Testing the Fidelity of Climate Reconstruction Methods

Two distinct methods have been used for reconstructing past climate histories from so-called “proxy” climate data: The Climate Field Reconstruction ('CFR') method, which assimilates proxy records into a reconstruction of the underlying patterns of past climate change, and the 'composite-plus-scale' (CPS) method, which combines a number of proxy series and scales the resulting composite against a target instrumental series (e.g. Northern Hemisphere temperature) during a modern period of overlap. CFR methods offer the advantage of estimating spatial patterns, while CPS methods involve a simpler statistical procedure. Climate model simulations provide the only means for evaluating the likely fidelity of these methods in long-term climate reconstruction.

We tested these methods using a simulation of the climate of the past millennium (AD 850-1999) employing the NCAR Climate System Model 1.4 coupled ocean-atmosphere model driven by estimated long-term natural and anthropogenic radiative forcing histories. The simulation exhibits forced Northern Hemisphere (NH) temperature variations in past centuries that are modestly greater than most other simulations, providing a challenging test for climate reconstruction methods. “Pseudoproxy” data were constructed from the model surface temperature field to have signal-vs.-noise attributes similar to actual proxy data networks used in reconstructing past climates.

Our findings suggest that both CPS and CFR methods are likely to provide a faithful estimate of actual long-term hemispheric temperature histories, within estimated uncertainties. The CFR approach was found to underestimate some short-term changes associated with large volcanic cooling events because no large explosive volcanic eruptions were present during the modern calibration interval. The CPS approach, by contrast, was found to resolve these short-term events well, but tends to underestimate long-term changes for low signal-to-noise ratios (SNR). The CFR method showed no evidence of any systematic underestimation of low-frequency variability. This finding conflicts curiously with claims by von Storch et al. in the 22 October 2004 issue of *Science* who argued that CFR methods greatly underestimate low-frequency variability. It has recently been disclosed that the simulation they used suffered from an initialization error that lead to a spurious long-term global temperature decrease of more than 1^{o}C over the course of the simulation. An important lesson here is that the conclusions of statistical exercises using climate simulations are only meaningful if the climate model results are realistic.

We encourage similar experiments to our own using realistic model simulations and appropriate experimental designs for simulating proxy-based climate reconstruction approaches.— Michael E. Mann (Pennsylvania State University), S. Rutherford, E. Wahl, and C. Ammann, "Testing the Fidelity of Methods Used in Proxy-Based Reconstructions of Past Climate," in the 15 October *Journal of Climate*.

[FIGURE AND CAPTION ON FOLLOWING PAGE]

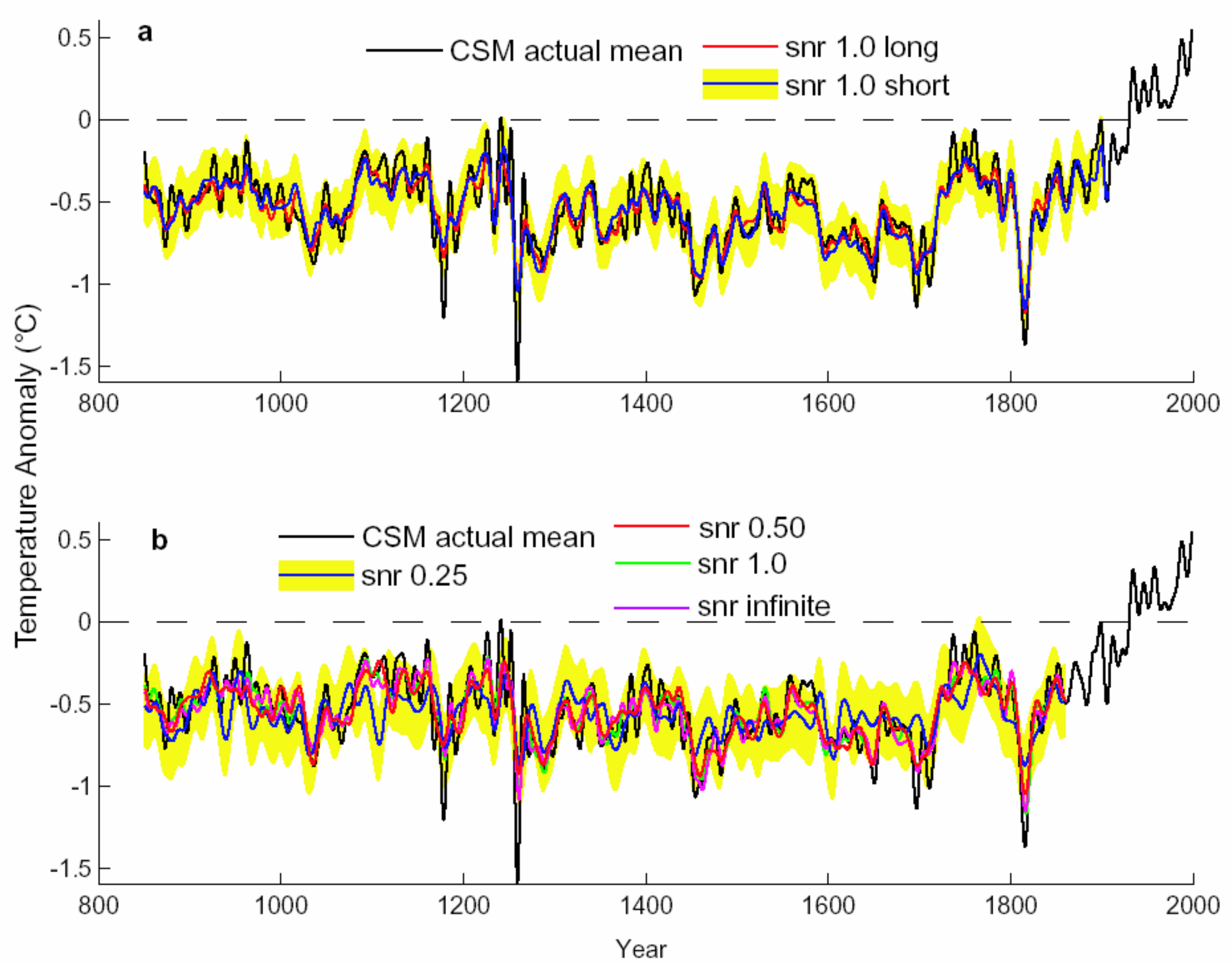

Figure Caption: "Pseudoproxy" reconstruction of Northern Hemisphere mean temperature (AD 850-1999) based on CFR approach compared with actual model NH series (decadally-smoothed data are shown). (a) SNR=1.0 using two alternative calibration intervals (1856-1980 and 1900-1980). Yellow shading indicates an error region of two standard deviations. (b) Four SNR values and an 1856-1980 calibration interval. Statistical uncertainties (shading of two standard error region) are shown for lowest SNR value (0.25) based on pre-1856 verification residuals.