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@A Climate

Climate is the average condition of the weather at a place over a period of years. The issue of whether changes in climate have had a significant impact on history is controversial. It should not be overlooked that both *climate* and *history* are blanket terms located on such a high level of abstraction that relationships between them cannot be investigated according to the rules of scientific methodology. To be more meaningful, the issue needs to be broken down to lower scales of analysis, for example, by focusing on specific human activities and/or needs in relation to a given set of climatic variables. Regarding preindustrial societies this concerns primarily the availability of biomass (the amount of living matter, e.g., food, fodder) and energy (e.g., wind, water power, draft animals), secondly population dynamics (e.g., patterns of disease, fertility of humans and livestock), and thirdly communications as well as military and naval operations. Undoubtedly, beneficial climatic effects tend to enlarge the scope of human action, whereas climatic shocks restrict it or even lead to emergency situations. Seasonal patterns of temperature and rainfall mattered for energy availability and population dynamics depends on the environmental, cultural, and historical context.

Regular instrumental observations of temperature and precipitation were taken within national networks from the 1860s. For the previous period the study of climate draws on proxy (indirect) data from natural and human archives. Data from natural archives (e.g., corals, varves [pairs of layers of alternately finer and coarser silt or clay believed to comprise an annual cycle of deposition in a body of water], fossil pollen, tree rings, ocean and lake sediments, ice cores) are essential for those times and places for which documentary evidence is sparse or nonexistent, such as precolonial United States or the high latitudes.

Documentary evidence (human archives) allows reconstructing seasonal or monthly conditions and disentangling temperature and precipitation. Therefore, documentary evidence is better suited for investigating the human dimension of climatic change. Documentary evidence is well researched in Europe and eastern Asia. In Latin America promising research has begun. For the major oceanic areas a worldwide database of daily weather information is gathered from naval logbooks. For Africa documentary evidence is still spotty. In the Islamic world the possibly abundant documentary evidence remains to be explored.

Documentary evidence is investigated by the historical climatology branch of science, which is situated at the interface between climatology and environmental history. Historical climatology focuses on interpreting current natural disasters within a historical context, investigates the vulnerability of past economies and societies, and explores past discourses on, and social representations of, climate.

Documentary evidence is classified according to several criteria. (See table 1.)

Table 1.

Classification of Documentary Evidence

Perception of Weather and Climate	***Kind of Evidence***	
Direct	*Observed* Weather anomalies Natural Hazards Weather spells Daily weather *Pictorial*	*Measured* Barometric pressure Temperature Precipitation Water-gauge, etc.
Indirect (Proxy Data)	*Organic* Phenology Crop yields Time of crop harvests *Cultural* Rogation ceremonies	*Inorganic* Water levels Duration of snow, frost, and ice *Epigraphical* Archeological remains

Source: Pfister, Brázdil, & Glaser (1999).

Direct observations include chroniclers' narratives of weather patterns memorable to a particular region. A special focus is on rare but socioeconomically significant extreme events. In China records have been kept for more than two thousand years, in Europe for nearly one thousand years. Daily weather observations were promoted in Europe beginning in the late fifteenth century by the rise of planetary astronomy. Narrative and/or early instrumental observations were discontinuous.

In order to more objectively portray the character of extreme climatic events, chroniclers often referred to physical and biological proxy indicators, such as the duration of snow cover, the freezing and altitude of water bodies, or the development of crops. Some kinds of indirect data were the product of routine administrative processes, that is, they were recorded in an institutional framework for socioeconomic reasons. In this case they were often continuous. For example, for centuries the beginning of wine and grain harvests was regulated by many communities in order to prevent tax evasion. For another example, wages paid on Saturdays for community work (e.g., cutting ice at the mills, harvesting) in the town of Louny (northwestern Bohemia) were record regularly. These were scrupulously recorded in a book of accounts from 1450 to 1632 and can be used as proxies for temperature reconstruction. In Spain the Catholic Church organized *rogativas* (rogations), which were standardized liturgical actions meant to end climatic stress situations connected with long dry (*pro pluvia* [for rain] rogations) or wet spells (*pro serenitate* [for sun] rogations) that jeopardized crops.

