On Past Temperatures and Anomalous Late-20th Century Warmth -- A Response

We write in response to the Forum article by *Mann et al.* (July 8, 2003, "M03"), noting first two points of apparent agreement with our work [*Soon and Baliunas*, 2003; *Soon et al.*, 2003; "SB03"]:

(1) studies of climatic and environmental changes (including temperature) on hemispheric- or global-scales over time periods of millennia based on paleoclimate proxies must contend with significant uncertainties, and
(2) knowledge of past climatic changes does not have a direct bearing on the climatic effects of anthropogenic carbon dioxide added to the air during the 20th century and beyond.

M03 relies mainly on a Northern Hemisphere reconstruction of average annual temperature by *Mann et al*. [1999]. Their reconstruction calibrates environmental proxies going back many centuries using the thermometer record that extends back only to the 1860s. Their Northern Hemisphere reconstruction prior to 1400 C.E. depends sensitively on tree growth from one region, namely, trees growing at high elevations in western North America.

For some tree species, annual growth rings can be measured to yield a proxy for warm-season temperature. The tree growth indices, based on the width of an annual growth ring, and the growth-ring density formed in late summer, yield a positive correlation with warm-season temperature where thermometry is available. The value of tree growth records is that some extend back many centuries, well beyond the period for which instrumental temperature measurements exist. However, the 20th century – the instrumental calibration period for the tree growth indices – shows declining patterns of tree growth, despite rising temperatures, especially at high northern-latitude sites. Several causes have been offered for the divergence of recent tree growth and summer temperature – for example, land use or soil property changes, changes in the length of the growing season, or even changes in the efficiencies of water and nutrient utilization through perhaps physiological adaptation [*Graybill and Idso* 1993; *Jacoby and D'Arrigo* 1995; *Briffa et al.* 1998; *Feng* 1999; *Barber et al.* 2000; *Jacoby et al.* 2000; *Knapp et al.* 2001], but none has been convincingly established.

The resultant uncertainty in the calibration of tree growth to temperatures, combined with the general difficulties with the subtraction of biological growth trends [*Briffa et al.* 1998], may explain the different results derived independently, for example, from measurements of several thousand boreholes drilled through rock and ice. Results for boreholes show that *Mann et al.* [1999] have significantly underestimated variations of the Northern Hemisphere annual mean temperature on timescales of several decades to centuries [*Huang et al.* 2000], and that the 20th century may not be as warm as it was roughly 1000 years ago [*Huang et al.* 1997]. Additional discussions were given on pp. 258-264 (see especially footnote 18 on pp. 261-262) of *Soon et al.* [2003].

Each proxy for a climate variable has sampling deficiencies related to its spatial and temporal resolution. Added to these difficulties is the problem of calibrating proxies to

temperature based on surface thermometer records which can have potentially large biases related to historical land use changes, the growth of cities ("urban heat island effect"), uneven spatial sampling, and instrumental or technique changes [*Christy et al.*, 2001; *DeGaetano and Allen*, 2002; *Pielke et al.*, 2002; *Arnfield*, 2003; *Chase et al.*, 2003; *Davey and Pielke*, 2003*; Kalnay and Cai*, 2003].

These are some of the reasons for the significant uncertainties that arise in reconstructing temperature on large spatial scales from proxy data that provide information at particular locations, and which may be influenced by variables other than temperature or in addition to temperature. SB03 attempted to overcome some of those uncertainties by carrying out an extensive survey of many different proxy studies. Results for each proxy were primarily based on the opinions of the researchers who constructed the proxies. Those results provide clear and widespread (not just Northern European) evidence for climate and environmental anomalies related to two periods previously defined by proxy researchers, namely the Medieval Warm Period (~800-1300, "MWP") and Little Ice Age (~1300-1900, "LIA"). Here 'anomalies' are roughly viewed as 50-year or longer intervals of sustained warmth during the MWP and sustained cold during the LIA together with concurrent water, ice, chemical, and biological evidence during such intervals.

Taken together, the results from available climate and environmental proxies suggest that neither higher temperatures (where a proxy has been related to temperature) nor more extreme climate variability (where a proxy relates to other climate or environmental variables) occurred in the 20th century than during the MWP.

For the proxy data alone, the temperature reconstruction within the uncertainties of M03 (Figure 1 of M03) and even the updated results in *Mann and Jones* [2003] are in general agreement with our assessment of climate proxies. For example, Figure 2 of *Mann and Jones* [2003] clearly shows temperatures in the MWP that are as high as those in the 20th century.

Finally we comment on several assertions made by M03.

M03 state that the "SB03 approach ... defines a global 'warm anomaly' ..." SB03 wrote: "A global association for the Little Ice Age or Medieval Warm Period is premature because proxy data are geographically sparse and either or both phenomena could be multi-phased events acting under distinct local and regional constraints and modes." [p. 91, *Soon and Baliunas*, 2003].

M03 caution against making "the patently invalid assumption that hydrological influences can literally be equated with temperature influences in assessing past climate." SB03 agree and noted that the MWP and LIA should be based on the temperature field but cautioned that thermal anomalies cannot be easily dissociated from hydrological, cryospheric, chemical, and biological influences, and historical accounts [pp. 235-239, 243, *Soon et al*. 2003].

M03 also caution that "any analysis (SB03) that considers simply '20th century' mean conditions ... can provide only very limited insight into whether or not recent warming is

anomalous in a long-term and large-scale context." SB03 distinguished between early and late 20th century climate anomalies, when the endpoints and the resolution of the proxies allowed such consideration. Observed early -20th -century and late-20th -century patterns of climate change were specifically noted [see p. 236, 243 and Figure 3 of *Soon et al.*, 2003]. The SB03 study recognizes various man-made factors of climate change throughout history and briefly discusses the topic of climatic forcing by anthropogenic carbon dioxide [see pp. 269-271 of *Soon et al*., 2003].

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—WILLIE SOON, SALLIE BALIUNAS, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA; DAVID R. LEGATES, Center for Climatic Research, University of Delaware, Newark, DE