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Climate History and the Sun

By Sallie Baliunas
and Willie Soon

George C. Marshall Institute
Washington, D.C.

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The 20th Century temperature pattern shows a strong correlation to energy output of the sun. Although the causes of the changing sun's particle, magnetic and energy outputs are uncertain, as are the responses of the climate to the Sun's various changes, the correlation is pronounced. It explains especially well the early 20th Century warming trend, which cannot have much human contribution. Drs. Baliunas and Soon present their latest findings on the relationship between the sun's varying energy output and climate change on earth.

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Climate History and the Sun

Sallie Baliunas and Willie Soon*

June 5, 2001

The United Nations International Panel on Climate Change *Summary for Policymakers* (SPM)[1] published in 2000 includes a 1,000-year estimated temperature record (Fig. 1) inferred from climate proxies which suggests a discernible human influence on global climate in the 20th century: "There is a longer and more closely scrutinized temperature record . . . Reconstructions of climate data for the past 1,000 years . . . indicate that [the] warming [over the past 100 years] was unusual and is unlikely to be entirely natural in origin." (SPM, p.10) Further, the *Summary* states, "in the Northern Hemisphere, the 1990s was likely the warmest decade and 1998 the warmest year" of the 1,000 years (p. 2).

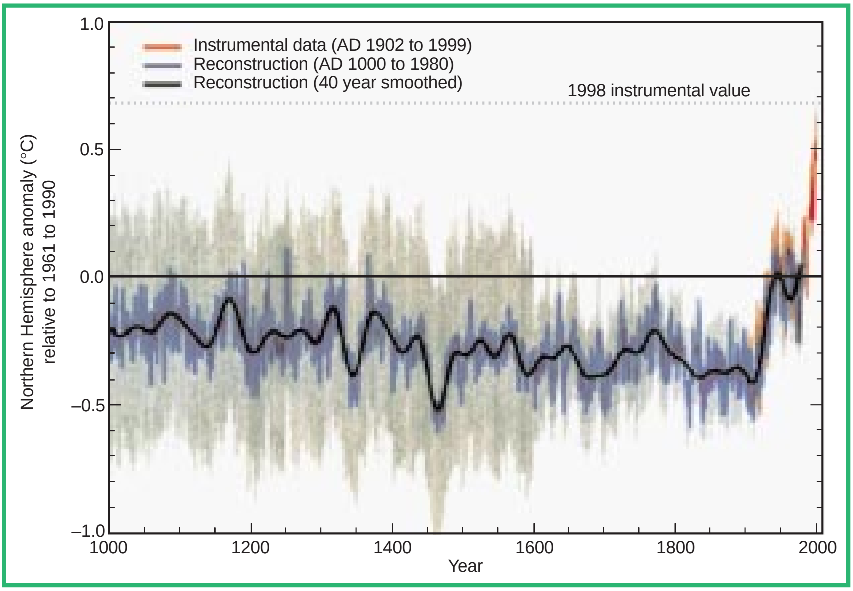

Figure 1. U.N. I.P.C.C. record of Northern Hemisphere temperature change estimated from proxies (1000-1980) and instruments (1981-1999). The U.N. SPM concludes, "[T]he rate and duration of the 20th century warming has been much greater than in any of the previous nine centuries. Similarly, it is likely that the 1990s have been the warmest decade and 1998 the warmest year of the millenium." (source: U.N. I.P.C.C. SPM, Figure 1, p.3).

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1 Available from http://www.ipcc.ch/ (Working Group I report).

Research over the last several decades has provided additional climate proxy results. Analyses of climate proxies, which include tree growth, boreholes, pollen, sea sediments, coral, ice cores and mountain glacier deposits, document two climate anomalies in the last 1,000 years. One is the so-called Little Ice Age (ca. 1300 – 1900 A.D.); the other is the Medieval Warm Epoch (ca. 800-1200 A.D.) when the temperature was significantly warmer than in the 20th century in many regions of the world. These additional results, developed from expert opinions, came from such disparate proxies that they cannot generally be quantitatively compared on a temperature scaled to each other or to the SPM record. However, the local record can be aggregated to yield qualitative results on the two major anomalies of the Second Millennium.

