowing *new, and Antient Bounds*,
Swept Flocks and Herds out of the lower Grounds.

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[21] This poem has often been attributed to the Royalist John Cleveland and was first published in a collection of his poetry. Cleveland, however, preceded Cromwell in death. John Nichols identified Sidney Godolophin as a stronger candidate for authorship as early as 1780. This quotation is from the 1688 imprint of the poem, edited by Jane Barker. See John Cleveland, "An Answer to the Storm" in *The Works of Mr. John Cleveland, Containing his Poems, Orations, Epistles, Collected into One Volume, With the Life of the Author* (London: Printed by R. Holt for Obadiah Blagrave, 1687), 383-84; [Sidney] Godolphin, *Upon the Death of Oliver Cromwell, In Answer to Mr. W[aller]'s Verses*, in *Poetical Recreations: Consisting of Original Poems, Songs, Odes, &c. With several New Translations*, ed. Jane Barker (London: Printed for Benjamin Crayle, 1688), 53-55; John Nichols, ed., *A Select Collection of Poems: With Notes, Biographical and Historical*, vol. 1 (London: Printed by and for J. Nichols, 1780), 116n2.

The *Air*, by *Storms* and *Blastings*, *Frosts*, and *Snows*,
Destroy'd our *last Crops*, in their fairest shows.

Intriguingly, however, he acknowledged that "naturalists" disputed such alarmism:

Hereto, the *Naturalist*, perhaps will say,
Such things do happen to us every day,
Or, in a short time, either more or less:
Which I will grant; but notwithstanding, this
He must grant too, that from the *Worlds beginning*
These were, and are, the known *Rewards of Sinning*.[22]

Although theological and peccatogenic interpretations of weather prevailed during the Civil War and Interregnum, several authors maintained a rational, even journalistic, perspective of meteorology. Stationer George Horton published a brief account of a sudden inundation of Deptford and Greenwich on the Lower Thames that occurred on December 18, 1650. According to his *True Relation of The great and terrible Inundation of Waters* (1651), unusually strong northeasterly winds were responsible for the flood. "The Wind sitting in the North-East Point," he wrote, "had such power and influence upon the waters, that it forced the waves in abundance from the main Ocean; insomuch that the bounds of the Earth could not contain the limits thereof." According to Horton's sources, ten feet of water submerged lower Deptford, drowning over 600 livestock, and flooded several basements along London's Thames Street.[23]

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[22] George Wither, *Salt upon Salt: Made out of Certain Ingenious Verses Upon the Late Storm and the Death of Highness Ensuing* (London: Printed for L. Chapman, 1659), 1, 21-22.

[23] *A True Relation of The great and terrible Inundation of Waters, and over-flowing of the Lower-Town of Deptford, on Thursday last, about two of the clock in the*

One of the letters in the aforementioned *Strange and Terrible News, from Holland, and Yarmouth* (1651) adopted similar language to explain the flooding of Holland and the Zuiderzee. The author, G.T., explained that "there happened a mervailous in-undation of waters in this City and in several other parts of Holland and Friesland, occasioned by the over-flowing of the South-Sea, that (to the remembrance of the oldest man living) the like hath not been known of in these Provinces." He correctly attributed the flood to the "winde flowing hard Northwest," which "drove the water so excessively into the City, that it overflowed the Bourgwals, and broke into Cellars and Warehouses to the utter ruine of divers people (especially on the South-side of the City) who were forced to take to their chambers for refuge." G.T. remarked that three additional hours of northwesterly winds would have "destroyed and washed away" Haarlem and endangered Delft, The Hague, and Leiden.[24]

Such attention to the details of a meteorological event also characterized the remarkable 1660 pamphlet, *An Exact and true Relation, Of the wonderfull VVhirle-VVind*. Published by stationer Francis Coles, the pamphlet describes a funnel cloud that

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Afternoon: With the manner how the River of Thames brake into the Merchants yard, Greenwich Meadows, and several other places; removed great Trees, level'd strong Foundations, drowned many hundreds of Cattel, and flowing up to the second story of the Chambers, insomuch, that the Water-men were forced to row up and down the streets with their Boats, to take men, women, and children, out at their Windows, and to save little Children than swum in their Cradles: With the appearing of three black Clouds immediately before the Floud, foreshewing the strange things that will happen, a sudden change, and each man to enjoy his own again (London: Printed for George Horton, 1651), 3-7.

[24] *Strange and Terrible News*, 1-3.

touched down near Ashby-de-la-Zouch in Leicestershire on June 2, 1660. Six-pages long, it is a smorgasbord of meteorological tropes—a detailed narrative of a storm, a brief history of local weather, an attempt to pin blame on political opponents. Coles artfully linked political and atmospheric turbulence. The storm struck four days after the Restoration of Charles II, a "whirle-wind of Joy," while strong opposition to the Crown still lingered in the county. "[I]t seemes that there remained still in those parts some turbulent Ayre, which had not the leysure to vent it self untill the Second of this present Moneth," he wrote, "which it did then in the most prodigious manner as almost was ever heard of." England had seen its share of "strange and high winds and Tempests" in the preceding decade, including that which accompanied Cromwell's death. Specificity, however, distinguishes *Whirle-Wind* from its peers. So carefully scripted is its chronology, that one can plot the funnel's path on a map and estimate, relatively speaking, its strength on the Fujita Scale.[25]

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[25] *An Exact and true Relation, Of the wonderfull VVhirle-VVind, on Saturday, June the 2. about 4. of the Clock in the Afternoone at Worthington, and Worthington Hall, and at Tongue, and some other Places in the County of Leicester. As also, The terrible Devastation that it made in beating downe many Trees and Houses, and with a sudden violence stripping naked many great Okes, and plucking their barkes from their Bodies; As also taking away a Hive of Bees, and great store of Linnen, which could never since be heard of. Together with the miraculous mercy of God in preserving many Men, Women, and Children, who were desperatly involved in that dreadfull Danger. Very necessary to be Read. Attested by Colonel Tho: Ragge, and Major Fran. Beniskin of Tongue, to whom the said Hive of Bees belonged; and by many thousands of others, whose Names are too many to be here inserted* (London: Printed by T.F. for Fr. Coles, 1660), 1-3.

According to Coles' sources, dark clouds gathered over the town of Worthington shortly after 4 P.M. Soon after, "there arose a great & violent Whirlwind, which wrastling with the clouds, and the aire made a dreadfull noyse, and sweeping through the towne untiled many of the houses, and ruined a great part of the Chappel." The tempest gathered strength and "suddenly passed from thence" to nearby Worthington Hall, where it "exercised its former fury," unglazed and broke several windows, forced open locked doors, and tore buildings from their foundations. The funnel cloud next touched down in Springwood, an enclosed forest located some two miles northwest of Worthington (Fig. 12).[26] Even the Ranger in *The Play of the Wether* would have eschewed such windfall:

[26] Springwood belonged the Earl of Stamford. There is no "Springwood" today, but the location appears to correspond to a copse of trees (.25 sq mi) at the southern end of Staunton Harold Reservoir, a 209-acre lake built in the 1960s. Willem Blaeu's 1645 map of Leicestershire (Fig. 12) include an illustration of an unnamed enclosure between Staunton Harold and Breedon on the Hill—the precise location of the modern forest and reservoir. The forests at Staunton Harold are protected once again; they now form the northern limits of the growing National Forest. Joan Blaeu, *Leicestrensis Comitatus* (Amsterdam: 1645), Bibliothèque nationale de France, http://gallica.bnf.fr/ark:/12148/btv1b53056214s, Public Domain; "About Staunton Harold," *Severn Trent Water*, accessed April 8, 2015, http://www.stwater.co.uk/leisure-and-learning/reservoir-locations/staunton-harold/*/tab/about/; "All about the Forest," *The National Forest Company*, accessed November 7, 2013, http://www.nationalforest.org/forest/; The National Forest Company, *A Forest in the Making* (Derbyshire, UK: 2008), http://www.nationalforest.org/document/information/forest_in_the_making.pdf.

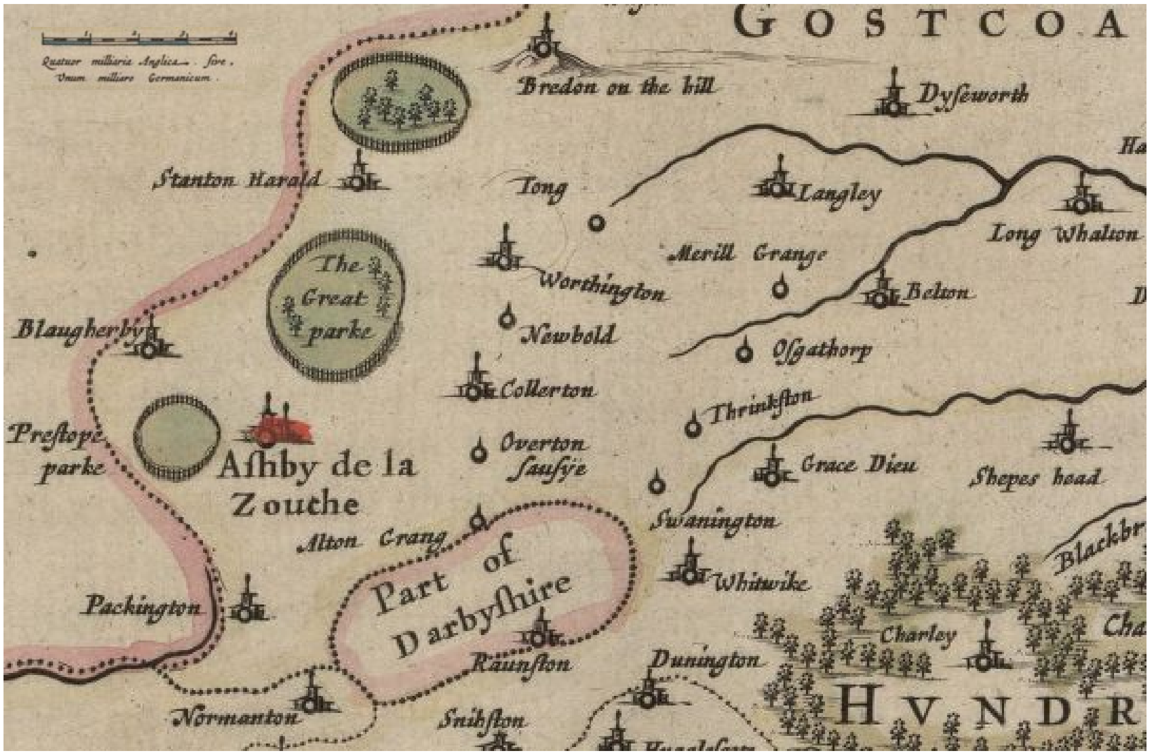

Fig. 12. *The Vicinity of Ashby de la Zouche in Northwestern Leicestershire*. *Worthington and Tonge are identified in the center. Springwood corresponds to the unnamed enclosure at the top of the map. The correct scale has been superimposed for reference. Extract from Joan Blaeu*'s Leicestrensis Comitatus (1645).

> It is a common saying, that things that are lightest are alwaies in greatest danger; and so it appeared in this wood, for the whirlwind wrestling with the fairest, and the tallest of the Timbers, did lay many of them upon their backs with their heels higher then their Heads, many it tore up by the roots, and did cleave and split their vast bodies, as if they had been laboured by so many Wedges. . . . But one thing is indeed yet more wonderfull, and shewes that the Whirlwind pertakes with the lightning both in the suddenness, and the subtleness of his effects; for ranting thus . . . in the wood, it tooke off the barkes and stripped naked many of the trees, which it performed in a moments space, and with such dexterity, and handsomenesse that a deliberate labourer could not have taken off the barkes so artificially in a whole day.[27]

[27] *VVhirle-VVind*, 5-6.

According to the Fujita Scale used for categorizing and comparing historical tornadoes, the debarking of trees suggests wind speeds in excess of 261 miles per hour, an "F5" tornado.[28] The whirlwind next struck the village of Tonge, where it destroyed a mature orchard and several houses. From there it "ran afterward two Miles and a half doing much hurt all along to the Trees of Fruit & dwelling Houses as it passed them." Since Worthington, Springwood, and Tonge are arranged in a triangular pattern, it is quite possible that more than one tornado struck Leicestershire on that June afternoon.[29]

Although Coles' brief pamphlet included a few religious references, it focused almost exclusively on describing the geography, chronology, and physical consequences of a discrete weather event. It would not seem altogether misplaced in a modern newsmagazine—especially with its pointed barbs at latent Roundheads. The invention of meteorological instruments like the thermoscope, thermometer, evaporimeter, barometer, and hygrometer in the seventeenth century facilitated increasingly methodical approaches to measuring weather phenomena. The Medici family of Florence promoted the creation of such instruments and organized the first network for recording the

[28] Under the Enhanced Fujita Scale now used by the National Oceanographic and Atmospheric Administration (NOAA), the debarking of hardwood trees like oak suggests wind speeds in excess of 200 miles per hour—an "EF5" tornado. "Enhanced F Scale for Tornado Damage," *National Oceanographic and Atmospheric Administration*, accessed November 7, 2013, http://www.spc.noaa.gov/efscale/ef-scale.html.

[29] *VVhirle-VVind*, 5-6.

resultant data. The “Medici Network” of 1654-1670 comprised, at its peak, seven stations in Italy and eleven in Europe, in cities as distant as Warsaw and Paris.[30]

Christopher Wren, Robert Hooke, Thomas Sprat, and other members of the Royal Society of London, established in 1660, shared in the excitement of developing new instruments and methodologies for recording weather phenomena. Wren explained the potential benefits of such efforts in a 1662 address to the members of the Royal Society. “[I]nstead of the Vanity of prognosticating,” he explained, “I could wish we would have the Patience of some Years, of registring past Times, which is the certain Way of learning to prognosticate;—Experiment and Reason is the only Way of prophesying natural Events.” He felt no need to “press the Utility” of such an approach before an audience of scholars: “I am confident there is none here, but apprehends what excellent Speculations, what a Multitude of new ingenious Consequences will hence arise conducible to Profit, Health, Convenience, Pleasure, and Prolongation of Life.”[31]

Wren called his approach to meteorology the “History of Seasons.” “The History of Seasons is this excellent work I would recommend to you, desir’d by all modern Philosophers,” he explained, “though no Body hath had yet the Patience to pursue it.” It

[30] Dario Camuffo and Chiara Bertolin, “The earliest temperature observations in the world: the Medici Network (1654-1670),” *Climatic Change* 111 (2012): 337-40.