Reconstructing climate from documentary evidence involves the construction of temperature and precipitation intensity indices ranging from –3 (very cold or dry) to +3 (very warm or wet). Series of intensity indices are included in statistical models to reconstruct monthly gridded mean air pressure at sea level and temperature for the eastern North Atlantic-European region. These spatial reconstructions of climate in terms of colored charts are made on a monthly level back to 1659 and on a seasonal level back to 1500.

@H1 Climate before 1000 CE

Climate during the last 2 million years is characterized by alternating warm and cool periods. These variations are initiated by changes in the Earth's orbital parameters. During the last ice age temperatures were generally lower and were characterized by large and irregular fluctuations. A global warming trend, starting eighteen thousand years ago, put a provisional end to full glacial climate conditions. Five thousand years later temperatures plummeted again about 3 to 4° C within a few decades. This last ice age relapse, called the “Younger Dryas,” lasted about a thousand years and put an end to the last ice age. The climate of the subsequent and current postglacial period, the Holocene, has so far remained fairly stable. In Europe it is divided into century-long cold periods that alternate with warm periods. The longest and most pronounced warm period took place nine thousand to fifty-five hundred years ago. Since then a more rapid irregular alternation of warm and cold periods has been observed.

@H1 The Last Millennium

The best known of these periods are the Medieval Warm Epoch (the more appropriate term *Medieval Climatic Anomaly* is suggested because it removes the emphasis on temperature as its defining characteristic) from about 900 to 1300 and a subsequent cool period lasting to the late nineteenth century that is called the “Little Ice Age” because glaciers in most regions of the globe were expanding during that time. In the Northern Hemisphere the average annual temperature during the twentieth century was the highest of the last millennium, the 1990s being the warmest decade of the millennium, partly as a consequence of the increased greenhouse effect (warming of the surface and lower atmosphere of the Earth caused by conversion of solar radiation into heat). The primary sources of interannual variability in global surface temperature patterns during past centuries are the El Niño Southern Oscillation (ENSO) in the Pacific and the North Atlantic Oscillation (NAO).

However, such generalizations mask a broad array of regional and local trends. In order to investigate human vulnerability to climatic impacts, the perspective of “ages” needs to be broken down to monthly or seasonal temperature and precipitation patterns on the regional level. So far this time resolution is available only for Europe and China.

@H1 Central Europe

After a cold relapse in the twelfth century winters were mild from 1180 to 1300. Subsequently the winter half-year was colder than today until the end of the nineteenth century. This is connected to a more frequent and sustained advection (horizontal transfer) of cold-dry continental air masses from the northeast. Icy winters were frequent during the periods of 1306<N>1328, 1430<N>1490, 1565<N>1615, 1655<N>1710, 1755<N>1860, and 1880<N>1895. From 1365 to 1400, 1520 to 1560, and 1610 to 1650 winters were somewhat warmer. Springs were particularly chilly in the 1690s and in the 1740s. Temperature and precipitation in winter increased over most of the twentieth century.

Summers do not show distinct long-term characteristics. Those during the thirteenth century were warm and dry. During the fourteenth century clusters of cool and wet summers occurred repeatedly (e.g., in the 1310s and 1340s). From 1380 to 1430 and again from 1530 to 1565 the summer half-year was as warm as during the twentieth century. During the last one-third of the sixteenth century cold spells and long rains in midsummer expanded at the expense of warm anticyclonic (relating to a system of winds that rotates about a center of high atmospheric pressure clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere) weather. This trend culminated in the 1590s. Summers in the early and late seventeenth century were rather cool; temperatures from 1630 to 1687 were close to the twentieth-century average. During the 1700s several warm decades (1720s, 1730s, and 1780s) stand out in England and in central Europe, whereas the first half of the nineteenth century, particularly the 1810s, was markedly cooler.

@H1 Russia

Winters became severe during the final decades of the sixteenth century, particularly from 1620 to 1680, and during the first half of the nineteenth century. Summer droughts were frequent between 1201 and

1230, between 1351 and 1380, and between 1411 and 1440. Conditions were rather warm in all seasons in the first half of the sixteenth century. Subsequently, pronounced cold spells stand out from 1590 to 1620 and from 1690 to 1740. Summer droughts were frequent from 1640 to 1659 and from 1680 to 1699. The period from 1770 to 1830 was warm, and numerous droughts are reported from 1801 to 1860. Summers from 1890 to 1920 were by far the chilliest of the last five hundred years; this period also included an unusually large number of extreme dry and wet seasons.