The great British climatologist Hubert H. Lamb[2] had already noted the array of such proxy information on past climate in 1965: ". . . [M]ultifarious evidence of a meteorological nature from historical records, as well as archaeological, botanical and glaciological evidence in various parts of the world from the Arctic to New Zealand . . . has been found to suggest a warmer epoch lasting several centuries between about AD 900 or 1000 and about 1200 or 1300 . . . Both the 'Little Optimum' in the early Middle Ages and the cold epochs [i.e., 'Little Ice Age'], now known to have reached its culminating stages between 1550 and 1700, can today be substantiated by enough data to repay meteorological investigation . . . It is high time therefore to marshal the climatic evidence and attempt a quantitative evidence." (pp. 14-15).

"The commonest indications from very diverse types of evidence are that prevailing temperatures in many parts of the world at least between 1000 and 1200 . . . were about 1-2 degrees C above the present values . . ." (p. 17). Further, "the medieval warm epoch and the subsequent cold centuries, the so-called "Little Ice Age", are confirmed" (p. 34).

Lamb continued to develop the evidence for extensive climate anomalies: "Evidence already cited at various places in this volume suggests that for a few centuries in the Middle Ages the climate in most parts of the world regained something approaching the warmth of the warmest postglacial times. The climax of this warm epoch was not quite contemporaneous everywhere, and the duration of the fairly stable warm regime seems nowhere to have exceeded 200 to 300 years. In the heartland of North America, as in European Russia and Greenland (see also Dansgaard et al. 1975), the warmest times may be placed between about AD 950 and 1200. In most of Europe the warmest period seems to have been between 1150 and about 1300, though with notable warmth also in the later

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[2] H. H. Lamb, 1965, *Paleogeography, Palaeoclimatology, Palaeoecology,* vol. 1, pp. 13-37.

900s. In New Zealand the peak may have been as late as 1200 to 1400. In southernmost South America the forest was receding rapidly to western aspects only, indicating more effective rain shadow from the Andes, i.e., more predominance of W'ly winds, than in the previous 1500 years."[3]

Lamb's results, covering the globe "from the Arctic to New Zealand" suggest a widespread impact of the Little Ice Age and Medieval Warm Epoch. Modern studies of proxy records strengthen Lamb's careful analysis. We show here examples.

For example, in discussing samples taken from mountain glacier deposits worldwide, Grove and Switsur write: "Dating of organic material closely associated with moraines in many montane regions has reached the point where it is possible to survey available information concerning the timing of the medieval warm period. The results suggest that it was a global event occurring between about 900 and 1250 AD, possibly interrupted by a minor re-advance of ice between about 1050 and 1150 AD."[4] (Figure 2)

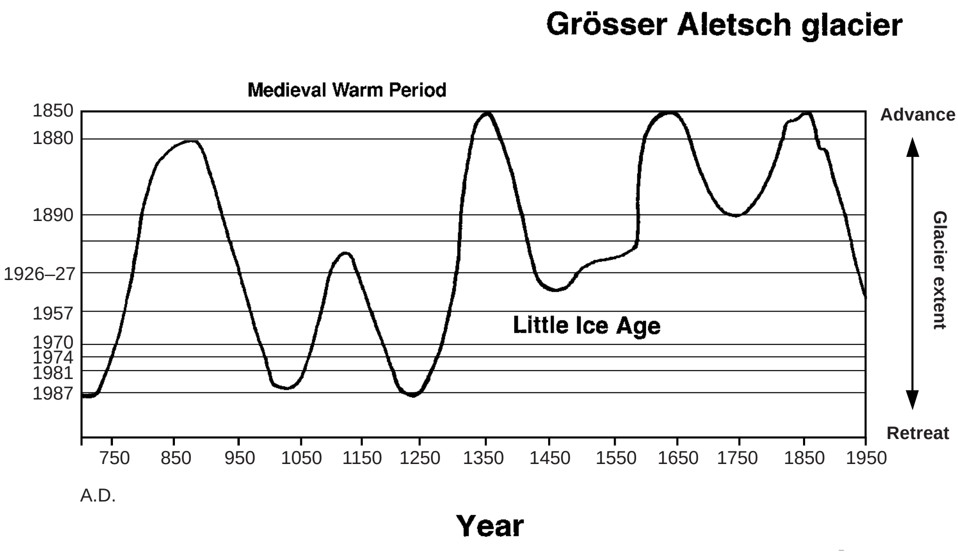


Figure 2. Glaciers, Switzerland (Grove 1996)[5]

The glacier and borehole records are important because they are sampled worldwide and can be converted to a temperature scale. Broecker notes that "at