[31] J.A. Bennett, *The mathematical science of Christopher Wren* (1982; repr., Cambridge: Cambridge University Press, 2002), 83-86; Christopher Wren, “To the Royal Society,” in *Life and Works of Sir Christopher Wren. From the Parentalia or Memoirs by His Son Christopher*, ed. Christopher Wren, Jr., rev. ed. (London: T. Osborn and R. Dodsley, 1750; London: Edward Arnold, 1903), 51-59. Citations refer to the Edward Arnold edition.

consisted of two parts, “A meteorological History” and “A History of Things depending upon Alteration of the Air and Seasons.” Wren’s meteorological history would be comprised of five recordings:

> 1. A punctual Diary of the Motion of the Air, the winds; wherein should be noted, not only the Rumb but Force of the Wind, as the Seamen have these Distinctions, if I mistake not; from a Calm they begin with a soft Wind; a fresh Wind; a stiff Gale; a Storm; and sometimes a Hurricane. These may be noted down by a Cypher, and 1, 2, 3, 4 &c. And the Rumb by Letters.
> 2. A punctual Diary of the Qualities of the Air, as to Heat and Cold observ’d by a Thermometer; and likewise of the Moisture of the Air observ’d by some other Instrument.
> 3. The Refractions should be observ’d, and the Rising of dry Vapours by the Telescope, and the Tremulation of the Air.
> 4. A Diary of the State of the Air, as fair, cloudy, Rain, &c.
> 5. A Register of other accidental Meteors, as figur’d Snows, Parelii, Coronae, unusual Colours and Shapes of Clouds, call’d Fights in the Air. Fiery Meteors in the Night, falling Stars, (in which I could give Direction for finding, if any Thing falls from them in their Extinction.)[32]

His second history would be comprised of five additional recordings:

> 1. The History of the Growth of those annual Things of Food, as Fruits and Grain. The causes of Dearth and Plenty and Diseases. Especially the Annals of the Plough should be kept. How the Weather retarded or accelerated Seed Time, springing, flow’ring, corning, ripening and Harvest; with the Diseases and Enemies of that Year . . . . Lastly, the Plenty, Scarcity, and Price of Corn. We are enough to learn this in every County of England, by enquiring and corresponding with those that are a little more curious in Country Affairs.
> 2. The State of Grass and Hay, and consequently of Cattle; the Plenty, Dearth, Diseases and Murrains of them.
> 3. Wines, which though foreign, bear a great Share in our Diet, and therefore a Note should be given of them; of their Goodness or Vices that Year. So for Coffee, Tobacco, and such like of general Use.
> 4. The Seasons of Fish & Fowl are retarded or accelerated by Weather . . . and of many other the like Things are very well worth registring; and all other Things found to be either Consequence, Signs, or Presages of Weather and Seasons.

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[32] Wren, “To the Royal Society,” 53.

> 5. Above all, the Physicians of our Society should be desir'd to give us a good Account of the epidemical Diseases of the Year; Histories of any new Disease that shall happen; Changes of the old; Difference of Operations in Medicine according to the Weather and Seasons, both inwardly, and in Wounds: and to this should be added, a due Consideration of the weekly and annual Bills of Mortality in London.[33]

The "History of Seasons" remains a remarkable plan of study. Only a handful of governments today could afford to collect the data that Wren sought; even fewer organizations in seventeenth-century Europe could hope to achieve the plan's stated goals. Wren was well-aware of such challenges: "The only Thing I fear is, lest we should want Patience, and flag in the Design, since in few Years at the Beginning, it will hardly come to any visible Maturity." He remained optimistic that a dose of early modern crowd-sourcing might facilitate its completion. "But as it is a long Work," he mused optimistically, "so it is of no Difficulty, nor will take up more Time, than once a Year to have an Audit wherein everyone shall bring in his Account of that Part which, in this History was enjoin'd him." The diaries of temperature and wind presented the greatest challenges because they appeared to require "constant" attention. Wren proposed delegating the task to several people in each location who "may sometimes compare Notes" to satisfy absent or conflicting observations.[34] To make the task easier, he proposed the construction of an engine capable of independently measuring and recording weather data:

> I might seem to promise too much, should I say, an Engine may be fram'd, which if you visit your Chamber but one half Hour in the Day, shall tell you how many

[33] Ibid., 53-55.
[34] Ibid.

> Changes of Wind have been in your Absence, though there were Twenty, and at what Hour every Change happen'd, and whether it were soft, stiff, or vehement. Neither shall the Instrument be subject to be out of Tune, or if it be, your own Hand may rectify it.[35]

Wren designed a rudimentary weather-clock a few years later, and the Royal Society tasked Robert Hooke with creating a working model, a task he completed in 1679.[36]

Thomas Sprat celebrated the spirit of collaborative and systematic research that prevailed in the Royal Society in his *History of the Royal Society* (1667). He was particularly excited by Wren's "History of Seasons," an endeavor that "will be of admirable benefit to Mankind, if it shall be constantly pursued, and deriv'd down to *Posterity*." Although he worried that the scheme was too grand to be sustained, he offered a resounding defense of the plodding work of scholarship: "If any shall yet think they have not usefully employ'd their time, I shall be apt to suspect, that they understand not what is meant by a *diligent* and *profitable labouring* about *Nature*." The society's members went "leisurably on; but their slowness [was] not caus'd by their idleness, but care." They had, Sprat suggested, "contriv'd in their thoughts, and couragiously begun an *Attempt*, which all *Ages* had despair'd of." Because of the novelty of the enterprise, "the nature of their *Work* requir'd that they should first begin with *immethodical*

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[35] Ibid.

[36] J. A. Bennett, *Mathematical Science*, 83-86; Robert P. Mulhaus, *The Introduction of Self-Registering Meteorological Instruments*, Contributions from the Museum of History and Technology, no. 23 (Washington, D.C.: Smithsonian Institution, 1963), 99-102; W. Derham, ed., *Philosophical Experiments and Observations Of the late Eminent Dr. Robert Hooke, S. R. S. And Geom. Prof. Gresh. And Other Eminent Virtuoso's in his Time* (London: Printed by W. and J. Innys, Printers to the Royal Society, 1726), 41-42.

Collections and *indigested Experiments*." He exhorted his fellow members to remember that "the *Subject* of their *Studies*" was "as large as the Univers," and their "Method . . . may well be justified, seeing they have the *Almighty Creator* himself for an *Example:* For he at first produc'd a confus'd and scatter'd Light; and reserv'd it to be the *work* of another day, to gather and fashion it into beautiful *Bodies*."[37]

Sprat included a brief article by Robert Hooke that outlines a method for "the better making" of "a History of the weather." Like Wren, Hooke identified eight characteristics that required observation and notation: the "Strength and Quarter of the Winds," the "Degrees of Heat and Cold in the Air," the "Degrees of Dryness and Moisture in the Air," the "degrees of Pressure in the Air," the "constitution and face of the Sky or Heavens . . . [as seen] by the eye," the presence of illness or disease, the occurrence of "Thunders and Lightnings," and "[a]ny thing extraordinary in the Tides." These, Hooke contended, "should all or most of them be diligently observed and registered by some one, that is alwayes conversant in or neer the same place."[38]

Hooke included instructions for the construction and usage of necessary instruments, and he described—at length—the dimensions of a standardized table for recording data: "[Allow] fifteen dayes for one side, and fifteen for the other. Let each of those pages be divided into nine Columes, and distinguished by perpendicular lines;

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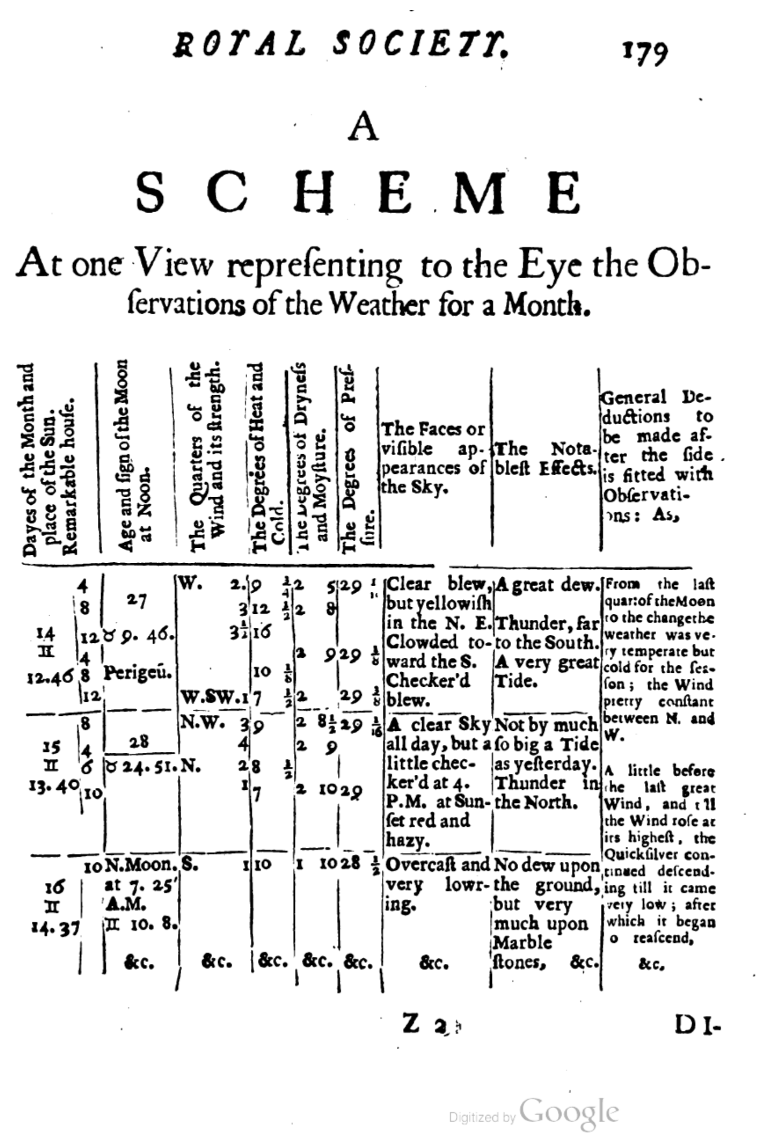
[37] Thomas Sprat, *The History of the Royal Society of London, For the Improving of Natural Knowledge* (London: Printed by T.R. for J. Martyn, 1667), 312-19.

[38] Robert Hooke, "A Method For making a History of the Weather," in *The History of the Royal Society of London, For the Improving of Natural Knowledge*, ed. Thomas Sprat (London: Printed by T.R. for J. Martyn, 1667), 173-75.

let each of the first six Columes be half an inch wide, and the three last equally share the remaining of the side" (Fig. 13).[39] He defined the titles for each column and included a guide to the terms scholars should use to describe conditions: "[L]et *Cleer* signifie a very cleer Sky without any Clouds or Exhalations." Hooke's strict methodology was undoubtedly a reflection of his own attention-to-detail, but he probably intended that it serve as encouragement for scholars to complete the full spectrum of meteorological observations. Failure to do so would leave much of the prepared form bare—a most unenlightened dereliction of scientific duty.[40]

Hooke hoped that his scheme, or one similar to it, would be widely adopted. "It were to be wisht," he wrote, "that there were divers in several parts of the World, but especially in distant parts of this Kingdom, that would undertake this work, and that such would agree upon a common way somewhat after this manner, that as neer as could be, the same method and words might be made use of." The benefit of such organization, he wrote, was "easily enough conceivable." Hooke dedicated few words to defining those benefits. Like Wren, he expected his audience to recognize the undiscovered value of all

[39] Hooke included a three-day example of his scheme (Fig. 13). Ibid., 175-79.
[40] Ibid.



ROYAL SOCIETY. 179

A

SCHEME

At one View repreſenting to the Eye the Obſervations of the Weather for a Month.

Dayes of the Month and place of the Sun. Remarkable houſe.		Age and ſign of the Moon at Noon.	The Quarters of the Wind and its ſtrength.	The Degrees of Heat and Cold.	The Degrees of Dryneſs and Moyſture.	The Degrees of Preſſure.	The Faces or viſible appearances of the Sky.	The Notableſt Effects.	General Deductions to be made after the ſide is fitted with Obſervations: As,
14 ♊ 12.46	4 8 12 4 8 12	27 ♉ 9. 46. Perigeũ.	W. 2. 3 3½ W.SW. 1	9 ¼ 12 ½ 16 10 ⅛ 7 ½	2 5 2 8 2 9 2	29 1/10 29 ⅛ 29 ⅜	Clear blew, but yellowiſh in the N. E. Clowded toward the S. Checker'd blew.	A great dew. Thunder, far to the South. A very great Tide.	From the laſt quarter of the Moon to the change the weather was very temperate but cold for the ſeaſon; the Wind pretty conſtant between N. and W.
15 ♊ 13.40	8 4 6 10	28 ♉ 24. 51.	N.W. 3 4 N. 2 1	9 8 ½ 7	2 8½ 2 9 2 10	29 1/16 29	A clear Sky all day, but a little checker'd at 4. P.M. at Sunſet red and hazy.	Not by much ſo big a Tide as yeſterday. Thunder in the North.	A little before the laſt great Wind, and till the Wind roſe at its higheſt, the Quickſilver continued deſcending till it came very low; after which it began to reaſcend,
16 ♊ 14.37	10	N.Moon. at 7. 25' A.M. ♊ 10. 8.	S. 1	10	1 10	28 ½	Overcaſt and very lowring.	No dew upon the ground, but very much upon Marble ſtones,	
		&c.	&c.	&c.	&c.	&c.	&c.	&c.	&c.

Z 2 DI-

Fig. 13. Robert Hooke's Scheme for Recording Meteorological Observations. Published as part of Thomas Sprat's History of the Royal Society (1667). Digitized by Google.

systematic information, including meteorological data. "As for the Method of using and digesting those so collected Observations," he concluded, "[t]hat will be more advantageously considered when the *Supellex* is provided; A Workman being then best able to fit and prepare his Tools, for his work, when he sees what material he has to work upon." The data from the eight observations "may be registred so as to be most convenient for the making of comparisons, requisite for the raising *Axioms,* whereby the Cause or Laws of Weather may be found out."[41]

Christopher Wren's and Robert Hooke's labors would not bear fruit, statistically speaking, for some time, but their insistence on meticulous research, observation, and comparison was immediately influential. William Aglionby, a Fellow of the Royal Society, penned a thoughtful discussion of weather and climate as part of a 1671 treatise on the United Provinces. Informed by history, Aglionby found it difficult to categorize the Dutch climate. He wrote that "the Air is pretty well tempered in *Holland*, though cold do a little predominate, there being continual winds and frequent rains," but he nevertheless concluded that "the inconstancy of the Climate is such, that the seasons seem to be in a perpetual confusion." To make sense of a climate where "the heat is never violent" and "the cold is seldome lasting," Aglionby turned to the Annals of the Netherlands, where he discovered records of several "long and hot Summers, and violent cold lasting Winters."[42]

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[41] Ibid.

[42] The Dutch were well-adjusted to cold weather: "When the Chanels are frozen, they slide upon them with a certain sort of Shooes called *Skates,* which have a long, shining, narrow, crooked Iron, that stands out before. They that are perfect in this exercise turn their Feet inwards, that the Iron may take the more hold of the Ice, upon which they fly like Birds in the air with that swiftness, that one can hardly follow them with the eye. The Women too use this as a diversion, and many do very pretty tricks upon the Ice, but most are content with a straight course, as much as needs to get heat and ground. Every Sunday after Sermon all the people of the Towns come out upon the Ice, some to slide and others to look on. I knew a young Clown of ten years old, who did brag *that he had gone eighteen miles or six leagues in an hour* upon his Skates. The

Robert Plot, a Fellow of the Royal Society, also expressed interest in the history of weather. In a 1677 essay on the natural history of Oxfordshire, Plot suggested that the county had experienced tempests with "deplorable Effects" in the past, but he lamented that these were "no where transmitted to Posterity." Seeking to fill this lacuna, at least for the present, Plot described two storms of unusual intensity that occurred during the 1660s. As for earlier tempests, he acknowledged that it might now "be wish'd . . . that some old Almanacks were written instead of New." Plot hoped that, "[i]nstead of the conjectures of the Weather to come," some "ingenious and fit Persons would give a faithful account from divers parts of the World, not only of the Storms, with the antecedents and consequents of them, but of the whole Weather of the Years past, on every day of the Month." Such an extensive record would aid in the prediction and mitigation of future disasters through "remedies, or prevention." These observations, Plot believed, if regular rather than random, and if drawn from local as well as "foreign and remote parts," might allow for the development of "true Investigations of Heats and Colds, and of the bredth and bounds of coasting Rains and Winds."[43]

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same laid a Wager with a Peasant his neighbour, that he would sooner slide three leagues, than the other should ride one and a half with the best Horse he should get. It is ordinary for these sort of people to go from *Leyden* to *Amsterdam* in an hour and a quarter, if the Ice be even, and yet that is near eighteen miles." William Aglionby, *The Present State of the United Provinces of the Low-Countries as to the Government, Laws, Forces, Riches, Manners, Customes, Revenue, and Territory of the Dutch*, rev. ed. (London: Printed by John Starkey, 1671), 216-18.

