Reply

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Smerdon and Kaplan (hereafter SK07) have independently identified a technical issue in the original Mann et al. (2005, hereafter MRWA05) procedure that was first identified and brought to our attention by F. Zwiers and T. Lee (2006, personal communication) and since corrected (Mann et al. 2007). As we discuss below, this has no significant consequences for the results or conclusions of MRWA05 or related studies. In more recent work, Mann et al. (2007) recover the results and conclusions of MRWA05 using an implementation of the "regularized expectation maximization (RegEM)" procedure that does not suffer from the technical issue SK07 note.

SK07 confuse the RegEM climate field reconstruction (CFR) method, which does not in general suffer from the issue they raise, with one particular implementation of the method as employed by MRWA05 (and previously by Rutherford et al. 2005). In that particular implementation, "ridge regression" was used to accomplish the "regularization" step in the RegEM CFR procedure (e.g., as in Schneider 2001). The problem lies in the use of a particular selection criterion [generalized cross validation (GCV)] to identify an optimal value of the "ridge parameter," the parameter that controls the degree of smoothing of the covariance information in data (and thus, the level of preserved variance in the estimated values, and consequently, the amplitude of the reconstruction). While MRWA05 standardized all (proxy and instrumental) data over the full interval of the model simulation (A.D. 850–1980), in real-world reconstructions (e.g., Rutherford et al. 2005) the instrumental data must be standardized in relation to the considerably shorter period (e.g., a late nineteenth-/twentieth-century calibration interval) during which they are defined. When this shorter period standardization is done with the "instrumental" data in the original MRWA05 framework, GCV fails to identify an appropriate ridge parameter, and a poor reconstruction is indeed produced, as SK07 note.

This problem is easily fixed, however (see Mann 2007; Mann et al. 2007). Mann et al. (2007) describe an alternative implementation of RegEM that accomplishes regularization through truncated total least squares (TTLS) [see discussion by Schneider (2001)] in conjunction with a simple objective criterion for choosing the appropriate value of the "truncation parameter" (which plays a similar role in TTLS to the ridge parameter in ridge regression). Using this alternative RegEM implementation removes the sensitivity observed in MRWA05 to the way in which data are a priori standardized and yields equally skillful reconstructions using either of the possible standardization procedures. In Fig. 1, we compare the results shown in MRWA05 with