[3] H. H. Lamb, 1977, *Climate – Present, Past and Future.*
[4] J.M. Grove and R. Switsur, 1994, *Climatic Change,* 26, 143-169.
[5] We show only several illustrative examples in this brief report of evidence for the Medieval Warm Period and the Little Ice Age from proxies over different regions of the world.

least for time scales greater than a century or two, only two proxies can yield temperatures that are accurate to 0.5°C: the reconstruction of temperature of mountain snowlines and borehole thermometry."[6] The distinct warmth of the Medieval Warm Period and cold during the Little Ice Age are clearly seen in the recent temperature reconstruction from borehole studies (Figures 3a through 3d).

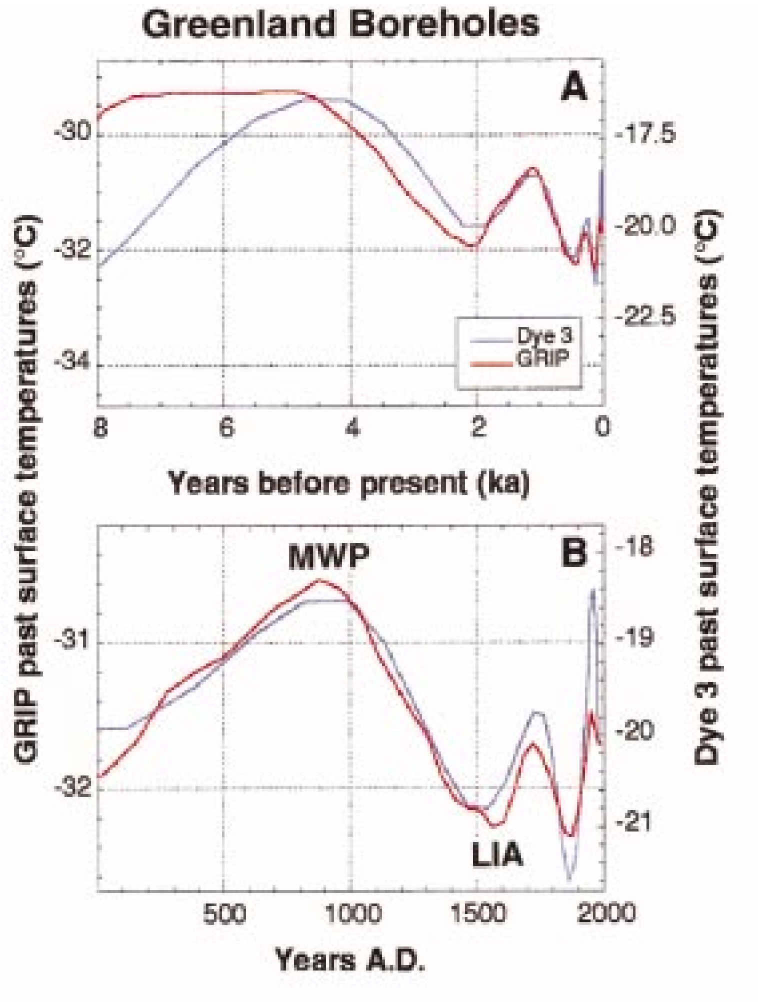


Figure 3a-b. Borehole, Greenland (Dahl-Jensen et al. 1998)

[6] W. S. Broecker, 2001, *Science*, 291, 1497-1499.