[43] Robert Plot, *The Natural History of Oxford-shire, Being an Essay toward the Natural History of England* (London: Moses Pits, 1677), 4-7.

The cold winters of the Little Ice Age returned to Britain in 1676. Once again, the freezing of the Thames encouraged the reassessment of meteorological ideas. English author Roger L'Estrange described the winter in *A true Account Of the late Extraordinary Frost and Snow* (1677). He believed the winter to be a dramatic departure from its predecessors:

> It may be remembered how mild and gentle the Winters, for several Years past, have proved in our Climate; as if that sacred Prophecy, reckoning up amongst other Signs of the last Times, *That Summer should scarce be known from Winter, but by the fall of the Leaf*, had had some special Reference to the Age we live in. But this present Season, it hath pleased Providence to change the Weather, into a sharper and more severe Constitution. Which seem'd so much the more harsh and insupporrable, by how much it was more rare, and our tender Bodies less accustomed thereunto.

L'Estrange suggested that there might be some astrological explanation for the change, namely the opposition of Saturn with Venus and Mars with the Sun in "Cold, Earthly and Watery Signs." "But," he acknowledged, "we are not now writing an Astrological Discourse, but a Relation, and therefore hasten to the matter of Fact."[44]

According to L'Estrange, the frost began in November and peaked after December 9, when "a continual discent of Snow" plagued London for almost forty-eight hours and some parts of England for even longer. Two weeks of bitter cold followed,

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[44] Roger L'Estrange, *A true Account Of the late Extraordinary Frost and Snow, And the great Damages Thereby sustained in divers parts of England. As also how Twenty five Children lost their lives all at once on the Ice at Wisbich. And the destruction of divers Cattle in the North, &c. Faithfully Collected from Letters sent to several Persons in London, and other certain Informations. With a Description of the Tents, Booths, &c. Erected upon the River of Thames* (London: Printed for D.M., 1677), 3-8.

and “several aged and judicious persons averr’d, That they never knew it freeze in *England* more fiercely in their lives.” Once again, the Thames provided an icy setting for transportation and commerce:

> [T]housands have gone over the *Thames* on foot, and at this instant Carts, Drays, *&c*. pass the same on this side *Braindford*; and Tents, Booths, and Shops kept on the Ice against *Westminster*, where they made Fires, roasted Meat, sold Drink, *&c*. the like whereof hath not been known in our Age; and is but once, as I can finde to be parallell’d in all our antient Chronicles.[45]

L’Estrange emphasized the hardship of the frost: “This Severity of the Weather, together with the deepness of the Snow in many places, occasion’d much Damage not only to Cattle, but several Persons also lost their Lives.” A correspondent from Lincolnshire reported three feet of snow, such that “the oldest Man alive cannot remember the like.” Several people perished from injuries sustained on slippery roads and thin ice, and one child was lost to the snow. Wisbech, Cambridgeshire, bore witness to the most disturbing accident, when several boys playing football on the ice fell through while huddling after a goal. “Which sad Example,” L’Estrange scolded, “may serve as a warning to all Lads, not to expose themselves hereafter in such dangerous attempts, as some very imprudently have done during this Frost, by venturing too soon or too far upon the Ice.”[46]

Seven years later, in 1683, the Thames froze again. Thomas Pigot, a Fellow of the Royal Society, reported from Oxford a “very hard frost for the season” in mid-

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[45] Ibid., 6-8.
[46] Ibid.

September. According to the ballad *Londons Wonder*, the frost settled upon the capital in early December and continued through February 4, 1683/4.[47] The Great Frost of 1683 is one of the best-documented meteorological events in early-modern history. Almost two dozen ballads, poems, pamphlets, broadsheets, articles, and labeled maps testify to the bitter winter, when temperatures plunged to their lowest point in the nascent instrumental record.[48] According to Thomas Tryon, who published a brief chronology of the frost prior to its conclusion, the Thames remained frozen through the commencement of the Legal Term in late January, when "*Coaches* Ply'd at the Temple-Staires, and carried the *Lawyers* to *Westminster* on the *Ice*." "Whole Streets of *Shedds* [were] every where built on the *Thames*," Tryon explained, with "Thousands Passing, Buying, Selling, Drinking, and *Revelling*, (I wish I could not say on the *Lords Day* too,) and most sorts of Trades-Shops on the Ice, (and amongst the rest a Printing-house there Erected) *Bulls* Baited, and Thousands of Spectators."[49] According to the poem *Great*

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[47] Thomas Pigot, "An account of the *Earthquake* that happened at *Oxford* and the parts adjacent *Sept. 17. 1683.* by a fellow of a *College* in that *University*, and of the *Royal Society*," *Philosophical Transactions* 151 (September 20, 1683): 313; *Londons Wonder; Being a Description of God's Mercy and Goodness, in the breaking of this late mighty Frost which began about the beginning of December, 1683. and continued till the 4th. of February following* (London: Printed for J. Deacon, 1685), 1.

[48] Gordon Manley, "1684: The Coldest Winter in the English Instrumental Record," *Weather* 30 (December 1975): 382-88.

[49] Tryon's chronology records: "The present Wonderful *Frost*, which is the General Theme of Discourse . . . began about the midst of *December* 1683, at first by mean and ordinary Degrees, but towards *Christmas* became very Sharp . . . all of which still continues at the Writing hereof, being *Ianuary* the 29th 1683/4." Thomas Tryon, *Modest Observations on The Present Extraordinary Frost* (London: Printed by George Larkin, 1684), 1.

Fig. 14. *London Frost Fair, 1684. From* An Exact and Lively Mapp or Representation of Booths and all the varieties of showes and humours upon the Ice on the River of Thames by London, *1684, etching, British Museum, London. Trustees of the British Museum ©*

Britains Wonder, "There was . . . a Street of Booths built from the *Temple* to *Southwark*, where were Sold all sorts of Goods imaginable, namely, Cloaths, Plate, Earthen Ware, Meat, Drink, Brandy, Tobacco, and a Hundred sorts of other Commodities not here inserted." Booths with names like the "Flying Piss-pot" competed for coins with unusual amusements, including rolling boats that battled upon the ice: "as they pass they little Guns do fire" (Fig. 14).[50]

Poets and songwriters reveled in the algid air, backlighting the nameless souls who gingerly tread the water's surface. If one is to believe the poets—and they are usually right about such things, to step from the Temple stairs onto the ice was to enter a different world. Some compared the "Blanket Fair"—so called for the blankets used to build tents each day—to Paradise: "I do think no Man doth understand, / Such merry Fancies ne'r were on the Land; / There is such Whimsies on the Frozen Ice, / Makes some believe the *Thames* a Paradice."[51] The lyricist behind *News from the River of Thames* suggested that "*England* almost seems to be / Like to another Nation. / All things Topsie Turvy turn'd, / As may be well Observ'd." The ballad has a strong claim to authority: it was printed in a booth on the ice itself.[52]

Rumors of immorality abounded in the carnivalesque atmosphere. One poet wrote, "Here is also a Lottery and Musick too, / Yea, a cheating, drunken, leud, and

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[50] *Great Britains Wonder: Or, Londons Admiration. Being a True Representation of a Prodigious Frost, which began about the beginning of Decemb. 1683. and continued till the Fourth Day of February following. And held on with such violence, that Men and Beasts, Coaches and Carts, went as frequently thereon, as Boats were wont to pass before* (London: Printed by M. Haly and J. Millet, 1684), 1-2; *An Exact and Lively Mapp or Representation of Booths and all the varieties of showes and humours upon the Ice on the River of Thames by London*, 1684, etching, British Museum, London. © Trustees of the British Museum. By permission of the Museum.

[51] *Britains Wonder*, 2.

[52] *News from the River of Thames* (Frozen-Thames: Printed by E. and A. Milbourn, S. Hinch, and J. Mason, 1683), 1.

debauch'd crew."[53] One described the scene as an "Icey Bear-Garden."[54] Another poet, equal parts witty and saucy, warned women that the ice was unsafe—for their virtue:

> *Women*, beware you come not here at all;
> You are most like to slip and catch a Fall:
> This you may do, tho' in your Gallants Hand,
> And if you fall, he has no Power to stand.
> 'Tis ten to one, you tumble in a Trice;
> For you are apt to fall, where there's no Ice;
> Oft on your back, but seldome on your Face,
> How can you stand then on a slippery place?
> Yet you will venture brisquely to a Booth,
> To take a Glass or two with Youngster Smooth,
> Then back again as brisquely to the shore,
> As Wise and Honest as you were before.[55]

The author of *Great Britains Wonder* was inclined to agree: "And some do say, a giddy senseless Ass / May on the *Thames* be furnish'd with a Lass."[56] The ballad *Blanket-Fair* proffered an even more explicit warning:

> All you that are warm both in Body and Purse,
> I give you this warning for better or worse,
> Be not there in the Moonshine, pray take my advice
> For slippery things have been done on the Ice.
>   Maids there have bin said
>   To lose Maiden-head,
> And Sparks from full Pockets gone empty to Bed.
> If their Brains and their Bodies had not bin too warm,
> 'Tis forty to one they had come to less harm.[57]

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[53] *Britains Wonder*, 1-2.

[54] *Freezland-Fair, or the Icey Bear-Garden. A new Ballad: To the Tune of Packington's Pound* (London: Printed for Charles Corbet, 1685), 1.

[55] *A Winter Wonder, Or, The Thames Frozen Over; With Remarks on the Resort there* (London: Printed for J. Shad, 1684), 1-2.

[56] *Great Britains Wonder*, 2.

[57] *Blanket-Fair, or the History of Temple Street. Being a Relation of the merry Pranks plaid on the River Thames during the great Frost* (London: Printed for Charles Corbet, 1684), 1.

Many ballads and poems published during the frost also expressed concern that the plight of the poor and the chastisement of God were lost among the revels.

Despite the widespread attention attracted by the Great Frost, only a few writers wrestled with questions of environmental change and causation. Like others before him, the author of *A Winter-Wonder* compared the bitter cold to that of Russia and the arctic: "*Greenland*, *Muscovy*, sure their Cold have lent, / And all their Frigid Blasts have hither sent, / Whilst *Boreas* with his keenest Breath has blown, / To make our Winter cold, as is their own."[58] By 1683, many Londoners were aware that the historical record included numerous frosts and examples of frozen rivers, and the Great Frost of 1676 remained a fresh memory. Broadsheets like *Wonders on the Deep* reinforced such notions by including a "brief *Chronology* of all the Memorable (strong) Frosts, for almost 600 Years."[59] The author of *A Strange and Wonderfull Relation* suggested that "Prodigious Observations of Natures Effects" characterized "the Island and Age wherein we live," but he declined to speculate about the origin of the late frost. "[W]hether the present unparraleld Frost, may be Attributed to the effects of Natural Causes, or not rather to the Scourging Hand of an Offended God," he wrote, "I shall not determine;

[58] *A Winter-Wonder*, 2.

[59] *Wonders on the deep; Or, The most Exact Description of the Frozen River of Thames; Also to what was Remarkably Observed thereon in the last great Frost, which began about the middle of December, 1683. and ended on the 8th. of February following. Together with a brief Chronology of all the Memorable (strong) Frosts, for almost 600 Years. And what happened in them to the Northern Kingdoms* (London: Printed by M. H. and J. M. for P. Brooksby, 1684), 1.

though the consequences . . . seem to proclaime the latter."[60] The author of *Great Britains Wonder* questioned whether the frost was a portent of additional change: "Though such unusual Frosts to us are strange, / Perhaps it may predict some greater Change; / And some do fear may a fore-runner be / Of an approaching sad Mortality."[61]

Physician John Peter penned the most careful examination of the cause of the frost in a brief 1684 pamphlet titled *A philosophical account of this frost*. Psalm 147:17—"He casteth forth his Ice like Morsels; who can stand before his Cold?"—appears on the title page, but Peter proffered no theological explanation for the frost. Nor did he propose an explanation from astrology or Aristotelian meteorology. "In undertaking to Salve the *Phaenomena of Meteors*," he thundered, "I shall not look back into the *Aegyptian Darkness* of the *Peripatetick* [Aristotelian] *Philosophy* . . . to ingulf my self and you in untelligible *Notions*." Instead, Peter adopted a corpuscular theory of cold that emphasized the natural exhalation of sulfur and salts. He proposed that "*Particles* of Cold," lifted aloft by the winds, transmitted temperature from one climate to another:

> The *Particles* of Cold being conceived in the Frozen *Womb* of the Earth (in that *Climate*, where the enlivening and thawing *Beams* of the Sun seldom or never approach) passing through the *Pores* of the Earth into the Airy *Region*, are brought to us through the *Air* (their proper Vehicle) by certain peculiar *Winds*,

[60] *A Strange and Wonderfull Relation Of many Remarkable Damages Sustained, both at Sea and Land, by the present Unparraleld Frost* (London: Printed for J. How, 1684), 2.

[61] *Great Britains Wonder*, 2.

> which in their Motion, meeting with Liquid *Watery Bodies*, do co-agulate them; by which means those Bodies we call *Ice*, *Snow*, *&c.* are constituted.[62]

Unfortunately, he did not explain why the winter of 1683 brought so many corpuscles of cold to England. The most reasonable inference from the text is that the northerly winds were stronger than usual: "the Minute Keen *Particles* of Cold are in such swarms brought to us by the Northern Winds, their peculiar *Vehicle* for this *Climate*." Peter suggested that warmth would return when "the *Southern Winds* shall fill our *Hemisphere* with the *Particles* of Heat and Moisture . . . unhinging and unriveting the *Atomes* of *Cold*."[63]

The earth seized the attention of natural philosophers again in 1692 when violent tremors rattled Jamaica, England, Flanders, and Sicily in the span of seven months. The nonconformist preacher Thomas Doolittle dubbed it "The trembling year 1692."[64] On June 7, a catastrophic earthquake destroyed Port Royal, Jamaica. In two letters later published in England, Reverend Emmanuel Heath described the "great Calamity that hath befallen this Island by a Terrible Earthquake . . . which hath thrown down almost all the Houses, Churches, Sugar-Works, Mills, and Bridges through the whole Country."[65]

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[62] John Peter, *A Philosophical Account of This Hard Frost* (London: Printed for Samuel Smith, 1684), 3.

[63] Ibid., 1-5, 8.

[64] Thomas Doolittle, *Earthquakes Explained and Practically Improved: Occasioned By the late Earthquake on Sept. 8. 1692. in London, many other parts in England, and beyond the Sea* (London: Printed for John Salusbury, 1693), 140-41.

[65] Emmanuel Heath, *A full Account of the Late Dreadful Earthquake At Port Royal in Jamaica* (London: Printed for Jacob Tonson, 1692), 1-2. See also [Captain] Crocket, *A True and Perfect Relation of that most Sad and Terrible Earthquake, at Port-Royal in Jamaica, Which happened on Tuesday the 7th of June, 1692* (London: Printed

The letters were licensed for publication on September 9, 1692—one day after a series of tremors shook southeastern England and northwestern Europe. According to Nathaniel Crouch's *General History of Earthquakes*, the ground shook for a few short moments and did relatively little damage, though it provided ample material for Sunday sermons.[66] In January 1692/3, Sicily, Malta, and Calabria convulsed in a paroxysm of destruction that left some thirty-seven cities in ruin and more than sixty thousand dead. One Italian priest, who wrote the most detailed narrative of the earthquake, mourned, "a

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by R. Smith, 1692), 1; John Tutchin, *The earth-quake of Jamaica describ'd in a Pindarick poem* (London: Printed by R. Baldwin, 1692); *The Truest and Largest Account of the Late Earthquake in Jamaica, June the 7th. 1692. Written by a Reverend Divine there to his Friend in London. With some Improvements thereof by another Hand* (London: Printed for Thomas Parkhurst, 1693).

