Medieval Climatic Optimum

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*The Medieval Climatic Optimum (also known as the Little Climatic Optimum, Medieval Warm Period, or Medieval Warm Epoch) refers to a period of climatic history during which temperatures in Europe and neighboring regions of the North Atlantic are believed to have been comparable to, or to have even exceeded, those of the late 20th century. This period is conventionally believed to have occurred from approximately 900–1300 AD, terminating with the more moderate conditions of the 15th century, and the Little Ice Age (*see ***Little Ice Age***, Volume 1) which impacted Europe during the 16th–mid 19th centuries. The Medieval Climatic Optimum appears to have been in large part a feature of the North Atlantic and neighboring regions (Wigley* et al.*, 1981). Indeed, when Lamb (1965) coined the term Medieval Warm Epoch, it was based on evidence largely from Europe and parts of North America. Regional temperature patterns elsewhere over the globe show equivocal evidence of anomalous warmth (see Wigley* et al.*, 1981; Hughes and Diaz, 1994) and, as Lamb (1965) noted, episodes of both cooler as well as warmer conditions are likely to have punctuated this period.*

It is evident that Europe experienced, on the whole, relatively mild climate conditions during the earliest centuries of the second millennium (i.e., the early Medieval period). Agriculture was possible at higher latitudes (and higher elevations in the mountains) than is currently possible in many regions, and there are numerous anecdotal reports of especially bountiful harvests (e.g., documented yields of grain) throughout Europe during this interval of time. Grapes were grown in England several hundred kilometers north of their current limits of growth, and subtropical flora such as fig trees and olive trees grew in regions of Europe (northern Italy and parts of Germany) well north of their current range. Geological evidence indicates that mountain glaciers throughout Europe retreated substantially at this time, relative to the glacial advances of later centuries (Grove and Switsur, 1994). A host of historical documentary proxy information such as records of frost dates, freezing of water bodies, duration of snowcover, and phenological evidence (e.g., the dates of flowering of plants) indicates that severe winters were less frequent and less extreme at times during the period from about 900–1300 AD in central Europe. Lamb (1965) (*see* **Lamb, Hubert H**, Volume 1) concluded that winters in Europe were less severe, and summers far drier, during the interval from AD 1080–1200. Farther south in the subtropical North Atlantic, there is also evidence for warmer sea surface temperatures during Medieval times (Keigwin, 1996).

Some of the most dramatic evidence for Medieval warmth has been argued to come from Iceland and Greenland (see Ogilvie, 1991). In Greenland, the Norse settlers, arriving around AD 1000, maintained a settlement, raising dairy cattle and sheep. Greenland existed, in effect, as a thriving European colony for several centuries. While a deteriorating climate and the onset of the Little Ice Age are broadly blamed for the demise of these settlements around AD 1400, the best evidence suggests that it was a combination of societal factors and trade relationships with mainland Europe. These in turn were probably influenced by a variety of seasonal climatic changes that were occurring throughout the North Atlantic region, rather than any simple local cooling trend (see McGovern, 1981, and also *see* **Little Ice Age**, Volume 1).

Although Lamb (1965) did not argue for a globally-synchronous warm period, his characterization has often been taken out of context, and used to argue for global-scale warmth during the early centuries of the millennium comparable to or greater than that of the latter 20th century. The best available evidence does not support such a notion. Outside of Europe and other regions neighboring the North Atlantic, the evidence for a Medieval Warm Period is indeterminate, at best (see Hughes and Diaz, 1994). Even those regions which appear to have experienced greater warmth exhibited it at quite different times. Indirect estimates of temperatures over the globe (based on proxy climate indicators such as tree rings, ice cores, and ocean sediments, and in certain regions, human documentary and phenological evidence – *see* **Little Ice Age**, Volume 1, Figure 2) provide an estimate of the considerable regional variations in timing of cold and warm periods around the globe during the Medieval period. Estimates of long-term changes in Central England temperatures (the basis, in large part, for the original definition of the Medieval Warm Period) suggest warmth during the period from about AD 1150–1350 (though the reliability of these estimates has been called into question – see Hughes and Diaz, 1994). In contrast, estimates of temperatures in western Greenland from ice cores (relevant to the earlier discussion of the Norse colonization of Greenland) suggest anomalous warmth locally only around AD 1000 (and to a lesser extent, around AD 1400), and in fact, quite cold temperatures during the latter part of the 11th century. The seasonality of this warmth (e.g., winter or summer) indicated by such proxy information is, however, not clear. Estimates of both sea surface temperatures in the subtropical North Atlantic from sediment cores and tree rings from Scandinavia and Eastern China imply unusually warm conditions only during the 11th and early 12th centuries. There is no evidence of unusual warmth in either tree-ring estimates of western North American temperatures or ice-core