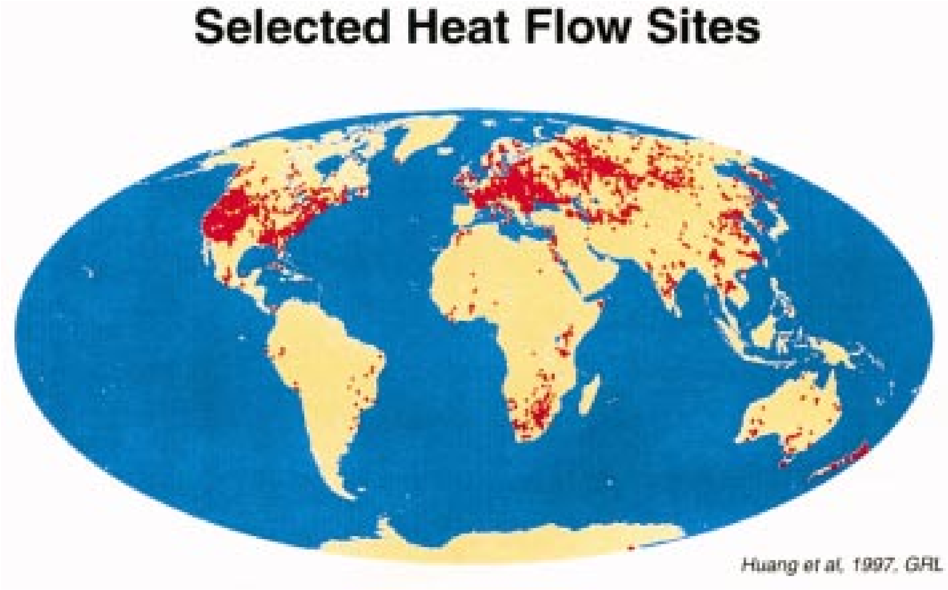


Figure 3c. Borehole, worldwide (Huang et al. 1997)

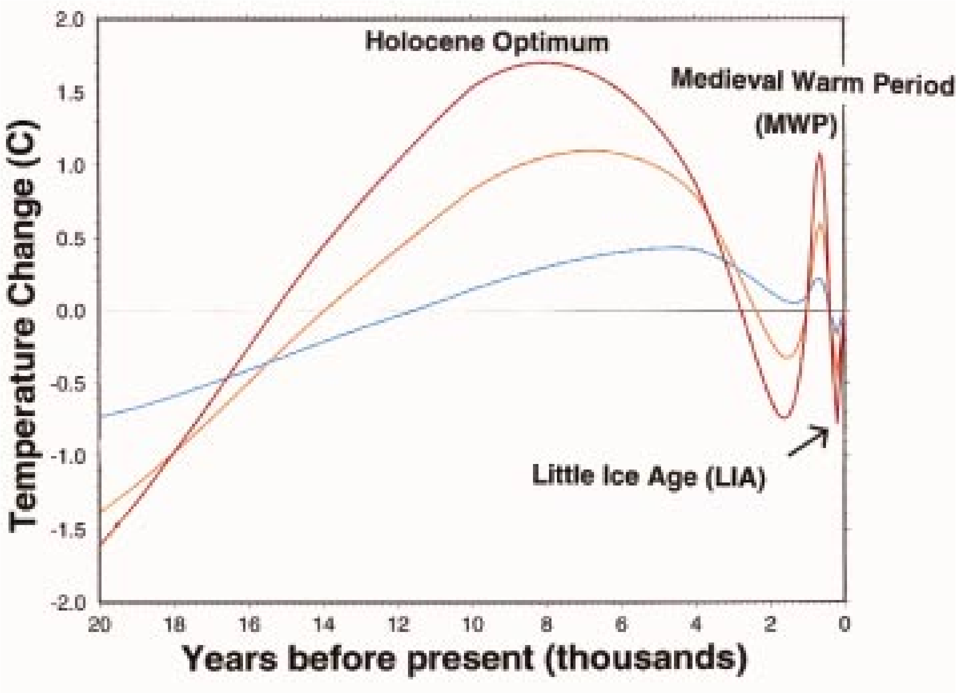


Figure 3d. Temperature curve by Huang et al. 1997

Likewise, the isotope records of Greenland's ice cores show distinct warm and cold periods corresponding to the Medieval Warm Period and Little Ice Age (Figure 4a).