[66] For examples of the earthquake sermons, see: Walter Cross, *The Summ of Two Sermons on the Witnesses, and the Earthquake That Accompanies their Resurrection. Occasion'd from a Late Earthquake, Sept. 8. And Preach'd on the Fast following, Sept. 14* (London: Printed by Jonathan Robinson, 1692), 2; Samuel Doolittle, *A Sermon Occasioned by the Late Earthquake Which happen'd in London, And other Places On the Eighth of September, 1692. Preached to a Congregation in Reading* (London: Printed by J.R. for J. Salusbury, 1692), 22. For narratives of the September 1692 earthquake(s), see: Richard Burton [Nathaniel Crouch], *The General History of Earthquakes* (London: Printed for Nathaniel Crouch, 1694), 125-26; *A True and Impartial Relation of a Wonderful Apparition that Happen'd in the Royal Camp in Flanders, the beginning of this Instant September 1692. concerning King William. In a letter to a Gentlemen in London, from his Friend, a Captain in the King's Camp* (Edinburgh: n.p., 1692), 1; John Ray, *Three Physico-Theological Discourses, Concerning I. The Primitive Chaos, and Creation of the World. II. The General Deluge, its Causes and Effects. III. The Dissolution of the World, and Future Conflagration. Wherein Are largely Discussed the Production and Use of Mountains; the Original of Fountains, of Formed Stones, and Sea-Fishes Bones and Shells found in the Earth; the Effects of particular Floods and Inundations of the Sea; the Eruptions of Vulcano's; the Nature and Causes of Earthquakes: With an Historical Account of those Two late Remarkable Ones in Iamaica and England*, 2 ed. (London: Printed for Sam. Smith, 1693), 210-16.

more astonishing, a more universal, or a more swift Destruction was never known. And *Sicily*, that was one of the beautiful'st, richest, and fruitful'st Islands in the World, is now a heap of Rubbish, and a continued Desolation."[67]

Many scholars surmised that the contemporaneous earthquakes of 1692/3 shared a common origin. One Protestant minister from France, known only as J. D. R., wrote, "The Earth was no sooner shook on the 8*th.* of *September* last, but that, that stupendious Event became the common Argument of the Discourse and Writings of the Learned Men of this Nation."[68] The March 1693 edition of the *Monthly Mercury* newsmagazine reported, "This year is a General Year for Earthquakes; they have been felt almost over all *Europe*."[69] Samuel Doolittle, a preacher like his father Thomas, also adopted the

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[67] *An Account of the Late Terrible Earthquake in Sicily; With most of its Particulars. Done from the Italian Copy Printed at Rome* (London: Printed for Richard Baldwin, 1693), 34-35; W. B., *A Dreadful Account of a most Terrible Earthquake, Which lately happened in Italy, Wherein Thirty Seven great Cities and Towns were totally Destroy'd, and One Hundred and Twenty Thousand of Men, Women, and Children Perished, &c.* (London: Printed by W. Downing, 1693), 1; Vincentius Bonajustus and Marcellus Malpighius, "An Account of the Earthquakes in Sicilia, on the Ninth and Eleventh of January, 1692/3. Translated from an Italian Letter wrote from Sicily by the Noble Vincentius Bonajutus, and Communicated to the Royal Society by the Learned Marcellus Malpighus, Physician to his present Holiness," *Philosophical Transactions* 18 (January 1, 1694): 10.

[68] J. D. R., *The Earth twice shaken wonderfully: Or, An Analogial Discourse of Earthquakes, its Natural Causes, Kinds, and manifold Effects; Occasioned By the last of these, which happened on the Eighth Day of September 1692. at Two of the Clock in the Afternoon. Divided into Philosophical Theorems, pick'd out of many Famous, Modern, and Ancient Treatises. Translated into English* (London: Printed for the Author by Edward Cooke, 1693/4), A3r-A3v.

[69] "Reflections upon the Advice from *Rome* and *Italy*," *The Present State of Europe, Or, The Historical and Political Monthly Mercury* 4, no. 3 (March 1693): 89-91. Also see Richard Burton [Nathaniel Crouch], *General History*, 163-64.

term “general” to distinguish the late tremors from those of local, or “particular,” significance.[70] The mechanics of the general earthquake were a mystery. Some, like minister Robert Fleming, believed no natural process could explain such disparate events.[71] Others, like Charles Hallywell, a student at Christ’s Church College, suggested that an “Earthquake may sensably be felt in divers Countries” because “the Earth is perforated throughout with innumerable Burrows and Cavities.”[72] Still others proposed that excessive rainfall and unusual temperatures could instigate tremors.[73] Echoing Godfrey Goodman, the author of *The Late Dreadful Earthquake* wondered whether the destruction of Sicily reflected the “Craziness of this Globe,” as it “yield[s] to the Injuries of time.”[74] All, however, shared the perception that the tremors were unprecedented.

The spring of 1698 once again brought bitterly cold and snowy weather to northern Europe and the British Isles. The *Monthly Mercury*, a short-lived but remarkably broad newsmagazine, described the impact of the season in England and France. “They write from *York*,” one May article explained, “that it freez’d in those Parts Two Days before *Easter* as hard as in the depth of Winter, and that the Snow fell Two Foot deep, which has not been known at this time of the Year since the Memory of

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[70] Doolittle, *A Sermon*, 19-20.

[71] Robert Fleming, *A Discourse of Earthquakes* (London: Printed for Thomas Parkhurst, 1693), 17-19.

[72] Charles Hallywell, *A Philosophical Discourse of Earthquakes: Occasioned by the Late Earthquake, September the 8th. 1692* (London: Printed for Walter Kettilby, 1693), 24-25.

[73] John Ray, *Three Physicotheological Discourses*, 209-10; *An Account of the Late Terrible Earthquake*, 5-6.

[74] *An Account of the Late Terrible Earthquake*, 5-6.

Man." The editor warned, however, that "in regard the Effects of these Disorders of the Celestial Influences have been felt no less in *Holland*, *France*, and other Parts, *England* has no reason to complain."[75] France faced similar obstacles: "The bad Season has very much endamag'd the Fruits of the Earth in *Orleanois*, *Guyonne*, *Lyonnois* and *Champagne*."[76] Rumors of highway robbery, hoarding, and profiteering took hold: "The unseasonable Weather, which has continu'd almost all the Year, and which caus'd People to fear a bad Harvest, and a worse Vintage, made several People let out their Barbs, and their Cellars, that they might not sell their Goods, till the Price was considerably risen." To forestall a crisis, the Council "put forth a Decree, which orders the Intendants of Provinces to cause to be sold the Corn and Wine of those who have monopoliz'd either the one or the other into Magazines, with a Design to make their Advantages of when the Prices come to be rais'd, by reason of the Inconstancy of the Season."[77]

Natural philosophers responded to the frost by proposing at least five theories of climatic change. Only tantalizing details of these theories remain, but the *Monthly Mercury* reported that the unseasonable weather had "very much exercis'd the Brains of

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[75] "Advice from *England*," *The Present State of Europe, Or, The Historical and Political Monthly Mercury* 9, no. 5 (May 1698): 204.

[76] "Advice from *France*," *The Present State of Europe, Or, The Historical and Political Monthly Mercury* 9, no. 6 (June 1698): 237-38.

[77] "Advice from *France*," *The Present State of Europe, Or*, *The Historical and Political Monthly Mercury* 9, no. 5 (May 1698): 198-99; "Advice from *France*," *The Present State of Europe, Or, The Historical and Political Monthly Mercury* 9, no. 7 (July 1698): 273.

our Philosophers and Astronomers." "The Weather has been very irregular for a long time," the editor acknowledged, "all People are sensible of it; but no body perhaps has yet penetrated the true Reason of it." The proposed theories apparently amused him: he penned the century's longest disquisition on theories of climatic change—two pages, largely drawn from the ideas of an unnamed French musician. "I must confess," he mused, "those Artists are Excellent at sweetening of Discords."[78]

The musician and the editor identified five theories of climate change, including universal decay. The first theory proposed that a planet circuited the Earth perpendicular to the horizon, which it crossed once per century. As the planet nears the horizon, it "stops the Vapours rais'd from the Earth, and hinders the Sun from dissipating 'em, not being able to penetrate with his Beams a thick and squeez'd Mass of Air." The second theory, a form of universal decay, "attributes these Changes to the declining and end of every Age." The third drew from the same well of ideas as John Peter, proposing that "Nitrous Fumes" were "the chief Cause of these Alterations." The fourth, and most interesting, theory seized upon the notion that the "General Earthquake" had shifted the Earth upon its axis, relocating Europe and the British Isles to climates farther north.[79]

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[78] "Reflections upon the Advice from *France*," *The Present State of Europe, Or, The Historical and Political Monthly Mercury* 9, no. 7 (July 1698): 277-79.

[79] Aristotelian meteorology also proposed a relationship between tremors and the atmosphere, attributing earthquakes to the violent combustion or escape of vapors and exhalations trapped within the earth. Thomas Pigot's 1683 article about a mild earthquake in Oxford, which happened to coincide with the first chills of the Great Frost, may have piqued interest in the subject. Pigot, however, only hinted at a possible relationship, one involving exhalations trapped beneath the snow. Pigot, "An account of the *Earthquake*," 319-20.

The May issue explained, “Some say, the late Earthquake has shogg’d the Northern Parts of the World, and remov’d ‘em at a farther distance from the Sun. But they who affirm the Earth to move about the Sun, and not the sun about the Earth, reject this Conjecture as altogether absurd.” The July issue added: “Others will have it to be the Earthquake in 1692. which remov’d the spacious Continent between the Mediterrranean and the Northern Ocean, which composes our Temperate Zone, some Degrees from the Equator.”[80]

The editor rejected all four theories for a variety of reasons and proposed one of his own: an expansion of Arctic sea-ice in 1692 cooled the air descending from the North. “[T]his not being every Year alike,” he explained, “we are now sensible of the Sharpness of the Cold and Fogs which this unusual Ice sends among us.” Unfortunately, he offered no explanation for the expansion of the ice. “Our only Succour,” he explained, is “that frequent Storms may happen between the Tropicks, in the Months of *July* and *August*, which may afford us Winds sufficient to melt that unusual Ice, and hedge it in again within the Fourscorth Degree, before the Sun is gone into the other Hemisphere, and that our Countries may reassume their former Vigour.”[81]

The “General Earthquake” theory of climatic change grew so popular (and so widely mocked) that it became shorthand for a ridiculous or unknowable question. In a

[80] “Advice from *England*,” *The Present State of Europe, Or, The Historical and Political Monthly Mercury* 9, no. 5 (May 1698): 204; “Reflections” (July 1698), 277-79.
[81] Ibid.

September 1698 letter to English diplomat Joseph Williamson, Miles Cooke, a Master of the Chancery, made a joke about the ever-changing health of the Spanish King, "who hath been dead oftener than ever my lord of Oxford was." "It [has] become a moot point amongst the politicians how far we shall get by the one or lose by other," he explained, "and as doubtful as it is, amongst the astronomers, to know how many degrees the general earthquake, some years since, hath put back the terrestrial globe towards the north, which is the reason (till another shall shake it in place again) that we shall have no more ripe grapes."[82]

Several climatic theories also appeared in the anonymous 1699 pamphlet, *A Letter from Holland*. Published by London stationer D. Edwards, who affixed his name to few books, the letter describes the purported Arctic voyage of one John Vander Scheidam, a Dutch sailor. "It has been a common Observation," the pamphlet's author explained, "that for about ten years last past, the Summers have been very unseasonable, which has caused great Scarcity in all the more Northern Parts of *Europe*, but more particularly in those Countries that are seated nearer the North Pole." Like the editor of the *Monthly Mercury*, the pamphlet's author ridiculed prevailing notions of climatic change:

> Of this, our Astrologers have Assigned various Reasons; Some have attributed it to a particular Effect of some Constellations, but never could satisfie any Body what they were, and so left it wrapt up in unintelligible Universalities? Others who would be thought more Pious, making Reflection upon the great

[82] Miles Cooke to Joseph Williamson, London, 27 September 1698, SP 32/11, f. 9.

> Innundation of all sorts of immorality, and the great Growth of Libertinism and Atheism, have attributed it to a particular Judgment of God Almighty.[83]

He reserved particular scorn for the "General Earthquake" theory of climate change:

> Others, of which there have not been a few here in *England*, have arrived to that pitch of Madness, that rather than agree with the above-mentioned Reasons, have had the Impudence to assert, That the Earth was remov'd from its Center; and that by an Earthquake we were all removed several Degrees more Northward, and that we should remain in that Posture till another Dream'd of Earthquake removed us back; and that till then, *France* would remain in the Climate that *England* formerly was in; *England* where *Scotland*, and so of other Parts . . . .

This, the author mused, was "a melancholy Theme for our great Claret Drinkers, who were not till then to expect any more *Burdeaux* Wine."[84]

The pamphlet includes an extract from a letter written by John Vander Scheidam, an "antient Skipper of *Amsterdam*, who had a long time followed the *Greenland* Trade."[85] The pamphlet's author hoped the letter would "in a great measure clear up the Difficulty, and at the same time give us a pleasant Prospect of happy Seasons for the future." Called out of retirement, the seventy-year old skipper led two fishing expeditions to the "antient" fishing grounds of the far north. "According to his directions," the letter explains, "a Fleet was equipped early the Spring of this current

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[83] *A most impartial Account sent in a Letter from Holland; To a Person of Quality in London, Concerning John Vander Scheidam, A Dutch Skipper, Who in his Voyage to the North, met with most Terrible unknown Monsters; most Wonderful Mountainous Icy Islands, upwards of a degree or 60 Miles in Length, which shews by undeniable Arguments, to have been the Real Cause of the late Ten Years Cold, and unseasonable Weather in England, Scotland, &c. With his prospect of a prosperous fair Weather for the future; Confuting the Splenatick Predictions of J. Partridge, &c.* (London: D. Edwards, 1699), 1.

[84] Ibid.

[85] In the context of this document, "Greenland" refers to Spitsbergen.

year 1699, and our Noble Pilot Embarqued in the *Golden-Lyon* of *Amsterdam*." Upon reaching the North Cape of Norway, his crew laid eyes upon a remarkable scene:

> [O]ne of the Seamen who was on the Main-top, cryed out, he saw a wonderful sight of Castles, Towns, and Mountains, directly before them in their Course, most of them were amazed, and some thought he was Mad; But after they had few Leagues pursued their Course, they plainly discovered them to be floating Islands of Ice; the Wind which then was violent, beat them one upon another, which made such a dreadful Noise, Yelling and Cracking, that a thousand Cannons discharged all at once, would be a small Imitation of it.

The sailors observed a wide variety of wildlife on the icy islands, including "some Shaggy Animals bigger than Bears, unknown in these Parts, who made a fearful Roaring." The skipper navigated the icy waters and eventually reached the ancient fishing grounds, where he discovered whales of "prodigious" size and dispatched the letter found in the pamphlet. "From this Relation," the author explained, "we may with the greatest probability imaginable infer, the True Cause of the late Cold Summer":

> [T]he Winds coming from those Parts over a vast Ocean, Frozen into a solid thick Mountains of Ice, for above six hundred Leagues or upwards, and being of perpetual continuance for several years past, could not but cause in these Parts Cold Weather; as the Wind coming from the hot and parched Countries of the South, causes heat.

"Now the Ice being broken to the usual distance," he concluded, "will by degrees dissolve, and so the same Seasons return."[86]

It is unclear whether John Vander Scheidam actually existed. His name, regardless of spelling distinctions, appears in no known English or Dutch text. Only one copy of the pamphlet, in the British Library, is known to exist, and only one scholar has

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[86] Ibid., 1-2.

published comments about it—a five-sentence letter to the editors of the literary journal, *The Scriblerian and the Kit-Cats*. Maximillian Novak, Professor Emeritus at UCLA, suggests that the pamphlet describes “an imaginary voyage using a realist technique.”[87] English and Dutch shipping records reveal that several vessels carried the name *Golden Lion* in the late seventeenth century.[88] Only the discovery of D. Edward’s source material, the original Dutch publication, will reveal the truth about the ancient skipper’s voyage. The pamphlet itself, however, demonstrates that unseasonable weather and the potential for climatic change captured the attention of the literate public in the late seventeenth century.