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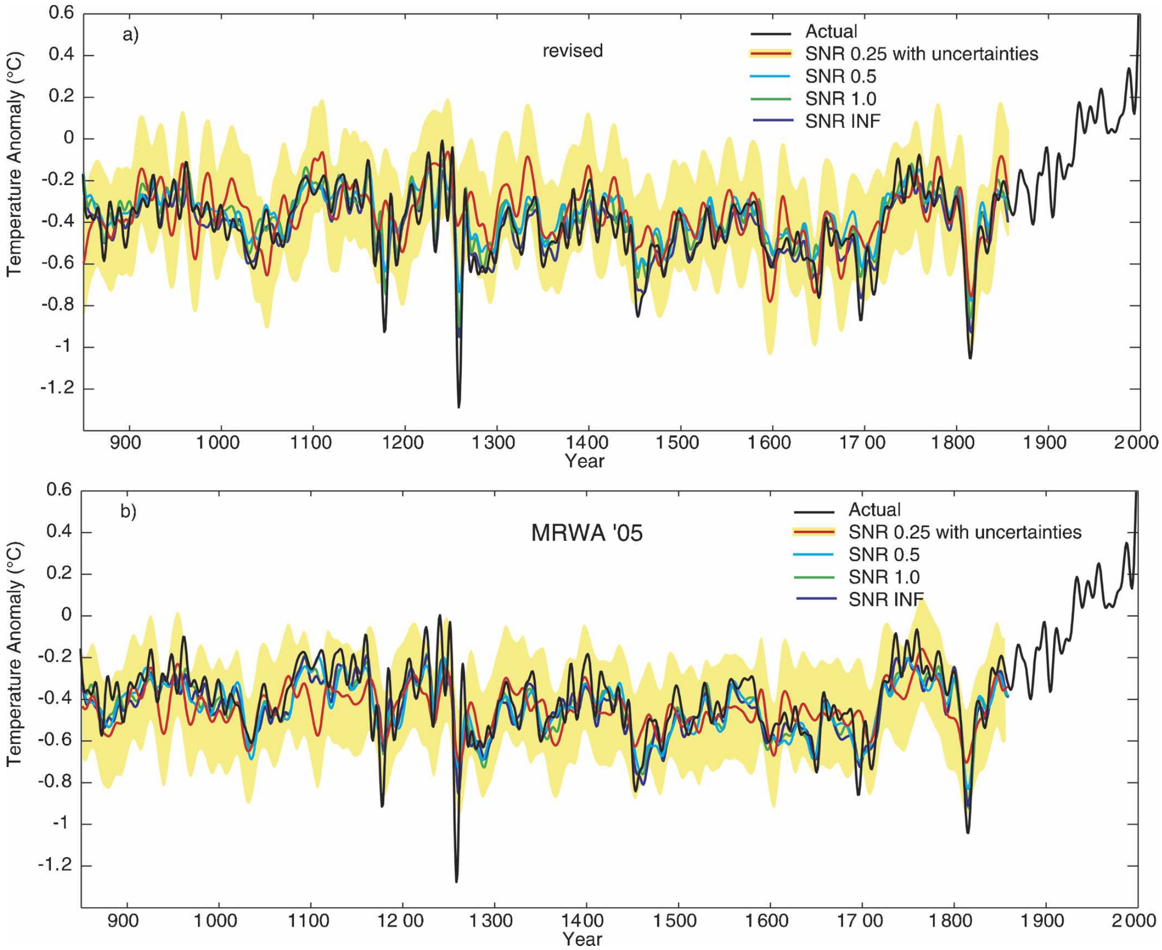

FIG. 1. Reconstruction of Northern Hemisphere mean temperature based on the RegEM CFR approach applied using "pseudoproxy" networks diagnosed from simulation of the National Center for Atmospheric Research (NCAR) Climate System Model (CSM) 1.4 simulation as in MRWA05. An 1856–1980 calibration interval is used. (a) Employing TTLS for regularization as in Mann et al. (2007), with both simulated target climate and pseudoproxy-reconstructed time series standardized over 1856–1980. (b) Results from MRWA05 (correct areal weighting has been used, as discussed in the text). Self-consistent uncertainties in the reconstructions are estimated from the unresolved residual variance during an 1856–1899 "validation" interval, based on a short (1900–1980) calibration. Actual model NH series is shown for comparison (black). All series are decadally smoothed as in MRWA05.

those using the alternative procedure of Mann et al. (2007) using the same signal-to-noise ratio (SNR) values (0.25, 0.5, 1.0, and infinity). No systematic underestimate of the low-frequency variability is observed, even for SNR = 0.25, which is lower than the estimates for actual proxy networks that have been used in large-scale temperature reconstructions (Mann et al. 2007).

There are some additional assertions by SK07 that warrant further comment. SK07 make the curious assertion that colored noise models that have been adopted in previous work (Mann and Rutherford 2002; von Storch et al. 2004, 2006; M05) do not "fully mimic the nonlinear, multivariate, nonstationary characteristics of noise in many proxy series (e.g., Jacoby and D'Arrigo 1995; Briffa et al. 1998; Esper et al. 2005; Evans et al. 2002; Anchukaitis et al. 2006)." While the cited studies reiterate the well-known point that climate signals contained within proxy records are often complex, we could not find the claim in any of these studies that the noise component in proxy records is in general either "nonlinear" or "nonstationary." The use of the term "multivariate" by SK07 is also perplexing in this context, since, for example, the sum of a set of independent noise processes with similar characteristics is itself, in general, simply a noise process with those same characteristics.