@H1 China

In southern China the thirteenth century was the warmest of the last millennium. The Little Ice Age, the long cooling trend from the high Middle Ages until the late nineteenth century, was well documented in Europe and also evident in China. Three cold periods<M>1470<N>1520, 1620<N>1740, and 1840<N>1890<M>are identified, the 1650s being by far the coldest decade. After 1310 the temperature plummeted at a rate of .1° C per century. Temperatures during four cold periods were .6<N>.9° C lower than the modern mean: 1321<N>1350 (-.6° C), 1441<N>1470 (-.7° C), 1651<N>1680 (-1.1° C), and 1861<N>1890 (-.9° C). The 1650s were 1.1° C below the modern mean. Subsequently the winter half-year grew warmer. Climate variability increased markedly throughout the nineteenth century to a maximum in the early twentieth century. In northern China two cold periods<M>1500 to 1690 and 1800 to 1860<M>stand out over the last six centuries. Considering all seasons, the period from 1650 to 1670 was the coldest, but the summer half-year was almost equally cold from 1580 to 1600.

@H1 Mediterranean

After a cold twelfth century the period from 1200 to 1400 was warm in the southwestern part of the Mediterranean basin**.** Annual precipitation in Morocco was generally lower from the sixteenth to nineteenth centuries. In Catalonia (northeastern Spain) dry spells during the winter half-year were frequent in the mid-sixteenth century but almost absent from 1580 to 1620. Numerous autumnal floods were reported from 1580 to 1630, from 1770 to 1800, and again from 1840 to 1870.

@H1 Africa

In Africa the critical issue in most regions is the precipitation in the monsoon season. Annual rainfall levels mark the boundaries of vegetation zones, for example, between the Sahelian (semidesert fringe of the southern Sahara Desert) cattle zone and the savanna where rain-fed crops are grown. During wetter periods isohyets (lines on a map connecting areas of equal rainfall) advanced northward, during drier periods, they advanced southward. In western Africa a wet period stands out from 700 to 1300. It was followed by a drier period from 1300 to 1500. Between 1500 and 1700 rainfall was so plentiful that the savanna zone extended to Timbuktu (16° N latitude). Beginning in the eighteenth century the monsoon receded again. By 1850 the savanna had moved 200 to 300 kilometers southward. Arab camel nomads advanced in the wake of this shift, and black cattle raisers retreated. In the 1820s and 1830s rainfall was below average in large parts of the continent. From 1870 to 1900 rainfall increased. Lake levels and the discharge of major streams exceeded the twentieth-century average.

@H1 Latin America

In Latin America there seemed to have been a trend toward greater aridity in the 1700s compared to the previous century. Dendroclimatic evidence (obtained by analyzing the rings in the cross-section of a tree trunk) for central Chile indicates higher-than-average rainfall from 1450 to 1600, whereas several severe droughts were reported over the subsequent centuries (e.g., 1637<N>1640, 1770<N>1773, 1790s, and 1810s). In the Buenos Aires region (Argentina) the 1700s were drier than the 1600s. Severe droughts occurred in the 1690s, the 1710s, the 1750s, and 1771<N>1774.

@H1 ENSO and the Pacific

The El Niño Southern Oscillation (ENSO) is the result of a cyclic warming and cooling of the surface of the central and eastern Pacific Ocean that strongly affects rainfall in the areas around the Pacific and the Indian Ocean. It was defined in 1891, in northern Peru, as a combination of anomalously warm sea temperature, stronger-than-usual southward coastal current, and high rainfall in the Sechura Desert.

Archival data suggest that the effects of the ENSO episodes from 1600 to 1900 were more intense and more global than those of the twentieth century. For example, the worst droughts in the colonial history of India (mid-1590s, 1629<N>1633, 1685<N>1688, 1788<N>1793, and 1877<N>1878) were caused by ENSO-related failures of the monsoon. The last two events in particular had global effects. Beyond ENSO, global weather anomalies are also induced by large volcanic eruptions (e.g., the 1815 explosion of Tambora, Indonesia).