In 1698, scholars proposed at least five explanations for apparent changes in the weather and climate. Some were more rational than others, but most attributed the bitter conditions of the Little Ice Age to instruments of nature—the Sun, the Sea, the Ice, the Air. Armed with the methodology of Robert Hooke and the perspective of Christopher Wren, subsequent scholars would learn that each of these contribute to the countenance of the Earth’s climate. Eighteenth-century scholars would apply the lessons of their

[87] Maximillian Novak, letter to the editor, *The Scriblerian and the Kit-Cats* 22 (1989): 232-33.

[88] *Gouden Leeuw*, of course, was the name of Cornelis Tromp’s flagship at the Battle of Texel. At least one ship engaged in the herring trade sailed under the name Golden Lyon in 1703. Held under embargo in Bideford, Cornwall, the ship’s owners petitioned Queen Anne to permit them to proceed on their journey to Livorno. Robert Balle, petition, 4 March 1702/3, PC 1/1/5/276.

predecessors to the study of the ancient and medieval past. They sought the answer to a new question: Is climate change predictable?

CHAPTER VII

THE UNFASHIONABLE GARB OF TRUTH:

WEATHER AND CLIMATE IN THE EIGHTEENTH CENTURY

The most celebrated storm of the early modern era peaked on November 26, 1703. Savage winds and rain lashed southeastern England and London for seven straight days, toppling well-built structures, upending ships, and uprooting trees (17,000 in Kent alone). According to English author Daniel Defoe, who published the most complete account of the storm, it was "the Greatest and the Longest Storm that ever the World saw." "No Pen can describe it," he wrote, "no tongue can express it, no Thought conceive it, unless some of those who were in the Extremity of it."[1] Perhaps no tongue could express the terror of a seven-day tempest, but Defoe's publication of *The Storm* marked a turning-point in meteorological literature. Objective, detailed, and clearly-sourced, the 272-page treatise exemplified the scientific analysis of weather and climate celebrated by Christopher Wren and Robert Hooke. Over the course of the long eighteenth century, natural philosophers developed increasingly detailed explanations of weather phenomena, while historians worked to unravel the history of climate. By the beginning of the nineteenth century, few scholars remained skeptical of climatic change,

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[1] Daniel Defoe, *The Storm, or A Collection Of the most remarkable Casualties and Disasters, Which happen'd in the late dreadful Tempest, Both by Sea and Land, On Friday the Twenty-sixth of November, Seventeen Hundred and Three*, 2nd ed. (London: Printed for George Sawbridge and J. Nutt, 1705), 41, 68-70.

and many concluded that human settlement patterns and agriculture were ultimately responsible.

The Great Storm of 1703 followed on the heels of several unusually wet months. The first signs of the impending storm arrived on Wednesday, November 24. Violent wind and squalls of rain buffed England for two days before conditions took a dramatic turn for the worst. Late Friday evening, barometric pressure in London plummeted. Defoe wrote that, "about 10 a Clock, our Barometers inform'd us that the Night would be very tempestuous; the *Mercury* sunk lower than ever I had observ'd it on an Occasion whatsoever, which made me suppose the Tube had been handled and disturb'd by the Children." The storm worsened after midnight; by 2:00 a.m. few people were "so hardy" as to remain in bed. "The Fury of the Tempest increased to such a Degree," Defoe wrote, "that as the Editor of this Account being in *London*, and conversing with the People the next Days, understood, most People expected the Fall of their Houses." Even fewer dared venture outside:

> [N]o body durst quit their tottering Habitations; for whatever the Danger was within doors, 'twas worse without; the Bricks, Tiles, and Stones, from the Tops of the Houses, flew with such force, and so thick in the Streets, that no one thought fit to venture out, tho' their Houses were near demolish'd within. . . . [W]here there was room for them to fly, the Author of this has seen Tiles blown from a House above thirty or forty Yards, and stuck from five to eight Inches into the solid Earth.[2]

The storm worsened in the early hours of the morning, blowing with its "greatest violence" between 5:00 and 6:30 a.m. "[T]he Fury of it was exceeding great for that

[2] Ibid., 24-33.

particular Hour and half," Defoe reported, "that if it had not abated as it did, nothing could have stood its Violence much longer." Although its strength abated after 8:00 a.m. Saturday morning, thunderstorms and extreme winds lasted for four more days. "It might be called one continued Storm from *Wednesday* Noon to *Wednesday* Noon," Defoe explained, "in all which time, there was not one Interval of Time in which a Sailor would not have acknowledged it blew a Storm."[3]

Defoe contributed to *The Storm* a brief chronology of the tempest, as he experienced it, and a rough assessment of the extent of its damages. Uniquely, he invited submissions from witnesses "who were willing to contribute to the forwarding of this Work, and to transmit the Memory of so signal a Judgment to Posterity." He published more than seventy letters submitted by sailors, clergymen, and laymen from throughout the English countryside and the surrounding seas. Most of the contributors signed their submissions, giving leave to "hand their Names down to Posterity with the Record of the Relation they give." As such, Defoe felt comfortable publishing their accounts in full. "I am perswaded," he explained, that "they are all dress'd in the unfashionable Garb of Truth, and I doubt not but Posterity will read them with Pleasure."[4]

Defoe offered no clear assessment of the cause of the storm, but he apparently found much humor in the fact that the mechanics of weather continued to vex the minds

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[3] Ibid., 33-40.
[4] Ibid., 83-84.

of natural philosophers. "Those Ancient Men of Genius," he wrote with delightful excess, "who rifled Nature by the Torch-Light of Reason even to her very Nudities, have been run a-ground in this unknown Channel; the Wind has blown out the Candle of Reason, and left them all in the Dark."[5] "'Tis apparent," he crowed, "that God Almighty, whom the Philosophers care as little as possible to have any thing to do with, seems to have reserv'd this, as one of those Secrets in Nature which should more directly guide them to himself." Despite his evident delight, Defoe clearly recognized that philosophical inquiry brought real benefits to mankind, and he suspected that the atmosphere may yet reveal its secrets:

> I make no Question, the Search would be equally to the Advantage of Science, and the Improvement of the World; for without Doubt there are some Consequences of known Causes which are not yet discover'd, and I am as ready to believe there are yet in Nature some *Terra Incognita* both as to Cause and Consequence too.[6]

"The Christian begins just where the Philosopher ends," Defoe mused, "and when the Enquirer turns his Eyes up to Heaven, Farewel Philosopher; 'tis a Sign he can make nothing of it here."[7]

While natural philosophers wrestled with the origin of winds, questions of climatic change began to intrude upon the religious life of common folks. The first two decades of the eighteenth century witnessed a spirited debate over baptism that eventually lapsed into a discussion of climate and climatic change. William Wall, the

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[5] Ibid., 2.
[6] Ibid., 5.
[7] Ibid., 4-6.

Vicar of Shoreham in Kent, and John Gale, a Baptist theologian, published several pamphlets between 1705 and 1720 concerning the history of infant baptism.[8] Although the two differed on many issues, they agreed that fears of climatic change were encouraging some to reassess baptismal traditions. Both agreed that the Bishop of Salisbury, Gilbert Burnet, was responsible for encouraging such notions. Gale explained:

> I am necessitated humbly to take notice of the excuse which the most judicious and learned bishop of Sarum has thought fit to make, for changing the manner of baptizing by *dipping* into that of *sprinkling*. His lordship . . . says, 'The danger of *dipping* in cold climates may be a very good reason for changing the form of baptism to *sprinkling*.' This excuse is now become very common, and however insufficient it may seem in itself, has gathered considerable force by being used by men of his lordship's good sense and learning.[9]

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[8] Four of these are particularly useful: William Wall, *The History of Infant-Baptism, In Two Parts. The First being An Impartial Collection of all such Passages in the Writers of the four first Centuries as do make For, or Against It. The Second, Containing several things that do illustrate the said History*, 2 vols, 2 ed. (London: Printed by J. Downing for R. Sympson and H. Bonwick); William Wall, *The History of Infant-Baptism. In Two Parts. The First, being An Impartial Collection of all such Passages in the Writers of the Four first Centuries as do make For, or Against it. The Second, Containing several Things that do help to illustrate the said History*, 2 vols, 2 ed. (London: Printed by Joseph Downing for Richard Burrough, 1707); John Gale, *Reflections on Mr. Wall's History of Infant-Baptism. In Several Letters to a Friend* (London: Printed by J. Darby, 1711); William Wall, *A Defence of the History of Infant - Baptism Against the Reflections of Mr.* Gale *and Others. With An Appendix containing the Additions and Alterations in the Third Edition of the History of Infant - Baptism, that are most Material* (London: Printed for R. Bonwicke, T. Goodwin, J. Walthoe, S. Wotton, S. Manship, R. Wilkin, B. Tooke, R. Smith, and T. Ward, 1720).

[9] Gale, *Reflections*, 215.

Wall agreed that Burnet was responsible for such ideas, but he suggested that England's climate was "no colder than it was for those Thirteen or Fourteen Hundred Years from the beginning of Christianity here, to Queen *Elizabeth*'s Time."[10]

French diplomat and historian Jean-Baptiste Dubos penned an influential discussion of climatic change as part of his *Réflexions critiques sur la poésie et sur la peinture* (1719). French stationers republished the two-volume study of art and aesthetics in almost every decade of the eighteenth century; Thomas Nugent translated the fifth edition into English in 1748.[11] Dubos was in thrall to the popular notion that climate and the temper of the air shaped the character of nations—an ancient idea perfected by Jean Bodin in the sixteenth century.[12] The theory appeared to break down when one compared the inhabitants of modern Rome and Holland to those described in ancient histories and chronicles. The transformation of northwestern Europe was particularly perplexing:

> The Batavians and ancient Frieslanders (it will be still objected) were two warlike nations, who took up arms, as soon as the Romans attempted to lay any other tribute upon them, but that of military service. The present inhabitants of the province of Holland . . . are intirely addicted to commerce. They surpass all other people in the regularity and order of their towns, and in their *municipal* government. The people are readier to pay the heaviest taxes that are raised in

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[10] Wall, *Defence*, 144.

[11] Abbé Dubos, as he is better known, served as the secretary of the Académie Française from 1723 until his death in 1742. Jean-Baptiste Dubos, *Réflexions critiques sur la poésie et sur la peinture*, 2 vols (Paris: Jean Mariette, 1719), 2:261-86; Jean-Baptiste Dubos, *Critical Reflections on Poetry and Painting*, 2 vols (London: Printed for John Nourse, 1748), 2:204-23.

[12] Jean Bodin, "The Correct Evaluation of Histories," Chap. 5 in *Method for the Easy Comprehension of History*, trans. Beatrice Reynolds (New York: Columbia University Press, 1945).

> Europe, than to enter into the service. *The Belgians are very unfit for land service, and a Dutchman on horseback is a most ridiculous sight*, says Puffendorf, speaking of the present inhabitants of Holland, who are as willing to take foreign troops into their pay, as the Batavians were ready formerly to fight for foreigners.[13]

Dubos attributed the changed character of modern nations to "the physical alteration of the air," an alteration which included change in temperature.[14]

Like Justus Lipsius in 1601, Abbé Dubos turned to the historical record to search for evidence of meteorological change. Unlike Lipsius, he found what he was seeking. "Another proof we have, that there has been a physical alteration in the air of Rome and the adjacent country," Dubos wrote, using the term *climat*, "is, that the climate is not so cold as it was formerly in the time of the Caesars, tho' the country was better inhabited and cultivated at that time, than it is at present."[15] He found in Juvenal and Horace numerous references to snow and ice that suggested such conditions were more typical of the past than the present. "We should have been better informed concerning this subject had the ancients understood the use of Thermometers," Dubos explained, "but tho' their writers have not instructed us with respect to this point, they let us know enough to be convinced that the winters were formerly severer at Rome, than at present."

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[13] Dubos, *Reflections*, 2:204-05.

[14] Ibid., 2:209.

[15] Abbé Dubos used the French term *climat* when discussing long-term changes in air temperature. The French edition reads, "Ce qui prouve encore qu'il est survenu un alteration physique dans l'air de Rome & des environs, c'est que le climat y soit moins froid aujourd'hui qu'il ne l'etoit du tempts des premiers Cesars, quoique le pays fut alors plus habité & mieux cultivé qu'il ne l'est aujourd'hui." Dubos, *Reflexions critiques*, 2:268; Dubos, *Reflections*, 2:209-10.

"The Tiber is no more frozen there," he quipped, "than the Nile at Grand Cairo." As for Holland, Dubos proposed that the Dutch "do not live upon the same ground as the Batavians and ancient Frieslanders, tho' they inhabit the same country." Deforestation, the draining of bogs, and natural subsidence combined to produce an altogether new landscape.[16]

In a statement that would have pleased Wren and Hooke, Abbé Dubos suggested that such changes could be discerned by comparing annual temperature and precipitation records. "Experience," he wrote, "adds a great weight to this argument." He explained that there were "hardly two claps of thunder heard at Paris in the summer of 1716" while it "thundered thirty times and upwards the summer of 1717."[17] To the third edition (1733) Dubos added, "One can see in the almanacs of the Observatory the difference there is in the quantity of rain which falls in Paris in the course of one year and the quantity that falls in another year."[18] Temperature provided "quite another sort of variation":

> Some summers at Paris are intolerably hot; others are scarce a degree different from cold weather. 'Tis frequently colder on midsummer day, than it was six weeks before. The winter is sometimes very rigid in the same city; and the frost

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[16] Dubos, *Reflections*, 2:209-10.

[17] Ibid., 2:220.

[18] Translation mine. In his 1748 English translation of the fifth edition, Thomas Nugent suggested that one could "easily" find such information in almanacs. Dubos, however, never described the process as "easy." Jean-Baptiste Dubos, *Réflexions critiques sur la poésie et sur la peinture*, 2 vols (Paris: Pierre-Jean Mariette, 1733), 2:298-99; Dubos, *Réflexions critiques sur la poésie et sur la peinture,* 2 vols (Paris: Pierre-Jean Mariette, 1746), 2:298-99; Dubos, *Reflections*, 2:220.

> lasts days successively. Other years the winter slides away without three consecutive days of frost.[19]

According to Dubos, "the same may be observed of every country . . . [f]or all of them admit of a different temperature of years."[20]

Drawing on the language of Aristotelian meteorology, Dubos attributed atmospheric variability to the particular exhalations of the local environment. "The sun and the emanations of the earth decide in France, as well as elsewhere, the temperature of the different years," he wrote, "for we cannot assign any other cause, unless we should have recourse to the influence of the stars." Each region of the earth possessed a unique array of fluids and minerals that shaped the local atmosphere via exhalation or emanation. "[A]s the qualities of the earth decide the particular taste of fruits in different countries," Dubos explained, "so they determine also the nature of the air."[21]

Dubos acknowledged that some attributed climatic change to "some obstruction" of the face of the sun, "such as a spot, which may slacken his action in some years." If this were true, then the sun "would have the greatest share in producing those variations, whose cause you go in search of into the bosom of the earth." Dubos doubted, however, that the sun was responsible for the most recent incidents of climatic change:

> My answer is, that experience will not permit us to impute this variation to the sun. There would be a kind of rule in this irregularity, if it proceeded from the remissness of the action of the sun; I mean that all countries would feel this irregularity in proportion to their distance from the line, and that the sun's elevation would constantly decide the degree of heat, let it be what it will in a

[19] Dubos, *Reflections*, 2:221-22.
[20] Ibid.
[21] Ibid., 2:217-18; 2:220-21.