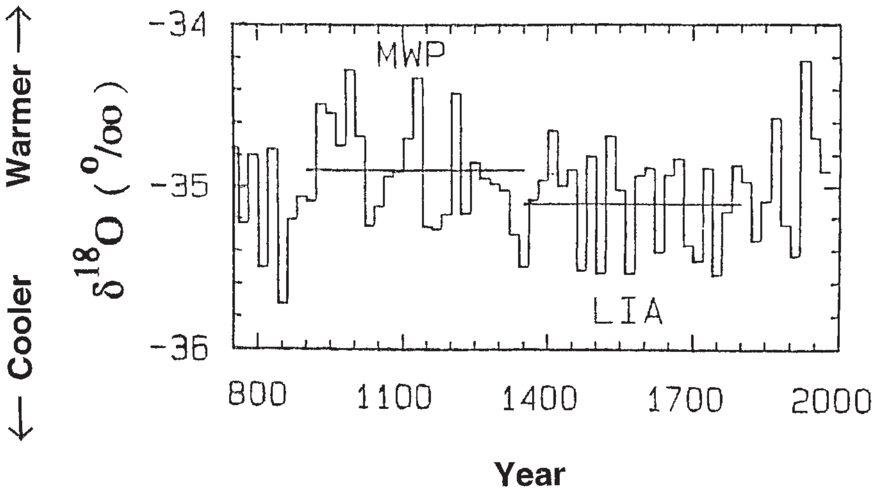
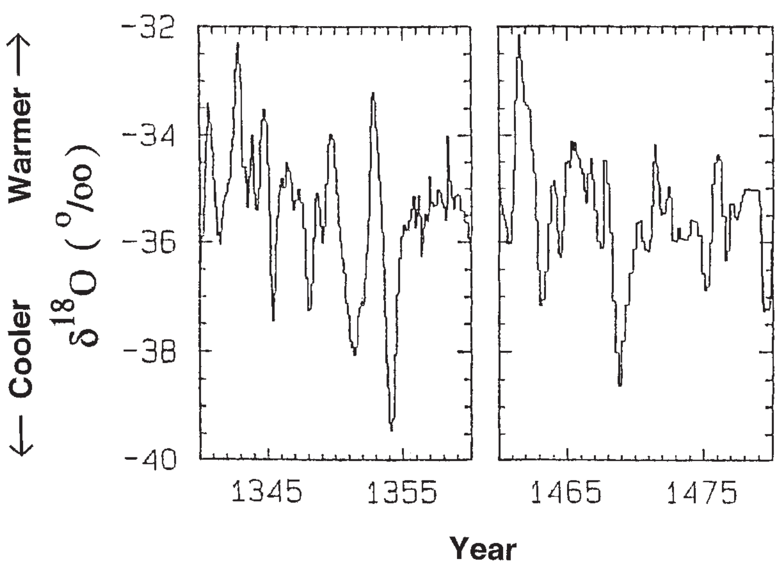


Figure 4a-b. Isotopic Analysis of Ice cores, Greenland (Stuiver et al. 1995)



Interestingly, the Greenland ice core record is temporally resolved enough to show highly variable temperature swings within a decade or less (Figure 4b). Apparently, large and abrupt changes (of the order of a few degrees C in less than a decade) occurred naturally around these northern high-latitude regions.

In China, isotope records of the cellulose found in peat deposits reveal the signal of warm and cold phases which agree with the Medieval Warm Period and the Little Ice Age, as well as earlier periods of warmth and cold (Figure 5).

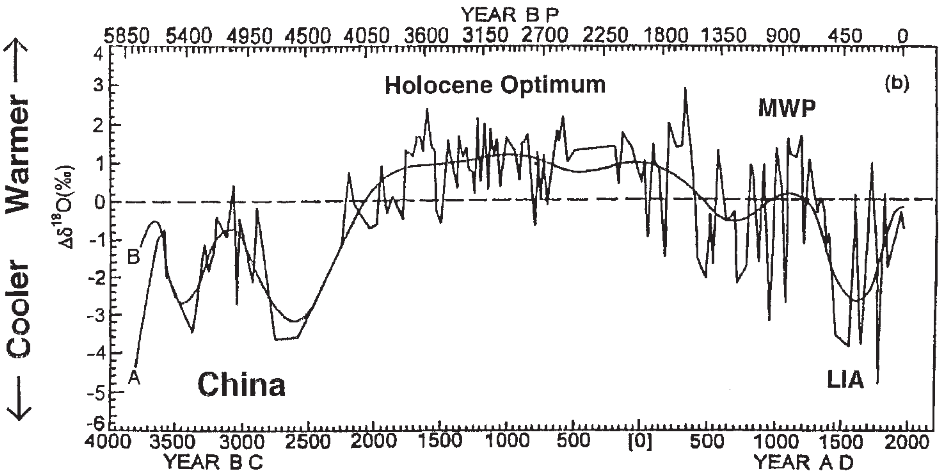


Figure 5. Isotopic Analysis of Peat Cellulose—China (Hong et al. 2001)

From an analysis of South African stalagmites (Figure 6), Tyson et al. conclude: "The climate of the interior of South Africa was around 1°C cooler in the Little Ice Age and may have been over 3°C higher than at present during the extremes of the medieval warm period . . . Extreme events in the record show distinct teleconnections with similar events in other parts of the world, in both the northern and southern hemispheres."[7]

Tree growth records for Siberia (Figures 7a through 7c) and for a northern 'high-latitude' composite (Figure 7d)—a location sensitive to the modeled impacts of manmade global warming—also contain clear signatures for both the Medieval Warm Period and Little Ice Age. These records also showed that the 20th century's warming in the high northern latitude peaked earlier in the 1930s-1950s and are not unusual within the context of the 2000-year records.