In fact, Mann and colleagues (Mann and Rutherford 2002; Mann et al. 2007) have rather generally investigated the influence of the "color" of the noise spectrum, examining the full range of possibilities from

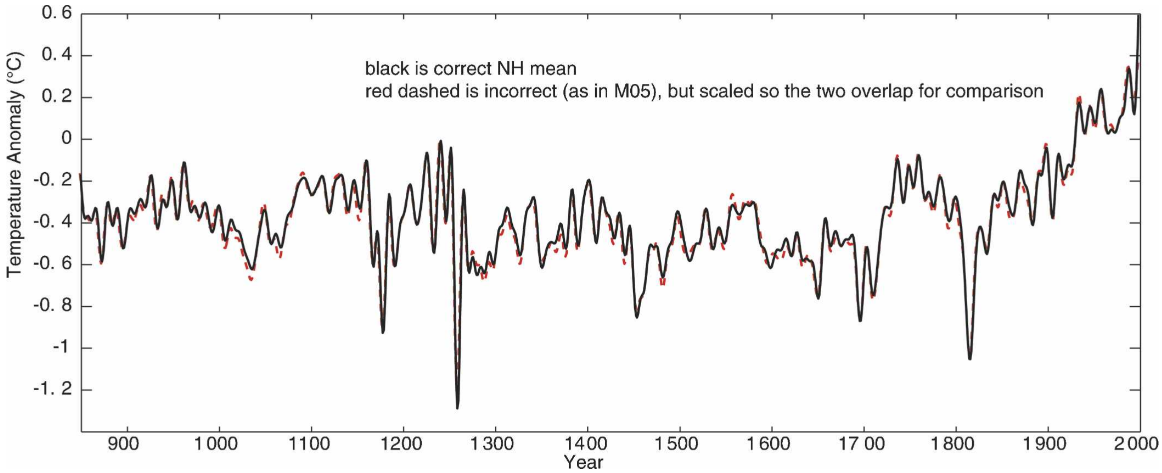

FIG. 2. Difference between incorrect (nonareally weighted, red) NCAR CSM 1.4 NH mean series, as shown in MRWA05, and correct (areally weighted, black) NH series, after multiplication by the associated constant offset factor.

"red" (positive noise autocorrelation, leading to selective loss of signal by proxies at lower frequencies) to "blue" (negative noise autocorrelation, leading to selective loss of signal by proxies at higher frequencies). Mann et al. (2007) further show that the skillful results demonstrated above in Fig. 1 hold up both for moderately red and blue proxy noise, using the estimated noise autocorrelation structure from actual proxy networks.

Finally, we add a note regarding the following statement by SK07: "We also plot for this comment the area-weighted reconstructions, pointing out that the M05 [MRWA05] mean reconstructions were only normalized by the sum of the area weights, not weighted by them." The authors have correctly identified a glitch concerning the plots shown in MRWA05, but not the underlying calculations. All statistical calculations (e.g., the reconstruction skill evaluations) in MRWA05 were based on the correctly areally weighted hemispheric means. However, the time series actually plotted in MRWA05 were accidentally missing the area weight factors. This mistake applied equally to both the true and reconstructed temperature series shown and (to a very good approximation, see Fig. 2) simply amounts to a fixed scaling factor by which all series shown were multiplied. The issue therefore has no bearing on any of the conclusions in MRWA05, nor does it impact at all any related studies (e.g., Rutherford et al. 2005; Mann 2007; Mann et al. 2007).

While SK07 note a small set of issues with previously presented results, these have been dealt with prior (Mann et al. 2007), and none of the issues raised influence our previous basic results or interpretations or our conclusions regarding the skillful nature of the RegEM approach to proxy-based CFR. We nonetheless share with SK07 the view that it is important to continue to investigate the relative strengths and weaknesses of competing approaches to paleoclimate reconstruction. Indeed, Mann et al. (2007) encourage continued investigation based on the reconstruction of a variety of different climate fields, not just surface temperature, and employing various possible alternative models for proxy signal and noise characteristics. A discipline-wide intercomparison of alternative approaches to paleoclimate reconstruction is currently being planned under the auspices of the International Past Global Changes (PAGES)/Climate Variability and Predictability (CLIVAR) Intersection (Mann et al. 2006), and we expect that this project will lead to further improvements and refinements in paleoclimate reconstruction methodologies.

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