> particular year. Thus a warmer summer than usual at Paris, would suppose a summer unusually warm at Madrid. A very mild winter at Paris, would suppose milder weather than usual at Madrid.[22]

Experience demonstrated otherwise:

> The winter of 1699 and 1700 was very mild at Paris, and very rigid at Madrid. It froze fifteen days successively at Madrid, and not two days successively at Paris; the same summer was exceeding rainy and tolerably cold in Lombardy. The day of the summer solstice is sometimes colder than the day of the equinox. Thus the variation of the temperature of years is such that it cannot be attributed to the sun.[23]

"We must therefore impute it to a particular cause in each country," Dubos concluded, "that is, to the difference of the emanations of the earth."[24]

Dubos proved influential in the study of historical climates. Scottish philosopher David Hume published two essays on climate in 1742, one of which cited *Réflexions*. Like his French predecessor, Hume was intrigued by the changed fortunes of ancient civilizations—particularly Greece. In the essay "Of National Character," Hume acknowledged that the "manners of a people change very considerably from one age to another."[25] Unlike Dubos, however, Hume attributed such change to moral rather than geophysical causes. He found social intercourse to be particularly influential because of the "imitative nature" of the human mind.[26] Hume addressed the issue of climatic change in "Of the Populousness of antient Nations," where he recalled the "observations

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[22] Ibid., 2:221-22.

[23] Ibid.

[24] Ibid.

[25] David Hume, "Essay XXI: Of National Character," in *Essays and Treatises on Several Subjects in Two Volumes* (1742; London: Printed for A. Millar, 1764), 1:232.

[26] Ibid., 1:228.

of L'Abbe du Bos, that Italy is warmer at present than it was in antient times."[27] Hume cited several ancient references to weather and atmospheric conditions that appeared to confirm Dubos' conclusions. "Allowing, therefore, this remark to be just, that Europe is become warmer than formerly," Hume wrote, "how can we account for it?" He attributed the change to the fact that "the land is at present much better cultivated, and that the woods are cleared, which formerly threw a shade upon the earth, and kept the rays of the sun from penetrating to it."[28] In a footnote, Hume explained that the "observations of L'Abbé Dubos should be admitted, that Italy is now warmer than in former times," but he warned that such warming could be a consequence of the clearing and cultivation of neighboring territories.[29]

In 1677, English historian Robert Plot wrote of the weather that it might "be wish'd . . . that some old Almanacks were written instead of New."[30] Seventy years later, English physician and epidemiologist Thomas Short published the first lengthy history of weather, *A General Chronological History of the Air, Weather, Seasons, Meteors, &*c. *in Sundry Places and Times*. Written in the form of a chronicle, Short's history includes entries for weather events dating to the days of Genesis, though a majority of its text concerns the medieval and early modern eras. According to Short,

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[27] David Hume, "Essay XI: Of the Populousness of antient Nations," in *Essays and Treatises on Several Subjects in Two Volumes* (1742; London: Printed for A. Millar, 1764), 1:477.

[28] Ibid., 1:479.

[29] Ibid., 1:485.

[30] Robert Plot, *The Natural History of Oxford-shire, Being an Essay toward the Natural History of England* (London: Moses Pits, 1677), 4-7.

the “several and different Effects” of the “Kind or Constitution of the Weather and Season” had “not yet been so well attended to and examin’d as the Extent and Usefulness of the Subject demands.”[31] He doubted that such a task could “possibly be done whilst these Scraps of Histories lay scattered in a vast Multitude of Authors of different Designs and Professions,” including “Historians civil, ecclesiastical, and political; Physicians, Divines, Naturalists, Monks, Fryars, Journalists, Travellers, &*c*.” Unfortunately, while such passages “lay dispersed so wide in an endless Number of Books, and frequently in small fragments,” people would remain “Strangers to the only true, valuable, and proper Use of them, so highly and inestimably beneficial to Mankind.”[32] Like Wren and Hooke, Short recognized that the comparison of meteorological histories might permit scholars to “make some tolerable Guess” about the constitution of future seasons.[33]

Short was not particularly impressed with existing histories of natural events, which he found “so stuft with Theory, that they seem only intended to support a favorite Hypothesis.”[34] He was equally concerned about the difficulties accompanying the study of global weather history. “A particular continued History of this Kind over the Globe,

[31] Thomas Short, *A General Chronological History of the Air, Weather, Season, Meteors, &c. in Sundry Places and different Times; more particularly for the Space of 250 Years. Together with some of their most Remarkable Effects on Animal (especially Human) Bodies, and Vegetables* (London: Printed for T. Longman and A. Millar, 1749), 1:v.

[32] Ibid., 1:vi.

[33] Ibid., 1:vii.

[34] Ibid., 1:ix.

for a long Series of Years, is not to be expected, however much it may be wanted and desired," he wrote, because a "great Part of the inhabited World is yet unknown to us" and because the "greatest Part of the *American*, *African*, and *Asiatic* Nations, are ignorant and illiterate."[35] Short was, of course, incorrect, particularly about Asia, where Chinese scholars maintained excellent meteorological records. He also believed that too many remained unaware of the "great Worth and Use" of such study "to all People who breathe in the Air, are fed by the Products of the Earth, and have Bodies to be influenced by the Vicissitudes and Alterations, or Extremes, good or bad, of Weather and Seasons."[36] *A General Chronological History of the Air* was one of the first scholarly attempts to examine weather on an annual or monthly basis. It helped illuminate and disseminate a relatively new concept: the authentic relationship between history and climate.[37]

Historian Adam Ferguson wrote a few remarks about climate as part of a 1767 essay on the history of policy and the arts. Ferguson was primarily interested in the influence of climate, but he also explored the manner through which climate might

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[35] Ibid., 1:vii.

[36] Ibid., 1:viii.

[37] An 1871 dictionary for practitioners of insurance made specific note of Short's chronology as part of an entry on "climate." The editors suggested that Short "may be regarded as one of the first English writers who entered upon a series of obs. [observations] in regard to the climate, and its influence upon human health and longevity." See Cornelius Walford, *The Insurance Cyclopædia . . . And a Compendium of Vital Statistics* (London: Charles and Edwin Layton, 1871), 1:593.

change.[38] Ferguson's understanding of climatic change reflected the Enlightenment principle of "civilizing nature" through settlement, flood control, and cultivation.[39] He attributed changes in temperature and precipitation to the interconnected relationship of forests, lakes, and the atmosphere. In America, Ferguson explained, "extensive marshes, great lakes, aged, decayed, and crouded forests, with the other circumstances that mark an uncultivated country, are supposed to replenish the air with heavy and noxious vapours, that give a double asperity to the winter." Consequent fogs, snow, and frost carried "the inconveniences of the frigid zone far into the temperate."[40]

Other historians shared Ferguson's interest in climatic change. In *The History of Great Britain* (1771), Scottish historian Robert Henry wrote that the "climate of a country hath so great an influence on the constitutions, tempers, and manners of its inhabitants" that "it is proper to pay some attention to the accounts which are given us by the most ancient writers, of the climate of this island, in their times." Citing Diodorus Siculus, Julius Caesar, and Tacitus, Henry concluded that Gaul "must have been much colder . . . than it is at present," while Britain "seems to have been remarkably mild and temperate." He suggested that "a considerable change must have happened in the climate of one of these countries, perhaps of both." Like Ferguson, Henry suspected that

[38] Adam Ferguson, *An Essay on the History of Civil Society* (Edinburgh: Printed for A. Millar and T. Caddel, 1767), 161.

[39] Jan Golinski, "Putting Weather in Order: Narrative and Discipline in Eighteenth-Century Weather Diaries" (paper presented at the William Andrews Clark Memorial Library, UCLA, Los Angeles, CA, May 16, 1998), http://www.unh.edu/history/golinski/paper3.htm (accessed June 27, 2009).

[40] Ferguson, *Civil Society*, 173.

the change was a consequence of the transformation of the landscape, but he acknowledged that it "belongs rather to the naturalist than the historian" to account for such alteration. Historians, though, might observe "that the mildness of the air of Britain was no small happiness to its inhabitants in these times, when they were so imperfectly clothed; and contributed not a little to its being so well peopled."[41]

American physician Hugh Williamson was a naturalist, and he maintained a lifelong interest in climatic change. In 1771, he published "An Attempt to Account for the Change of Climate, Which Has Been Observed in the Middle Colonies in North-America" in the first issue of *Transactions of the American Philosophical Society*. Williamson suggested that the North American climate had changed during the eighteenth century. "It is generally remarked by people who have resided long in Pennsylvania and the neighbouring Colonies," he explained, "that within the last forty or fifty years there has been a very observable Change of Climate, that our winters are not so intensely cold, nor our summers so disagreeably warm as they have been." "It is also agreed," he added, "that the hardness of our frosts, the quantity and continuance of our snows, are very unequal now, to what they have been, since the settlement of this Province."[42]

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[41] Robert Henry, *The History of Great Britain, From the First Invasion of It by the Romans under Julius Caesar* (London: Printed for the author, 1771), 1:430-32.

[42] Hugh Williamson, "An Attempt to Account for the Change of Climate, Which Has Been Observed in the Middle Colonies of North-America," *Transactions of the American Philosophical Society* 1 (January 1769 – January 1771): 275. Benjamin Franklin founded the American Philosophical Society in 1743 and served as president during the 1770s. Williamson lived a full life, studying medicine in Europe, serving as a

Williamson introduced his readers to the fundamental principles of climate and the seasons—the rotation of the earth, the unequal distribution of land and water upon its surface, and the unequal rates through which each is heated and cooled. He skillfully applied these "trite and general reasonings" to the local climate of the Middle Colonies:

> Our coast runs nearly from North-East to the South-West, so that if the land should at any time be colder than the sea, and a current of cold air should set towards the sea, it must pass from the North-West to the South-East: But such winds we find generally take place during our winter season. For the Atlantic, to the South-Eastward, is greatly heated during the summer season, and will not soon loose that heat when the Sun goes to the Southward in the winter; add to this, a very notable circumstance, which is, that our coast is constantly washed by a current of warm water, which being driven to the West by the easterly trade winds near the Equator, is checked in the Gulph of Mexico, and obliged to escape to the North-Eastward, to give place to the succeeding current. But the surface of these colonies soon grows cold in the absence of the Sun. Hence violent torrents of winds pass towards the Atlantic during the winter season; the colder the air is over the continent, the more violent will those North-Westers be.[43]

Unravelling the mechanics of climate change in Pennsylvania required discovering the "change of circumstances, which might reduce the violence of those North-Westers, or remove them entirely."[44]

Williamson attributed the apparent change of climate to the clearing and levelling of the mid-colonial landscape.[45] "A clear smooth field," he asserted, "reflects more heat,

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member of the Continental Congress, and serving as a signatory to the United States Constitution.

[43] Ibid., 274-75.

[44] Ibid.

[45] Contemporary microclimate studies suggest that forests typically have lower annual daily temperature maxima and averages than cropland. James Wickham and Timothy Wade write, "Our empirical analysis suggests that croplands tend to be warmer than forests." See James Wickham and Timothy Wade, "Comparison of cropland and

than the same space would have done, when it was covered with bushes and trees." Such reflection warmed the local atmosphere, reducing the temperature gradient between the land and sea and weakening the northwesterly winds. Williamson acknowledged that many were skeptical of his interpretation:

> It has been objected, that the small alteration which the surface of a country undergoes in being cleared and cultivated, is not equal to producing such considerable changes of climate, as has been observed to take place in many parts of the world. I shall not say, that a change of climate may not arise from other causes than the one I have described . . . yet I cannot recollect a single instance of any remarkable change of climate, which may not be fairly deduced from the sole cultivation of the country.[46]

Others objected by highlighting literary accounts of frost and snow in late republican and early imperial Rome, when Italy remained under extensive cultivation. Like Hume, Williamson warned that such comparisons ignored the influence of the vast German and Gallic forests on the ancient Italian climate.[47]

Williamson was cautiously optimistic about the consequences of climatic change. He expected temperate weather to facilitate the expansion of pastures and meadows—but only with sufficient precipitation. He was particularly concerned about the cultivation of wheat and winter grain without a predictable, protective blanket of snow. "The vicissitudes of freezing and thawing have already become so frequent," he explained, "that it is high time for the farmer to provide some remedy, whereby he may

forest surface temperatures across the conterminous United States," *Agricultural and Forest Meteorology* 166-67 (2012): 140.

[46] Williamson, "Middle Colonies," 276.

[47] Ibid.

prevent his wheat from being thrown out in the winter season." In a paragraph seemingly lifted from today's papers, Williamson warned that American settlers would have to adjust to the new climate:

> A considerable change in the temperature of our seasons, may one day oblige the Tobacco Planter to migrate towards the Carolinas and Florida, which will be the natural retreat of that Plant, when the seasons admonish the Virginian to cultivate wheat and Indian corn. The tender Vine, which could now be destroyed by our winter's frost, in a few years shall supply the North-American with every species of wine. Posterity will doubtless transplant the several odoriferous, aromatic, and medicinal plants of the eastern countries, which must flourish in one or another part of North-America, where they will find a climate and soil favourable to their growth, as that of their native country.[48]

Despite such agricultural and social disruption, Williamson suspected that every "friend to humanity" would rejoice as warmer winters and drying swamps led to fewer fevers and healthier constitutions. In Enlightenment fashion, he compared such "salutary effects" to the "cleaning and paving [of] the streets of Philadelphia."[49]

Historian Edward Gibbon addressed climatic change as part of *The History of the Decline and Fall of the Roman Empire* (1776). Like Henry, Gibbon found it difficult to reconcile ancient descriptions of the German climate with modern observations. Based on his reading of David Hume and Abbé Dubos, Gibbon concluded that Europe's climate had changed. These "ingenious writers," he explained, had "suspected that Europe was much colder formerly than it is at present; and the most ancient descriptions of the climate of Germany tend exceedingly to confirm their theory." Frozen rivers and

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[48] Ibid., 279.
[49] Ibid., 279-80.

the geographical distribution of reindeer were evidence of this.[50] Although Gibbon devoted relatively little discussion to climate, the popularity of *Decline and Fall* undoubtedly introduced notions of climatic change to new audiences.

French naturalist and scientist Georges-Louis Leclerc, Comte de Buffon, proposed a theory of global "refrigeration" in a 1774 supplement to his *Historie naturelle, générale et particulière.*[51] Drawing on ideas of Isaac Newton, Buffon reasoned that the earth began as a sphere of molten fire—perhaps born of a comet striking the sun—which progressively cooled thereafter. Buffon tested his theory by measuring the cooling rates of spheres composed of iron and other minerals, determining that the earth was much older than prior estimates suggested. "Now if we would enquire how long it would take for a globe as large as the earth to cool," he explained, "we should find . . . it would take 42,964 years, 221 days, to cool only to the point where it would cease to burn, and 86,667 years and 132 days, to cool to the actual temperature."[52] Presumably, such cooling continued in the present.

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[50] Edward Gibbon, *The History of the Decline and Fall of the Roman Empire* (London: Printed for W. Strahan and T. Cadell, 1776), 1:218.

[51] Georges-Louis Leclerc, *Histoire naturelle, générale et particulière, Servant de suite à la Théorie de la Terre, & d'introduction à l'histoire des Minéraux. Supplément*, vol. 1 (Paris: L'Imprimerie Royale, 1774), 145-72; Leclerc, *Buffon's Natural History. Containing A Theory of the Earth, A General History of Man, of the Brute Creation, and of Vegetables, Minerals, &c. &c,* trans. J. S. Barr (London: Printed for J. S. Barr, 1797), 10:109-34.