One important matter on reconstructing temperature from tree growth relates to the difficulty in reconciling the SPM's millennial record with the proxies cited above as well as others. One difference is that the SPM reconstruction finds little medieval warmth in the early centuries of the second millennium. There are at least three related explanations: first, the authors of the reconstruction admit the record is unreliable before 1400: "The sparser [proxy] networks available before

[7] P.D. Tyson et al., 2000, *South African Journal of Science,* vol. 96, pp 121-126.

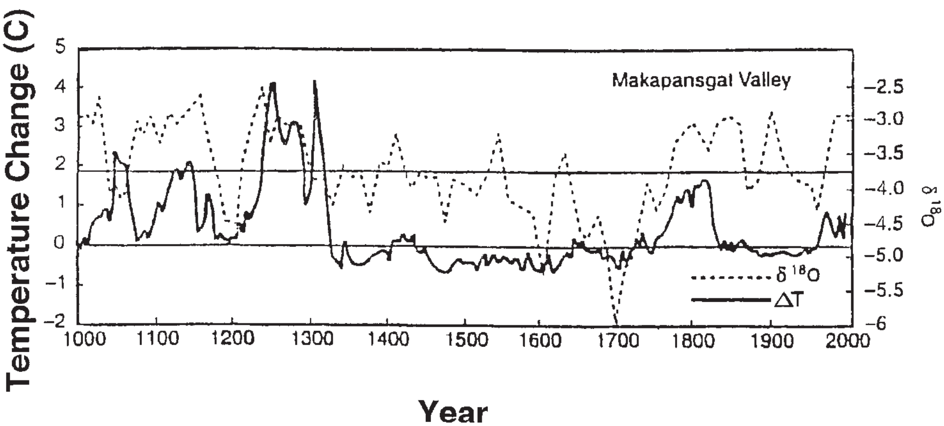


Figure 6. Isotopic Analysis of Stalagmite Samples, South Africa (Tyson et al. 2000)

1400 show little evidence of skill in reconstructi[on] ..."[8]. The reason is that only tree growth record over a single region [i.e., the U.S. Southwest] is used in the SPM reconstruction for the crucial period.

The second explanation involves the pattern of recent tree growth, which introduces significant uncertainty in any temperature reconstruction based on it (mainly on tree growth in comparison to the 20th century). The SPM's reconstructed record relies mainly on tree growth. As has been pointed out by many researchers, tree growth records, especially at high latitudes, have been showing unusual behavior: in recent decades, trees at high latitude have exhibited declining density of their growth rings, independent of rising temperature (see Figure 8). Experts on tree growth have been debating this strange phenomenon, with no resolution of the problem. Of course, factors other than temperature influence tree growth; possibly these other factors, such as levels of precipitation and available nutrients, change with time.

There are two points to note here: first, the unusual 20th century tree growth trend occurs in the period used for calibration of the SPM record [1902-1980], and perhaps partly in the period of validation (1854-1901). Without understanding the profound disagreement between temperature readings and tree ring density, it is impossible to make reliable statements on the temperature of the past 1,000 years. The second point is that without understanding the disagreement between temperature and tree growth, it is possible that this phenomenon *has occurred* from time to time earlier in the record, further making a conclusion about 1,000-year temperatures untenable.

[8] M. E. Mann, R. S. Bradley, M. K. Hughes, 1998, *Nature,* vol. 392, p. 782.