@H1 Historical Significance of Climatic Change

Models of climatic effects on society are often framed as a chain of causation. Climatic patterns have a first-order, or biophysical, impact on agricultural production or on the outbreak of diseases or epizootics. These may have second-order impacts (caused by the first-order impacts) on prices of food or raw materials, which may then ramify into the wider economy and society (third-order impacts). The farther people move away from first-order impacts, the greater the complexity of the factors masking the climatic effects. It is easier to investigate the effects of short-term (annual and perennial) effects. In dealing with the effects of multidecadal climate variations, researchers must account for modifications in the economic, institutional, and environmental settings so great as to flaw any attempt at strict comparison or measurement. Societies tend to adapt to climate changes.

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See also Droughts; Earthquakes; Floods; Weather Events, Extreme

@H1 Further Reading

Alverson, K. D., Bradley, R. S., & Pedersen, T. (2003). *Paleoclimate, global change and the future*. Heidelberg, Germany: Springer.

Bradley, R. S., & Jones, P. D. (Eds.). (1996). *Climate since A.D. 1500* (2nd ed.). London: Routledge.

Brázdil, R., & Kotyza, O. (2000). *History of weather and climate in the Czech lands: Vol. 4. Utilisation of economic sources for the study of climate fluctuation at Louny and surroundings in the fifteenth<N>seventeenth centuries*. Brno, Czech Republic: Masaryk University.

Claxton, R. H. (1993). The record of drought and its impact in colonial Spanish America. In R. Herr (Ed.), *Themes in rural history of the Western world* (pp. 194<N>226). Ames: Iowa State University Press.

Grove, R. H., & Chappell, J. (Eds.). (2000). *El Niño: History and crisis*. Isle of Harris, Scotland: White Horse Press.

Luterbacher, J., Xoplaki, E., Dietrich, D., Jones, P. D., Davies, T. D., Portis, D., Gonzales-Rouco, J. F., von Storch, H., Gyalistras, D., Casty, C., & Wanner, H. (2002). Extending North Atlantic oscillation reconstructions back to 1500. *Atmospheric Science Letters, 3*(2), 114<N>124.

Luterbacher, J., Xoplaki, E., Dietrich, D., Rickli, R., Jacobeit, J., Beck, C., Gyalistras, D., Schmutz, C., & Wanner, H. (2002). Reconstruction of sea level pressure fields over the eastern North Atlantic and Europe back to 1500. *Climate Dynamics*, *18,* 545<N>561.

Mann, M. E., Bradley, R. S., & Hughes, M. K. (1999). Northern Hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations. *Geophysical Research Letters, 26,* 759<N>762.

Martin Vide, J., & Barriendos, M. (1995). The use of rogation ceremony records in climatic reconstruction: A case study from Catalonia (Spain). *Climatic Change, 30,* 201<N>221.

McCann, J. (1999). Climate and causation in African history. *The International Journal of African Historical Studies, 32*(2<N>3), 261<N>279.

Metcalfe, S. E., del Rosario Prieto, M., Endfield, G. H., Davies, S. J., & O’Hara, S. L. (2002). The potential of archival sources for reconstructing climate and climate-related processes in Latin America. *PAGES News, 10*(3), 11<N>14.

Ortlieb, L., Gabriel Vargas, G., & Hocquenghem, A. M. (2002). ENSO reconstruction based on documentary data from Ecuador, Peru and Chile. *PAGES News*, *10*(3), 14<N>17.

Pfister, C., Brázdil, R., & Barriendos, M. (2002). Reconstructing past climate and natural disasters in Europe using documentary evidence. *PAGES News, 10*(3), 6<N>8.

Pfister, C., Brázdil, R., & Glaser, R. (1999). *Climatic variability in sixteenth century Europe and its social dimension*. Dordrecht, Netherlands: Kluwer.

Trenberth, K. E. (2001). Climate: El Niño-Southern Oscillation (ENSO). In J. Steele, S. Thorpe, & K. Turekian (Eds.), *Encyclopedia of ocean* sciences (pp. 815<N>827). San Diego, CA: Academic Press.

Wang, S. W. (1991). Reconstruction of temperature series of North China from 1380s to 1980s. *Science in China, Series B, 34*(6), 751<N>759.

Watson, R. T. (Ed.). (2002). *Climate change 2001: Synthesis report: Third assessment report of the Intergovernmental Panel on Climate Change (IPCC).* Cambridge, UK: Cambridge University Press.