[52] Leclerc, *Natural History*, 1:91-95; 10:113-14. For additional discussion, see Stephen G. Brush, *A History of Modern Planetary Physics: Nebulous Earth* (1996; repr., Cambridge: Cambridge University Press, 1998), 196-98; Olivier Rieppel, *Evolutionary Theory and the Creation Controversy* (Berlin: Springer-Verlag, 2011), 39; Leclerc, *Natural History*, 1:91-95; 10:113-14.

The American natural and political philosopher Thomas Jefferson dedicated one section of *Notes on the State of Virginia* (1781-82) to the examination of the state's climate. Jefferson compared recollections of eighteenth century climatic conditions to the observational records maintained at Williamsburg between 1772 and 1777. He determined that the local climate was changing:

> A change in our climate however is taking place very sensibly. Both heats and colds are become much more moderate within the memory even of the middle-aged. Snows are less frequent and less deep. They do not often lie, below the mountains, more than one, two, or three days, and very rarely a week. They are remembered to have been formerly frequent, deep, and of long continuance. The elderly inform me the earth used to be covered with snow about three months in every year. The rivers which then seldom failed to freeze over in the course of the winter, scarcely ever do so now.[53]

Like Williamson, Jefferson worried that springtime temperature fluctuations would compel tender buds to open prior to the onset of the last frost.

Irish geologist Richard Kirwan believed careful examination of meteorological records would reveal the spatial and temporal dimensions of weather and climatic change. In *An Estimate of the Temperature of Different Latitudes* (1787), Kirwan boldly asserted that meteorology began with the advent of instrumental observation. "However desirous the ancients might have been of cultivating this science," he explained, "the want of instruments necessarily denied them all access to it."[54] Kirwan described the

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[53] Thomas Jefferson, *Notes on the State of Virginia* ([Paris]: n.p., 1782), 148.

[54] Richard Kirwan, *An Estimate of the Temperature of Different Latitudes* (London: Printed by J. Davis for P. Elmsly, 1787), iii-iv.

potential benefits and challenges of meteorology in strikingly similar terms to those used by Wren and Hooke a century earlier:

> There is no science in the whole circle of those attainable by man, which requires such a *conspiracy*, if I may so call it, of all nations, to bring it to perfection as Meteorology; nor is there any, perhaps, more conducive to his security and comfort. It is not sufficient that observations should be made in one city, in one kingdom, or even in one hemisphere; but simultaneous observations must, if possible, be procured in all degrees of latitude, and longitude, in each hemisphere, in order that the correspondence, and connection of the phaenomena may be perceived. But in the present state of things, to expect all nations to be so sensible, and attentive to their true happiness, would indeed be extravagant; some ages of civilization must first elapse.[55]

Much of *Different Latitudes* is dedicated to the assembly and organization of global temperature averages, from locations as distant from England as Churchill in Canada and Manila in southeast Asia. Kirwan did, however, briefly address unusual weather conditions, including the "Causes of unusual Cold in Europe." He attributed such variability to the wind. "Since the astronomical source of heat is permanent, and the local causes of its modification undergo no annual variation," he explained, "it is evident, that this annual variation proceeds from causes equally variable." "Of these," he acknowledged, "there may be many, but at present, we know of none, that have a demonstrable influence on the weather, but winds." Kirwan suggested that unusually strong northerly or easterly winds, great precipitation and evaporation, and cloudy skies were responsible for summer distemperature. Cold winters were more difficult to explain. He attributed them to antecedently cold summers, prevailing American or

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[55] Ibid.

Siberian winds, the combination of heavy precipitation and northerly or easterly winds, the elevation of warm southerly winds by cold northerly winds, and low barometric pressure.[56]

Kirwan also alluded to the potential for climatic change, particularly in the context of North American meteorology. "[A]s the cultivated parts of America are at present much more temperate than they were a century ago," he explained, "it may be presumed, that when the country is still further cleared of woods, the climate will be still further improved, though, from the situation of the high lands, I believe it will never be so moderate as that of Europe."[57] In *Geological Essays* (1799), Kirwan suggested that falling sea levels and rising landforms were responsible for a form of climatic change in high elevations. "Trees have often been found deposited near the summits of many mountains," he wrote, "at heights in which from the degree of cold which at present prevails on them they could not grow." Therefore, he concluded, "they must have grown when the temperature of these summits was warmer, and consequently when they were less elevated over the surface of the sea, and less distant from it."[58]

Historian John Dalyell, in *Fragments of Scotish History* (1798), suggested that the Scottish historical record also provided evidence of climatic change. Dalyell found it difficult to reconcile descriptions of nakedness in ancient Scotland with the cold climate

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[56] Ibid., 107-11.
[57] Ibid., 50-51, 107-11.
[58] Richard Kirwan, *Geological Essays* (London: Printed by T. Bensley for D. Bremner, 1799), 32-39.

of its modern counterpart. "Formerly, I could not reconcile the ideas of a cold country and nakedness," he wrote, "but, since I learn the state of the natives of Cape Horn, the Streights of Magellan, and Nootka Sound, I will admit our climate is not so severe." He acknowledged, however, that Scotland "may have been warmer" in the past. Obliquely crediting Buffon, Dalyell explained that the "favourite idea of an illustrious philosopher" was "the gradual refrigeration of the earth."[59]

Although several prominent historians and natural philosophers adopted some variation of a theory of climate change, others remained rather skeptical. Lexicographer Noah Webster denounced the loosely-conceived theories of his contemporaries in a 1799 address to the Connecticut Academy of Arts and Sciences, titled "On the Supposed Change in the Temperature of Winter." "It is a popular opinion," Webster said, "that the temperature of the winter season, in northern latitudes, has suffered a material change, and become warmer in modern, than it was in ancient times." He acknowledged that "many writers of reputation" held such beliefs, including Abbé Dubos, Buffon, Gibbon, Holyoke, Hume, Jefferson, and Williams. "[I]ndeed," he admitted, "I know not whether any person, in this age, has ever questioned the fact."[60]

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[59] James Dalyell, *Fragments of Scotish History* (Edinburgh: Printed for Archibald Constable, 1798), 20-21.

[60] Noah Webster, "On the Supposed Change in the Temperature of Winter" (paper read before the Connecticut Academy of Arts and Sciences, 1799), in *A Collection of Papers on Political, Literary, and Moral Subjects* (New York: Webster & Clark, 1843), 119.

Webster addressed the evidence each author marshalled in defense of climatic change. His criticism focused on two primary errors, that of comparing incomparable (or marginally comparable) times and places, and that of defining average conditions by outliers. In one particularly thoughtful passage, Webster warned that temperature measurements were not inherently comparable due to microclimatic differences, like the urban heat island effect:

> I found by numerous observations in New York, that ice as thick as glass in our windows, was uniformly made at a mile's distance from the city, when an accurate thermometer in the coldest positions *in* the city stood at 40°. Such is the difference between the real temperature of an open country, and the artificial one of a city. The same difference will not run through the observations of the whole year, but it will amount to two or three degrees. I am inclined to believe this to be the source of great errors, in comparing meteorological observations in different countries.[61]

He further warned against "taking the accounts of a few *severe winters* as descriptions of the *ordinary winters*."[62]

Webster had no love for Jefferson, and he took particular pleasure in refuting Jefferson's notions of climatic change. "Mr. Jefferson," he explained, "seems to have no authority for his opinions but the observations of elderly and middle aged people."[63] Webster continued:

> It appears to me extremely unphilosophical to suppose any considerable change in the annual heat or cold of a particular country. We have no reason to suppose that the inclination of the earth's axis to the plane of its orbit has ever been

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[61] Ibid., 125.

[62] Ibid., 130.

[63] Ibid., 144. For an enjoyable account of Webster's and Jefferson's contributions to early American climatology, see Randy Cerveny, "Noah Webster: Lexicographer, Climatologist," *Weatherwise* (July/August 2009), 38-43.

> varied; but strong evidence to the contrary. If this inclination has always been the same, it follows that the quantity of solar rays, falling annually on a particular country, must have always been the same. Should these data be admitted, we are led to conclude that the general temperature of every climate, from the creation to this day, has been the same, subject only to small annual variations, from the positions of the planets in regard to the earth, or the operations of the element of fire in the globe and its atmosphere.[64]

Webster was also unconvinced that climatic change had influenced vegetation: "I do not find, in history, any evidence that a change of climate generally has carried any of the delicate fruits into latitudes where they did not thrive in the earliest ages."[65]

Webster asserted the uniformity of ancient and modern climates, but he missed an opportunity to identify a cooler, post-medieval period. In a remarkable passage, Webster explained:

> But Gibbon's assertion that the Rhine and the Danube, in modern ages, have not been covered with ice, strong enough to sustain loaded carriages, must not pass uncontradicted. I know not what ages precisely, that author intended to include in the description of *modern;* but both the rivers mentioned have *often* sustained men and carriages on the ice within the *last two centuries*, as well as in preceding ages. . . . I have no particular account of the effects of the rigorous cold of 1608, 1610, 1664, 1684, 1698, 1709, 1716, 1740, 1763, 1776, on those particular rivers; but the general accounts describe these and many other winters, during the last two centuries, as converting *all* rivers into highways for carriages, even as far south as Italy and Spain.[66]

Webster, so caught up in his attempt to utterly disassemble the assertions of scholars who had reasoned from limited—or incomplete—sources, completely overlooked the possibility that the "*last two centuries*" were, in fact, evidence of climatic change.

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[64] Webster, "Supposed Change," 145.
[65] Ibid., 134.
[66] Ibid., 135.

With the dawn of the nineteenth century came new emphasis on climate as an independent discipline of study. Natural philosophers and nascent climatologists published the first books about "climate," and they began applying the lessons of instrumental observation and historical research to the construction of climatic histories. John Williams' *The Climate of Great Britain*, published in 1806, was the first English book dedicated to the study of climate and "the change it has undergone." "It has been an opinion universally adopted of late years," Williams explained, "that the generality of our summers are more wet, and consequently colder, and winters less frosty and more mild than they formerly were." Agricultural reports from the countryside, which Williams attributed to "practical" and "observant" men, described the seasons as "invariably" wet and cold.[67]

Williams, however, found the prevailing explanations for climatic change unsatisfyingly dependent on superstition rather than observation and reason:

> Persons ignorant of the strong and uniform connection between cause and effect are utterly at a loss to account for it, while they acknowledge the fact; and the generality of such persons, being addicted to superstition . . . solve every difficulty by having recourse to supernatural means;—the malice of our grand enemy, or the judgments of the Almighty.[68]

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[67] John Williams, *The Climate of Great Britain; or Remarks on the Change It Has Undergone, Particularly within the Last Fifty Years. Accounting for The Increasing Humidity and Consequent Cloudiness and Coldness of our Sprints and Summers*; *With the Effects such ungenial Seasons have produced upon the Vegetable and Animal Economy*. *Including Various Experiments to Ascertain the Causes of Such Change*. *Interspersed With numerous Physiological Facts and Observations, illustrative of the Process in Vegetation, and the Connection subsisting between the Phenomena of the Weather and the Productions of the Soil* (London: Printed for C. and R. Baldwin, 1806), 3.

[68] Ibid., 3.

According to Williams, one popular explanation pinned the blame on the calendar reforms of 1752: "[T]he greater part of the observers have attributed it to that outrageously impious act of our legislature in the year 1752;—*for to change the style, with them, is to alter the season*." "To this," he explained, "has been attributed the cloudy and ungenial weather we have more or less experienced ever since, and the years of scarcity we have so frequently felt."[69]

Williams suspected that the late change of climate could not be attributed to celestial or solar causes because "we do not hear the same complaint of wet cold seasons from our neighbors." Like several of his predecessors, he was particularly interested in the potential for anthropogenic climate change. "[W]e may," he wrote, "suppose this increasing disposition to humidity in summer and mildness in winter, is owing to *some change effected on the surface of our Island*." "It will therefore be an useful and necessary inquiry," he explained, "to ascertain what changes of this nature have occurred for a series of years back, and how far they may have been affected by human art." According to Williams, Britain's exposure to Roman civilization and agriculture marked "the commencement of an improvement in the climate."[70] The more human civilization improved the land, the more they "improved" the local climate.

Williams suspected that such environmental change could have facilitated the cultivation of grapes in medieval England, as described by twelfth-century historian

[69] Ibid., 3-4.
[70] Ibid., 5.

William of Malmesbury.[71] Some of Williams' contemporaries doubted that the *vinea* of the historical record referred to grapes as the modern world understood them. They "suppose it meant not a plantation of grapes for the purpose of making wine," he exclaimed, "but an apple orchard, or currant garden!!"[72] Williams also suspected that climatic change was responsible for the abandonment of viticulture in England. He acknowledged that vineyards could have been a feature of Roman civilization that slowly faded away after their rule came to an end. He also recognized that commerce with France, and its superior wine, may have rendered local cultivation unnecessary. Williams concluded, however, that these were "auxiliary causes." The "most powerful" explanation, he wrote, "appears to be that which has been by most overlooked." Emphasizing his theory with italics, Williams asserted: *"A succession of unfavourable seasons was probably the promoting, if not the immediate cause of a general dereliction of such a profitable kind of husbandry*."[73]

Williams bolstered his argument by discussing failed attempts to reintroduce the vine to England. "Numerous trials have been made in the course of the last century to

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[71] In *Gesta Pontificum Anglorum*, Malmesbury described the prominence of viticulture in Gloucestershire: "More than the other parts of England this district is close packed with vineyards, producing a greater yield than anywhere else and better tasting wine. For its products, which are not far behind French wine in their sweetness, do not cause the drinker to wince at their bitter sourness." William of Malmesbury, *Gesta Pontificum Anglorum*, 4.153, trans. David Preest (Woodbridge, Suffolk: The Boydell Press, 2002), 196-97. For the original Latin see William of Malmesbury, *De gestis pontificum anglorum*, ed. N. E. S. A. Hamilton (London: Longman & Co., 1870), 291-92.

[72] Williams, *Climate of Great Britain*, 11.

[73] Ibid., 13.

cultivate the vine again," he explained, "but with unavailing success." "Indeed," he wrote, "latterly the summers have in general been so cool and cloudy that the grapes have seldom ripened properly, even with the advantage of a convenient wall and southern aspect." On the basis of such observation, experimentation, and historical research, Williams felt confident that climatic change had occurred:

> Admitting the authorities I have quoted to be authentic evidence, that the vine was successfully cultivated in former ages, and of the failure of such a culture in the present; it furnishes a strong proof of the increased coldness of our summers, and in a measure supplies the place of a thermometrical register of temperature in those times, enabling us to form a comparison with the present.[74]

Williams was primarily concerned with exploring the mechanics of heating, cooling, and evaporation. By examining historical records in light of present observation and experimentation, though, he also pioneered the comparative methodology that historical climatologists would later perfect.

The Climate of Great Britain did not go unnoticed. The authors of one review thought it noteworthy that Williams "not only endeavor[ed] to establish the fact" of climatic change, but also sought to explain why cooling had occurred and how it might be reversed. The subtly scathing and openly dismissive review, however, found little of favor in Williams' methodology and conclusions. Although the reviewers held that it was "the birthright of an Englishman to murmur at the uncertainty of the weather," they were not inclined to take seriously any suggestion of deteriorating climate. Echoing Noah Webster, they explained, "[W]hen we hear persons assert that the climate is

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[74] Ibid., 15.

becoming more unsettled and less congenial to the vegetable kingdom, we are generally disposed to impute this opinion either to the querulousness of old age, or to the moroseness of individual temper and disposition."[75]

The review warned that the "proof of the fact, that the climate of Great Britain has undergone a considerable change *during the last* 50 *years*, rests principally on the testimony of an old monkish historian, who flourished *in the* 12*th* century." Although it acknowledged that medieval descriptions of the flora of Britain were "very different from the present state of things in the most favoured parts of the island," the review asserted that the reliability of such accounts must be measured by "the accuracy of the narrator." And the reviewers were "extremely skeptical" of Malmesbury. "The general character of the writers of the period," they explained, "is such as to justify the utmost degree of caution in receiving their testimony; and in the present instance, we apprehend that the account is sufficiently extravagant to refute itself." Although the reviewers did not dismiss the former cultivation of grapes—suggesting instead that their quality was exaggerated, they determined that the abandonment of viticulture was the result of the "increased intercourse" between England and France.[76] The reviewers ultimately found little of value in Williams' groundbreaking publication. "[U]nder the impression which it must necessarily produce on the minds of all our readers," they explained, "we shall take our leave of the author and his hypothesis."[77]

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[75] "Art. III," *The Monthly Review* (September, 1807): 20.
[76] Ibid., 21.
[77] Ibid., 24.