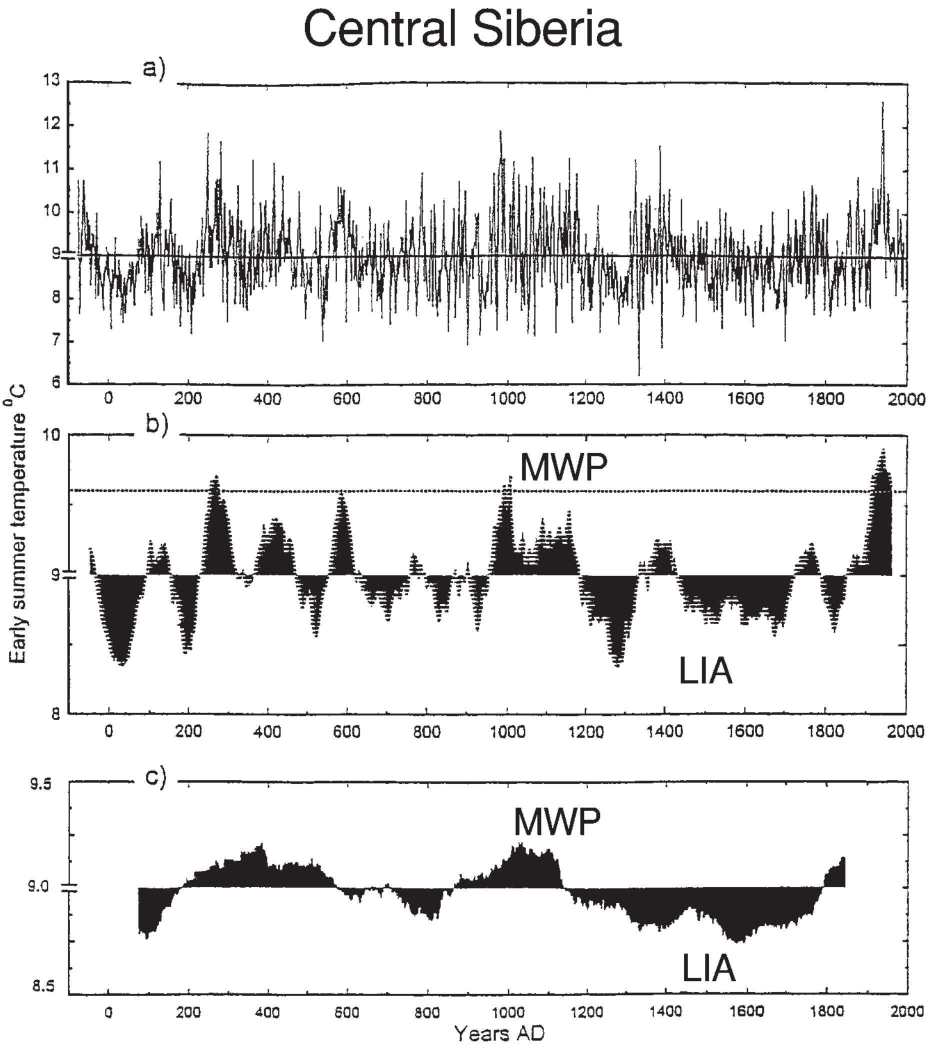


Figure 5. Reconstructed early summer temperature from C2 chronology: (a) 5-year smoothing. (b) 57-year smoothing. and (c) 300-year smoothing.

Fig. 7a-c — Tree growth—Central Siberia (Naurzbaez and Vaganov 2000)

Finally, a third explanation for the difference between the SPM record and the aggregated climate proxies is that tree growth records must be corrected for the normal decline in the growth rate that takes place as a tree ages. Within a decade or so, relative growth indictors of an individual tree give a reliable indication of interannual change within a decade or so. But over decades, different individual growth records must be amalgamated, and that process necessarily suppresses changes operating from decades to centuries. As a result, tree growth records can generally say little about such long-period climate variability.

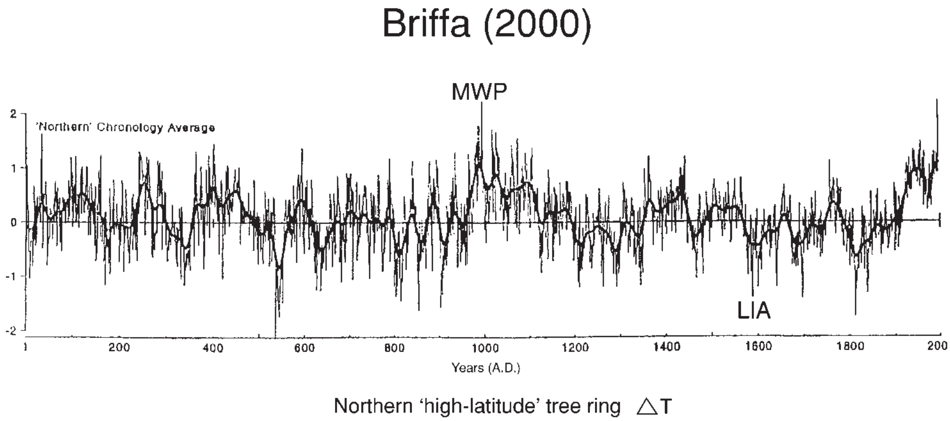


Figure 7d. Tree growth, composite for Northern "High-Latitude" (Briffa 2000)

