About AGU

Outstanding Student Paper Awards

The following members in the Geomagnetism and Paleomagnetism and Nonlinear Geophysics Sections received Outstanding Student Paper Awards at the AGU 2002 Fall Meeting in San Francisco. (Winners in other sections will be announced in subsequent issues of *Eos*.)

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Geomagnetism and Paleomagnetism

Brian Carter-Stiglitz, University of Minnestoa	*Numerical modelling of the low temperature magnetism of SSD magnetite*
Joshua Feinburg, University of California at Berkeley	*Crystallographic relationships of sillicate-hosted magnetite inclusions determined with electron backscatter pattern indexing (EBSP)*
France Lagroix, University of Minnesota	*The magnetic fingerprint of Alaskan loess from their modern and buried soils to their petrostratigraphic markers*
Aoife Mulhall, Cambridge University	*A 1-D full waveform time domain magnetotelluric inversion*
Sabine Stanley, Harvard University	*Numerical dynamo modelling and the magnetic fields of Uranus and Neptune*

Nonlinear Geophysics

Eric Dunham, University of California at Santa Barbara	*A new supershear transition mechanism for cracks*
Rosemarie McMenamin, University of Ulster, Coleraine	*Self-organized criticality at the onset of aeolian sediment transport*
Timothy Ulrich, University of Nevada at Reno	*Low temperature elastic behavior of rocks*

FORUM

On Past Temperatures and Anomalous Late-20th Century Warmth

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Evidence from paleoclimatic sources and modeling studies support AGU's official position statement on climate change and greenhouse gases; namely, that there is a compelling basis for concern over future climate changes, including increases in global-mean surface temperatures, due to increased concentrations of greenhouse gases, primarily from fossil fuel burning.

More specifically, a number of reconstructions of large-scale temperature changes over the past millennium support the conclusion that late-20th century warmth was unprecedented over at least the past millennium. Modeling and statistical studies indicate that such anomalous warmth cannot be fully explained by natural factors, but instead, require a significant anthropogenic forcing of climate that emerged during the 19th and 20th centuries.

Two recent (and nearly identical) papers [*Soon and Baliunas*, 2003 and *Soon et al.*, 2003]—henceforth both referred to as "SB03"—challenge this view, and have been used to support the claim that recent hemispheric-scale warmth is not unprecedented in the context of the past millennium (see e.g., "20th Century Climate Not So Hot," press release, Harvard-Smithsonian Center for Astrophysics, 31 March 2003; http://cfa-www.harvard.edu/press/pr0310.html). Such claims are inconsistent with the preponderance of scientific evidence. We therefore review these claims in light of the fact that they have found their way into the media and have been read into the record of the U.S. Senate.

Instrumental data for use in computing global mean surface temperatures are only available for about the past 150 years [*Jones et al.*, 1999]. Estimates of surface temperature changes further back in time must make use of historical documents and natural archives or "proxy" indicators, such as tree rings, corals, ice cores, and lake sediments, to reconstruct the patterns of past climate change. Due to the paucity of data in the southern hemisphere, recent studies have emphasized the reconstruction of northern hemisphere (NH), rather than global mean temperatures over roughly the past 1000 years. A large number of such reconstructions [*Mann et al.*, 1999; *Jones et al.*, 1998; *Crowley and Lowery*, 2000] now support the conclusion that the hemispheric-mean warmth of the late 20th century (i.e., the past few decades) is likely unprecedented in the last 1000 years [*Jones et al.*, 2001; *Folland et al.*, 2001]. Preliminary evidence [*Mann and Jones*, 2003] suggests that such a conclusion may well hold for at least the past two millennia (Figure 1). Climate model simulations employing estimates of natural and anthropogenic radiative forcing changes [*Crowley*, 2000; *Gerber et al.*, 2002; *Bauer et al.*, 2003] agree well, for the most part, with the proxy-based reconstructions (Figure 1).

The simulations, furthermore, show that it is not possible to explain the anomalous late-20th century warmth without the contribution from anthropogenic forcing factors [e.g., *Crowley,* 2000], and that the role of anthropogenic forcing can clearly be detected in the proxy-based temperature reconstructions [*Hegerl et al.,* 2003]. Here, we raise the following key points regarding recent assertions (SB03) challenging these findings:

(1) In drawing inferences regarding past regional temperature changes from proxy records, it is essential to assess proxy data for actual sensitivity to past temperature variability. Seminal work in the reconstruction of past climate [*Lamb,* 1965] examined a number of different variables, including hydrological indicators, for insights into past climate change, but only in a particular region (Europe) where the synoptic-scale relationship between temperature and hydrological variability was fairly well established and understood. The existence of possible underlying dynamical relationships between temperature and hydrological variability should not be confused with the patently invalid assumption that hydrological influences can literally be equated with temperature influences in assessing past climate (e.g., during Medieval times). Such a criterion is implicit, for example, in the SB03 approach that defines a global "warm anomaly" as a period during which various regions appear to indicate climate anomalies that can be classified as being "warm," "wet," or "dry" relative to "20th century" conditions. Such a criterion, ad absurdum, could be used to define any period of climate as "warm" or "cold," and thus makes no meaningful contribution to discussions of past climate change.