In 1807, the *The New Annual Register* published another review of Williams' treatise. Much like its predecessor, the review emphasized the unreliability of medieval scholarship:

> Our author assumes it as a fact, that the climate has changed, and is become much moister and colder than in former eras, chiefly upon a loose assertion of William of Malmesbury, who wrote in the twelfth century, that many parts of Gloucestershire and the Isle of Ely afforded as good vineyards as any of the provinces of France.[78]

This assumption, the reviewer believed, was utterly without merit, as William of Malmesbury's assertion "is so desultory and unsupported by other testimony, that it is scarcely worth attention, much less entitled to become the foundation of so sublime and daring a project" as *The Climate of Great Britain*.[79] As for Williams, the reviewers proposed that he and his theoretical committee for controlling climate be relegated to the "vaporous regions" of which he so often spoke.[80] None of the reviewers were particularly interested in the issue of contemporary climatic change. They rebuked methodology, condemned sources, and slandered character, but they left unexamined the issue at hand. No reviewer discussed other sources, publications, or observations from

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[78] "Physical and Mathematical. Comprehend'ng Medicine and Surgery, Natural History, Experimental Philosophy, Agriculture, Mechanics, Astronomy, Commerce, Arithmetic, Naval and Military Tactics," in *The New Annual Register, or General Repository of History, Politics, and Literature, For the Year 1806. To which is prefixed, The History of Knowledge, Learning, and Taste, in Great Britain, during the Reign of King William III.—Part III. With a Map of India* (London: Printed for John Stockdale, 1807), 316.

[79] Ibid.

[80] Ibid., 317.

the modern era. Williams' conclusions might have been strengthened by a broader array of sources, but one could say the same of his critics.

Scottish physician Henry Robertson examined historical variations of climate as part of a larger project on the relationship between atmospheric conditions and disease, *A General View of the Natural History of the Atmosphere* (1808). In a section titled, "Of the Supposed Change of Climates in Certain Countries," he acknowledged: "It has been a question frequently agitated, whether the temperature of climates be the same at the present period as they were in the early ages of the world." Although he had no time for "a tedious historical investigation," Robertson offered a few remarks comparing the climates of ancient, medieval, and modern Europe.[81] "Italy is found to be much warmer than it seems to have been in the time of the first Roman Emperors," he explained, "the winters in the south of Europe were then much more severe, according to the testimony of every author," including Diodorus Siculus, Ovid, Virgil, and Juvenal. According to Robertson, most philosophers attributed the "remarkable . . . change in the climate of Italy" to "the draining of marshes, the cutting down of forests, and putting the soil into a proper state of cultivation."[82]

Robertson did not find this explanation particularly satisfying. He suspected that cultivation "must have had a considerable influence in meliorating" the climate of

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[81] Henry Robertson, *A General View of the Natural History of the Atmosphere, and of its Connection with the Sciences of Medicine and Agriculture; Including an Essay on the Causes of Epidemical Diseases* (Edinburgh: Printed by Abernethy & Walker, 1808), 152-53.

[82] Ibid., 155.

Germany, but he also recognized that ancient Italy was extensively cultivated, as well. "[T]here is no doubt," Robertson wrote, "that in the days of Augustus the soil of Italy was in a much higher state of improvement than it has been for these many ages past." He concluded, "We therefore cannot ascribe this alteration in . . . temperature to any circumstance connected with agricultural improvements."[83]

Robertson also uncovered evidence for episodes of cold weather during the Middle Ages and the long seventeenth century. "[W]e have still other circumstances . . . which show that the winters must have been much colder in Europe, even in latter times, at an æra not very distant from the period in which we live." Anecdotal references to the frozen shores of the Mediterranean, Baltic, and Adriatic Seas suggested bitterly cold conditions in 775, 1668, and 1709, respectively.[84] Citing Kirwan's *Geological Essays*, Robertson agreed that it "would appear also, that our highest hills were formerly covered with growing wood; which probably decayed with the diminished temperature of the climate." Robertson doubted that geological uplift was responsible for the change in temperature, however, since some places—the Nile Valley—remained little changed since the days of Herodotus. "[W]e are not inclined to think," he concluded, "that any remarkable alteration of climate has occurred from this cause."[85]

For additional evidence of climatic change, Robertson compared the agricultural produce of medieval Britain with that of the present. "The decrease of the temperature

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[83] Ibid., 155-56.
[84] Ibid., 157.
[85] Ibid., 159.

of the climate of Britain," he asserted, "is likewise evinced by circumstances connected with the agriculture of the country." Robertson constructed a compelling argument for a warmer medieval England. Like Williams, he cited Malmesbury's twelfth-century account of fruitful English vines, but he uncovered several additional examples. "It is probably owing to a diminution of the temperature of the climate," he explained, "that of late years it has been found so difficult to raise certain species of apples in the cyder counties of England, which were formerly easily cultivated." Thirteenth-century chronicles also suggested that Scotland once had a longer growing season. In July 1298, during the Scottish Wars of Independence, English forces besieged Dirleton Castle, which overlooks the Firth of Forth fifteen miles east of Edinburgh. The English apparently sustained themselves on nearby fields of peas, which "gives a pleasing idea of the agriculture of East Lothian at that early period." "At the present day," Robertson explained, "peas do not ripen in the same fields till fully six weeks later."[86]

Robertson frequently suggested that medieval warmth came to an end by the beginning of the seventeenth century. Following an inspection of Scottish records, he concluded "that wheat was formerly paid to religious houses from lands where it is now impossible to raise that grain, and where it has not been attempted for nearly these 200 years." Further histories of Scotland suggested that "a considerable export trade in grain was carried on from Leith, even during the sixteenth century." He also noted that it was "evident" that "the climate of Britain has suffered a considerable change within these

[86] Ibid., 160-61.

two last centuries." He doubted, however, that the change would be reflected in annual temperature averages. Citing Williamson and Jefferson, Robertson concluded that "the annual temperature is not really diminished . . . although the summers are not now so warm as formerly, neither are the winters so cold, as they were experienced fifty or sixty years ago."[87]

Robertson addressed several explanations for climatic change, including the popular cultivation theory, but he found each incapable of accounting for the mechanics and timing of such change. In a moment of revolutionary clarity, Williamson suggested that the climate changed naturally and periodically. "When we come to treat of prognostics of the weather," he wrote, "it will then be made to appear, that the seasons undergo changes corresponding to others recurring at certain periods, and which seem to be produced from the connection of the globe with the other planets." Robertson apparently favored the planetary theory for its ability to account for periodic change rather than for its quasi-astrological mechanics. Bold if uncertain, Robertson suggested that climates "probably undergo an alternate increase and diminution of temperature for a certain period of years." Based on his reading of Pliny and several other natural philosophers, he proposed a "revolution of six hundred years."[88] If Robertson believed that the 600-year revolution included warm and cool phases, or at least moderate and

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[87] Ibid., 160-62.
[88] Ibid., 172.

immoderate phases, then he was the first to identify the two periods later known as the Medieval Warm Period and the Little Ice Age.

Robertson's peers were not particularly impressed with his accomplishment. One lengthy review in *The Medical and Physical Journal* failed to mention Robertson's ideas about climatic change, except in a laundry-list of included subjects.[89] Its authors, writing for an audience of physicians, were more interested in his ideas about weather and disease. Another review, in *The Literary Panorama*, suggested only that Robertson "confounded two distinct theories" of climatic change, those of Hugh Williamson and John Williams. Nevertheless, the review suggested that the "work contains much valuable information," even if "persons conversant with the subjects comprised in this treatise, will find few topics with which they have not, by reading or observation, been previously acquainted."[90]

Meteorology changed dramatically during the long eighteenth century. In 1699, explanations for climatic change, defined as such, were so rare that only a handful of references survive. By 1808, such ideas were so common that they attracted little

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[89] "Critical Analysis of the Recent Publications on the Different Branches of Physic, Surgery, and Medical Philosophy," *The Medical and Physical Journal* 20, no. 116 (October 1808): 365.

[90] "Robertson's *General View of the History of the Atmosphere*," *The Literary Panorama, Being a Review of Books, Magazine of Varieties, and Annual Register; Comprising Interesting Intelligence from the Various Districts of the United Kingdom; The British Connections in the East-Indies, the West Indies, America, Africa, Western Asia, &c. and from the Continent of Europe, Austria, Denmark, France, Germany, Greece, Holland, Hungary, Italy, Poland, Portugal, Prussia, Russia, Spain, Sweden, Turkey, &c*. 5 (March 1809): 1123-31.

attention in critical reviews. In the intervening years, natural philosophers developed increasingly nuanced understandings of microclimates and continental weather patterns. Historians, on the other hand, scoured historical chronicles, tax records, and government statistics to facilitate comparison of ancient, medieval, and modern environmental conditions. Both were slowly, if unknowingly, addressing the key points from Christopher Wren's plan for an all-encompassing history of the weather. Henry Robertson carried such efforts even further, discerning the first periodic explanation for climatic change—a 600-year revolution of warm and cool climatic regimes that predicted the "discovery" of the Medieval Warm Period and the Little Ice Age in the twentieth century.

CHAPTER VIII

CONCLUSION

The early modern era transformed the study of weather and climate. At the beginning of the sixteenth century, the body of English and French meteorological literature was quite small. With the exception of John Heywood's *Play of the wether* and a handful of astrological prognostications, few publications acknowledged the significance of weather. Three centuries later, stationers published dozens of pamphlets and books with "climate" in their titles each year. In 1506, Richard Pynson published *Here begynneth the Kalendar of the Shepherdes*; in 1806, John Williams published *The Climate of Great Britain*. Much, of course, had changed about the world, but few things had changed more than the weather. In the late sixteenth century, average temperatures in the northern hemisphere fell by 1°C. Growing seasons grew shorter, and marginal crops ceased to grow at all. The disruptive, at times dramatic, meteorological phenomena of the Little Ice Age provided ample opportunities to test new methods of observation and to formulate new explanations for environmental change.

The ancient world had no term for climate as it understood in the twenty-first century. In Greek geography, the latitudinal κλίματα (*klimata*) were defined by the inclination of the sun and the length of day. Like the frigid, temperate, and torrid zones, they were fixed in space by the tilt of the earth and the motion of the sun. In the ancient world, climate—quite literally—could not change. Meteorology, on the other hand, provided space for substantial terrestrial and atmospheric variability. Aristotle proposed an elemental explanation for weather based upon the revolution of the heavens and the interaction of the four elements. This model addressed precipitation, winds, comets, and other phenomena, as well as the erosion and accretion of land. Aristotle even hinted at the potential for cyclical atmospheric change: "[J]ust as there is a winter among the yearly seasons, so at fixed intervals in some great period of time there is a great winter and excess of rains."[1] Subsequent scholars discovered physical evidence of long-term environmental change. Eratosthenes and Straton wondered at the presence of seashells some distance from the shore, while the inhabitants of Crete attributed the loss of highland cultivation to the fact that "the winters are more severe, and more snow falls than formerly."[2]

The rediscovery and publication of classical texts in the late fifteenth century introduced Aristotelian meteorology to a generation of scholars seeking alternatives to the prevailing theological and astrological interpretations of weather. The dramatic environmental changes of the sixteenth and seventeenth centuries, however, exceeded even the boldest predictions of astrologers. Coastal and riverine flooding devastated central and eastern England in 1570. Two decades of unusually cool summers after 1590 led to subsistence crises and disease in northern Europe. The eruption of the Peruvian volcano Huaynaputina in 1600 triggered two years of particularly devastating winters. In 1607, the River Thames froze, to the delight of children and the horror of

[1] Aristotle, *Meteorologica* 1.14.352a20-35, trans. H. D. P. Lee (1952; Cambridge, MA: Harvard University Press, 1987).

[2] Theophrastus, *On Winds*, 13, trans. Jasper G. Wood, ed. G. J. Symons (London: Edward Stanton, 1894).

merchants and boatmen. After each of these incidents, observant scholars—Thomas Knell, Thomas Dekker, and Justus Lipsius—scoured the historical record for evidence of similar events in the past. The three gentlemen penned the first histories of English and European weather, and they determined that contemporary environmental disasters were well within the historical range.

When foul weather returned to northwestern Europe in 1612, however, several observers suggested that something unusual was afoot. A record number of meteorological publications recorded their observations and conclusions. One pamphleteer remarked that "[w]e haue within these few yeers, as well within this our natiue countrey of England as in forraine nations, béene most grieuously stroken with the bitter blasts" of drought, frost, flood, fire, and disease.[3] Another suggested that the "elements of Earth, Water, Ayre, and Fire haue seuerally commenced warre against us."[4] Theologian Godfrey Goodman proposed that the disturbed weather was a symptom of "universal decay," a slow and progressive corruption of creation that began with the Genesis flood. Fellow cleric George Hakewill found the argument unconvincing. Drawing on his own research as well as that of Justus Lipsius, Hakewill determined that

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[3] *The VVonders of this windie winter. By terrible stormes and tempests, to the losse of liues and goods of many thousands of men, women and children. The like by Sea and Land, hath not beene seene, nor heard of in this age of the World* (London: Printed for Joseph Hunt, 1613), A3r-A3v.

[4] *The Windie Yeare. Shewing Many strange Accidents that happened, both on the Land, and at Sea, by reason of the winde and weather. With A particular relation of that which happened at Great Chart in Kent. And Also how a Woman was found in the water, with a sucking Child at her brest, with the nipple in it mouth, both drowned; with many other lamentable things worthy to be read, and remembered* (London: Printed by G[eorge] Eld for Arthur Johnson, 1613), A4r.

recent disasters were comparable to those of the past in frequency and scale. The two scholars maintained a spirited, though professionally respectful, debate about climate change throughout the 1620s and 1630s.

The establishment of scientific organizations like the Royal Society of London and the invention of new instruments permitted more careful examination of meteorological phenomena. In 1662, Christopher Wren proposed a revolutionary approach to studying the weather based on the careful collection—preferably by multiple observers—of more than two dozen forms of data. A few years later, Thomas Sprat and Robert Hooke published a model datasheet to encourage participation. Dramatic frosts in the last three decades of the seventeenth century provided ample opportunity for such observation. By 1699, no fewer than five theories of natural climatic change were in circulation in pamphlets, newsmagazines, and the halls of government. Over the course of the eighteenth century, scholars like John Williams settled upon an anthropogenic explanation that emphasized the influence of cultivation, drainage, and land-use patterns on temperature and humidity. Others, like Henry Robertson, proposed that climatic change followed a cyclical pattern of some 600 years. Both agreed, however, that England's weather had been more temperate in the twelfth century than it was in the nineteenth. They had discovered the Little Ice Age.

This dissertation demonstrates that the study of climate and climatic change is not a product of the twentieth century. Likewise, it demonstrates that the Little Ice Age was not a "mid-twentieth century construction." Early modern authors and pamphleteers may not have had a proper name for the climatic changes they observed in the late sixteenth and seventeenth centuries, but they were well-aware that such phenomena were unusual by the standards of those times. Partially in response to such observations, natural philosophers and scientists outlined the first programs for assembling and interpreting agricultural, economic, medical, and meteorological data. Environmental history, ecology, and historical climatology are the culmination of such efforts. In many ways, we are still writing Christopher Wren's History of Seasons.

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