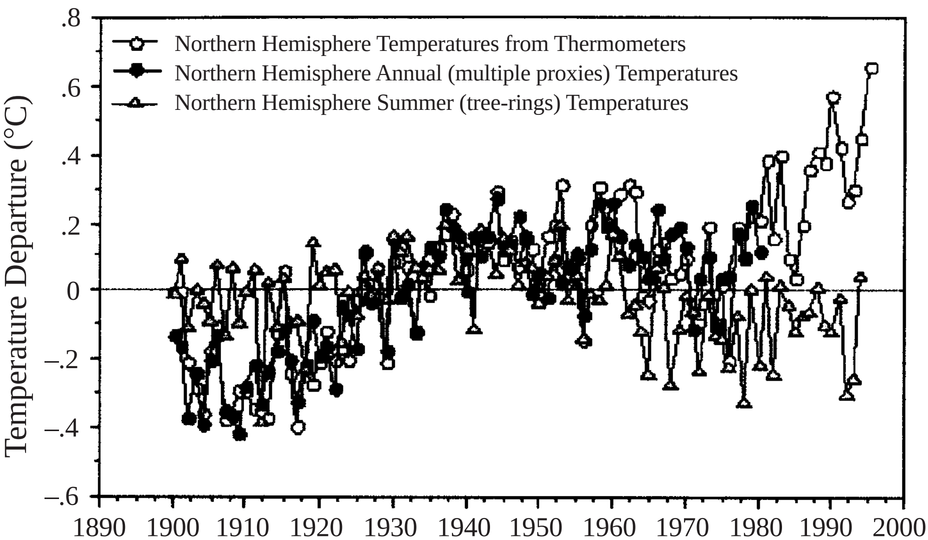


Figure 8. The Calibration Problem of Tree-Ring Proxy to Recent Instrumental Data (From: S. Baliunas and W. Soon, 1998, *World Climate Report*, vol. 3, No. 23, p. 11)

Most of these climate proxies cannot yet be reliably calibrated to yield a quantitative, globally averaged temperature record over the last 1,000 years. However, on a region-by-region basis, the records can be judged, with the following results. Over many regions of the world:

(1) The Medieval Warm Period, persisting ca. 800-1200 A.D. (but with cold excursions possible on time scales shorter than a decade) showed warmth greater than that of the 20th century.

(2) The Little Ice Age, persisting from ca. 1300-1900 A.D. (with brief, decadal warmth possible) brought retreat into unusual cold in nearly all regions of the world sampled.

(3) In order to consider anthropogenic global climate effects, the 20th century temperature record should be broken in two pieces about mid-century. Prior to ca. 1950, the amount of human-produced greenhouse gases in the atmosphere was small compared to the latter half of the century. The rapid, early 20th-century warming is largely unrelated to the air's increased greenhouse gases from human activities. The warmth seems largely a recovery from the unusual cold of the Little Ice Age, and has not yet reached the natural extremes of the early second millennium over most of the world.

Summary and Conclusions

The climate record shows that the global warming of 1°F observed over the last 100 years is not unusual. Global temperature changes of this magnitude have occurred frequently in the past and are a result of natural factors in climate change.

But is it possible that the particular temperature increase observed in the last 100 years is the result of carbon dioxide produced by human activities? The scientific evidence clearly indicates that this is not the case.

All climate studies agree that if the one-degree global warming was produced by an increase in carbon dioxide in the atmosphere, the additional CO_2 first warms the atmosphere, and the warmed atmosphere, in turn, warms the earth's surface. However, measurements of atmospheric temperatures made by instruments lofted in satellites and balloons *show that no warming has occurred in the atmosphere in the last 50 years*. This is just the period in which human-made carbon dioxide has been pouring into the atmosphere and according to the climate studies, the resultant atmospheric warming should be clearly evident.

The absence of atmospheric warming proves that the warming of the earth's surface observed in the last 100 years cannot be due to an increase in carbon dioxide in the atmosphere caused by human activities. The recent global warming must be the result of natural factors in climate change.

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