(2) It is essential to distinguish [e.g., by compositing or otherwise assimilating different proxy information in a consistent manner; e.g., *Jones et al.,* 1998; *Mann et al.,* 1998, 1999; *Briffa et al.,* 2001] between regional temperature anomalies and anomalies in hemispheric mean temperature, which must represent an average of temperature estimates over a sufficiently large number of distinct regions [see, for example, *Folland et al.,* 2001; *Trenberth and Otto-Bliesner,* 2003]. It is well known that weather patterns have a wave-like character to them. This character ensures that certain regions tend to warm (due, for example, to a southerly flow in the northern hemisphere winter mid-latitudes) when other regions cool (due to the corresponding northerly flow that must occur elsewhere).

In a similar vein, the specification of a warm period requires that warm anomalies in different regions should be synchronous, and not merely required to occur during any 50-year period within a very broad interval in time, such as AD 800–1300, as in SB03. Figure 2 demonstrates the considerable spatial variability in temperature variations of the past millennium, and the false impression one might gain regarding hemispheric-scale temperature changes from the apparent temperature changes in any particular region. The specific notions of the "Little Ice Age" and "Medieval Warm Period" arose, understandably, from the Euro centric origins of historical climatology [e.g., *Lamb,* 1965]. While relative hemispheric warmth during the 10th, 11th, and 12th centuries, and cool conditions during the 15th to the early 20th century are evident from reconstructions of hemispheric-mean temperature (Figure 1), the specific periods of coldness and warmth differ from region to region (Figure 2) from those for the northern hemisphere as a whole. Rather than indicating inconsistency, the difference between such regional and hemispheric-scale anomalies follows naturally from the physics governing atmospheric variability.

(3) It is essential, in forming a climate reconstruction, to define carefully a base period for modern conditions against which past conditions may be quantitatively compared. It is, furthermore, important to identify and, where possible, quantify uncertainties; and demonstrate, using independent data, the reliability of any reconstructions [*Mann et al.,* 1999; *Jones et al.,* 2001]. The conclusions of the most recent IPCC report [*Folland et al.,* 2001] that late-20th century mean warmth likely exceeds that of any time during the past millennium for the northern hemisphere is based on a careful comparison of temperatures during the most recent decades with reconstructions of past temperatures, taking into account the uncertainties in those reconstructions. As it is only the past few decades during which northern hemisphere temperatures have exceeded the bounds of natural variability, any analysis (SB03) that considers simply "20th century" mean conditions, or interprets past temperatures using the evidence from proxy indicators not capable of resolving decadal-timescale trends, can provide only very limited insight into whether or not recent warming is anomalous in a long-term and large-scale context.

Healthy debate with regard to the details of past climate change exists within the peer-reviewed scientific climate literature [*Briffa and Osborn,* 2002; *Huang et al.,* 2000; *Folland et al.,* 2001; *Esper et al.,* 2002; *Mann et al.,* 2003], and it remains a challenge to reduce uncertainties and properly synthesize global means. Nevertheless, the conclusion that late-20th century hemispheric-scale warmth is anomalous in a long-term (at least millennial) context, and that anthropogenic factors likely play an important role in explaining the anomalous recent warmth, is a robust consensus view.