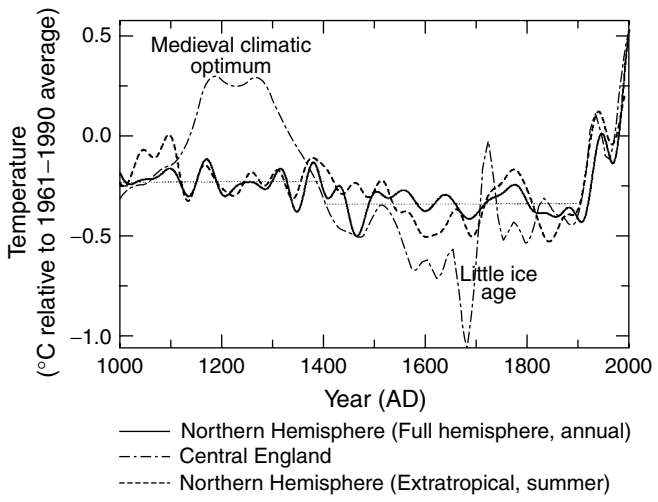

Figure 1 Estimated temperature variations during the past millennium for (1) the entire Northern Hemisphere estimated for the annual mean over the entire hemisphere (solid – Mann *et al.*, 1999) and over the extratropical region during the warm season (dashed – Jones *et al.*, 1998) based on global databases of proxy climate indicators, and (2) central England, based on a combination of thermometer, historical and proxy data records from central England (Lamb, 1965). Horizontal dashed lines indicate the moderately different Northern Hemisphere annual mean temperatures during the periods AD 1000–1400, and AD 1400–1900

based estimates of temperatures in the tropical Andes of South America.

Figure 1 compares estimated temperature variations for the Northern Hemisphere as a whole (based on combined temperature information over the globe from indirect sources) with estimated temperature trends in Central England alone. Northern Hemisphere annual mean temperatures (Mann *et al.*, 1999) and extratropical summer temperatures (Jones *et al.*, 1998), suggest only slightly warmer temperatures (a couple of tenths of a °C) during the period AD 1000–1400 relative to the later, colder period AD 1400–1900 (the latter associated with the Little Ice Age). Moreover, unlike European temperatures that indeed indicate a distinct warm phase earlier in the millennium, the large-scale trend represents a relatively monotonic long-term cooling. The less variable long-term fluctuations in temperature for the entire Northern Hemisphere result from the fact that the timings of cold and warm periods, so highly variable from region to region, tend to cancel in a hemispheric average. If one were to define hemispheric cold and warm periods during the past millennium by modern standards, only the 20th century could be termed a warm period; the period AD 1000–1400 would be termed a moderately warm period, and the period 1400–1900 a moderately cold period. Evidence for the Southern Hemisphere is far sketchier, and it is difficult as yet to reach any confident conclusions, although estimates of Southern Hemisphere temperatures (Jones *et al.*, 1998), uncertain as they are owing to the small amount of available information, show no evidence of a Medieval Climatic Optimum.

Thus, current evidence does not support the notion of a Medieval Climatic Optimum as an interval of hemispheric or global warmth comparable to the latter 20th century. Astronomical climate forcing may have contributed to a long-term cooling trend throughout the second millennium that terminated in the 20th century. Increased northward heat transport by an accelerated Atlantic thermohaline ocean circulation during Medieval times may have warmed the North Atlantic and neighboring regions, causing the warmest temperatures to be evident in Europe and lands neighboring the North Atlantic (albeit at notably varying times within the broader period of AD 900–1300).

A variety of factors thus may have contributed to both the moderate warmth of the Northern Hemisphere and the more sizeable and distinct North Atlantic/European warming during the early centuries of the second millennium.

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