

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 time scales 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; 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 the 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.” [Soon and Baliunas, 2003; p. 91]

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 [Soon *et al.*, 2003; pp. 235–239 and 243].

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 end points 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 pp. 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 Soon *et al.*, 2003; pp. 269–271].

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

Response

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Soon and his colleagues (“S03”) fail to address any of the three specific issues we raised in our *Eos* criticism (“M03”) of their previous work (“SB03”). These were the need for critical evaluation of proxy data to be used; consistent assimilation of widespread, well-dated, and

resolved records; and the objective, quantitative calibration of these records [see also Bradley *et al.*, 2003]. S03, instead, start with the implausible claim that we agree with their assertion, “knowledge of past climatic changes does not have a direct bearing on the climatic effects of anthropogenic carbon dioxide...” Reconstructions of past temperature histories do, indeed, have such a bearing. They provide one of several independent lines of evidence

supporting the consensus scientific conclusion, expressed in the 2001 report of the Intergovernmental Panel on Climate Change (IPCC), that anomalous, hemispheric, late-20th-century warmth cannot be explained by natural factors. S03 follow with an equally puzzling assertion that “M03 relies mainly on a northern hemisphere reconstruction of average annual temperature by Mann *et al.* [1999].” Our article, quite to the contrary, demonstrated that nearly a dozen

different published estimates based on proxy data and model simulations give the same picture—anomalous, late-20th-century warmth that is unprecedented in a millennial or longer context.

These “straw man” arguments set the tone for an ensuing list of myths and unsubstantiated claims. Ironically, many of the criticisms raised might better be applied to the ill-conceived, largely subjective approach taken by SB03. While the claims made by S03 are too numerous to address in detail, several are so at variance with the accepted science that they deserve special attention:

(1) The contention that the conclusions expressed by M03 for the period prior to AD 1400 rely mainly “on tree growth from one region” belies the fact that several of the proxy estimates shown were based on composites of estimates from regions across the northern hemisphere, some based primarily on non-tree ring proxy information. The claims of S03 regarding non-climatic impacts on tree growth, even if valid, would thus be irrelevant. However, the claims are not valid. Their assertion that “[20th-century] tree growth indices...show declining patterns of tree growth, despite rising temperatures” is misleading. Declines in the response of tree growth to temperature are found in certain high-latitude regions only. In such cases, relatively recent (i.e., post 1950) data are not used in calibrating temperature reconstructions. In many other (even high-latitude) areas, density or ring width records display no such recent bias.

(2) The statement by S03 that the *Mann and Jones* [2003] reconstruction “clearly shows temperatures in the MWP that are as high as those in the 20th century” is misleading, if not false. M03 emphasize that it is the late, and not the early- or mid-20th-century warmth, that is

outside the range of past variability. Mann and Jones emphasize conclusions for the northern hemisphere, noting that those for the southern hemisphere (and globe) are indeterminate, due to a paucity of southern hemisphere data. Consistent with M03, they conclude that late-20th-century northern hemisphere mean temperatures are anomalous in a long-term (nearly two millennium) context.

(3) S03 argue that borehole data provide a conflicting view of past temperature histories. To the contrary, the borehole estimates for recent centuries shown in M03 are potentially consistent with other estimates, provided consideration is given to statistical uncertainties, spatial sampling, and possible influences on the ground surface [e.g., snow cover changes; *Beltrami and Kellman*, 2003]. For times more than 500 years ago, uncertainties in the borehole reconstructions preclude any useful quantitative comparison [*Pollack et al.*, 1998].

(4) S03 promote the myth that “urban heat island” effects lead to significant biases in the instrumental record of surface temperature used to calibrate proxy data. A recent case study of modern urban thermometer measurements in the U.S. [*Peterson*, 2003] supports previous findings that the influence of urban heat bias on estimates of global surface temperature change is minimal [*Hansen et al.*, 1999].

(5) In contrast to their claims, land use changes are believed to have led to an overall cooling—not a warming—of global surface temperatures during the 19th and 20th century [*Govindasamy et al.*, 2001].

Articles in *Scientific American* and the *Chronicle of Higher Education* have quoted numerous other leading climate scientists as indicating that SB03 misinterpreted the paleoclimatological literature. The controversy over the publication

of SB03 has now led, since the publication of M03, to the resignation of the editor-in-chief and five other editors at the journal *Climate Research*. It is clear that we are not alone in finding the work of SB03 seriously flawed.

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—MICHAEL MANN, University of Virginia, Charlottesville; CASPAR AMMANN, National Center for Atmospheric Research, Boulder, Colo.; RAYMOND BRADLEY, University of Massachusetts, Amherst; KEITH BRIFFA, PHILIP JONES, and TIMOTHY OSBORN, Climatic Research Unit, University of East Anglia, Norwich; THOMAS CROWLEY, Duke University, Durham, N.C.; MALCOLM HUGHES, Laboratory of Tree-Ring Research, University of Arizona, Tucson; MICHAEL OPPENHEIMER, Princeton University, N.J.; JONATHAN OVERPECK, University of Arizona, Tucson; SCOTT RUTHERFORD, Roger Williams University, Bristol, RI.; and KEVIN TRENBERTH and TOM WIGLEY, NCAR, Boulder, Colo.