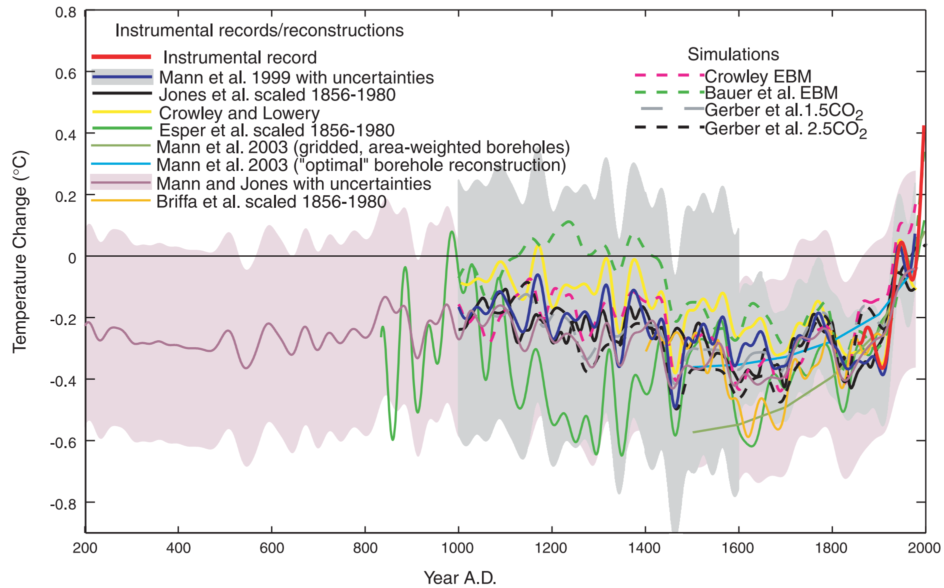

*Fig. 1. Comparison of proxy-based NH temperature reconstructions [*Jones et al., *1998;* Mann et al., *1999;* Crowley and Lowery, *2000] with model simulations of NH mean temperature changes over the past millennium based on estimated radiative forcing histories [*Crowley, *2000;* Gerber et al., *2002—results shown for both a 1.5°C/2*CO_2 and 2.5°C/2*CO_2 sensitivity;* Bauer et al., *2003]. Also shown are two independent reconstructions of warm season extra-tropical continental NH temperatures [*Briffa et al., *2001;* Esper et al., *2002] and an extension back through the past 2000 years based on eight long reconstructions [*Mann and Jones, *2003]. All reconstructions have been scaled to the annual, full northern hemisphere mean, over an overlapping period (1856–1980), using the NH instrumental record [*Jones et al., *1999] for comparison, and have been smoothed on time scales of > 40 years to highlight the long-term variations. The smoothed instrumental record (1856–2000) is also shown. The gray/red shading indicates estimated two-standard error uncertainties in the* Mann et al. *[1999] and* Mann and Jones *[2003] reconstructions. Also shown are reconstructions of ground surface temperatures (GST) based on appropriately areally-averaged [*Briffa and Osborn, *2002;* Mann et al., *2003] continental borehole data [*Huang et al., *2000], and hemispheric surface air temperature trends, determined by optimal regression [*Mann et al., *2003] from the GST estimates. All series are shown with respect to the 1961–1990 base period.*

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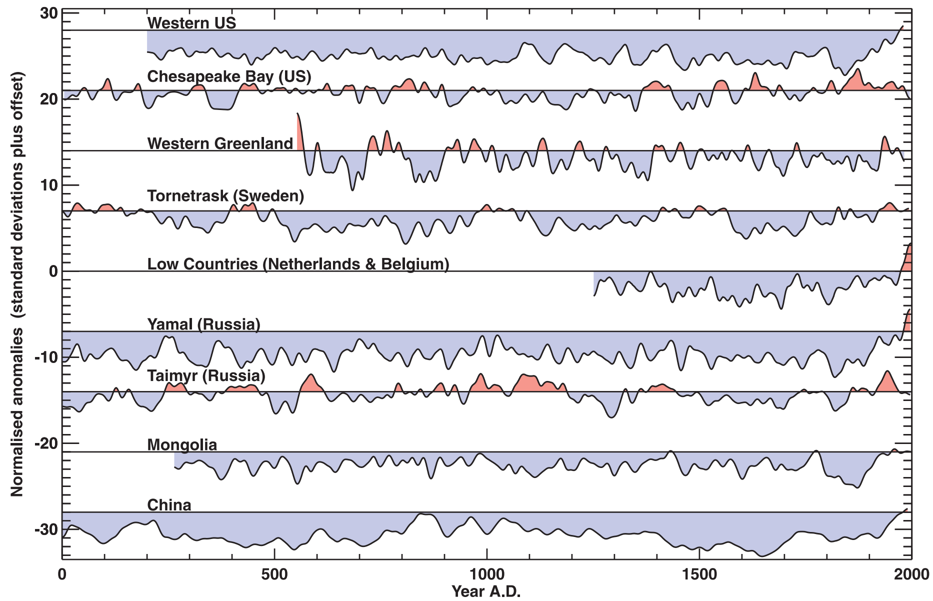

*Fig. 2. Temporal histories of nine temperature-sensitive proxy records, chosen to illustrate a variety of proxy types, NH locations, and spatial and seasonal representation. All series have been smoothed with a 40-year low-pass filter, then normalized so that the filtered series have unit standard deviation over 1251–1980 (when all series have data) and the unfiltered series (to avoid edge effects of the filter) have zero mean over 1961–1990 (to facilitate comparison with Figure 1). Series have been offset by steps of 7 standard deviations for display purposes. Blue (red) shading indicates filtered values below (above) the 1961–1990 means (the latter are shown by thin horizontal lines). Original sources for each series are: "Western U.S." [*Mann et al., *1999]; "Chesapeake Bay" [*Cronin et al., *2003]; "W. Greenland" [*Fisher et al., *1996]; "Tornetrask" [*Grudd et al., *2002]; "Low Countries" [*van Engelen et al., *2001]; "Yamal" [*Hantemirov and Shiyatov, *2002, reprocessed in* Briffa, *2000]; "Taimyr" [*Naurzbaev et al., *2002]; "Mongolia" [*D'Arrigo et al., *2001]; and "China" [*Yang et al., *2002].*

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