Reply to comment by Rutherford et al. on "Erroneous Model Field Representations in Multiple Pseudoproxy Studies: Corrections and Implications"†

Jason E. Smerdon * and Alexey Kaplan

Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY

Daniel E. Amrhein

Woods Hole Oceanographic Institution, Woods Hole, MA

* *Corresponding author address:* Jason E. Smerdon, Lamont-Doherty Earth Observatory of Columbia University, 61 Route 9W, P.O. Box 1000, Palisades, NY 10964. E-mail: jsmerdon@ldeo.columbia.edu

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Rutherford et al. (2011, hereinafter R11) confirm the errors in *Mann et al.* (2005) and *Mann et al.* (2007a, hereinafter M07) involving the processing of the CCSM (*Ammann et al.* 2007) and the GKSS (*González-Rouco et al.* 2003) millennial simulations, as we described in *Smerdon et al.* (2010, hereinafter S10). This is the principal information of note in R11 and it serves to underscore the necessity of our efforts to correct previous results in the published literature. Nevertheless, R11 also advance several additional arguments that require further detailed responses herein.

R11 initially make a distinction in their Comment between the two versions of the regularized expectation maximization (RegEM) method (*Schneider* 2001), with the apparent purpose of: (1) asserting that the RegEM method using truncated total least squares (RegEM-TTLS) is a better climate field reconstruction (CFR) method than RegEM using ridge regression (RegEM-Ridge), the latter of which is used by S10 to discuss the impact of the errors that they identified; and (2) implying that only errors in the peer-reviewed literature regarding RegEM-TTLS need to be corrected, while errors associated with RegEM-Ridge presumably do not. Leaving aside a more detailed discussion of the relative performance of these two RegEM regularization schemes, suffice it to say that any CFR method could have been used to describe the errors discovered by S10, making methodological distinctions in this context immaterial. Moreover, a methodological distinction as applied in (2) is clearly incorrect. Certainly every number published in the peer-reviewed literature is either correct or requires correction, regardless of its methodological provenance. R11 also provide a list of studies published subsequent to M07 (or even after S10) that are allegedly not affected by the errors discussed by S10. While we welcome the news that these later studies were not affected by the errors that we have identified, their existence is not germane to the occurrence

of previous errors or the need for their correction. Furthermore, no attempts were made in the later publications mentioned by R11 to address the errors in the previous pseudoproxy studies or to clearly indicate that the newer studies were free of those errors. It therefore is important to note that no methodological distinctions or references to subsequent papers circumvent the fact that important errors were present in the underlying pseudoproxy data used in multiple earlier studies and that these associated publications required corrections.

R11 subsequently insist that the M07 errors in the regridded GKSS model field were previously addressed in a Comment/Reply exchange between *Smerdon et al.* (2008b) and *Rutherford et al.* (2008) and that "*the GKSS experiments have been re-executed and the results published in Rutherford et al. (2008).*" The incompleteness of this previous exchange was specifically discussed by S10, who demonstrated that the source, scale, and character of the problem with the incorrectly regridded GKSS field had not been made clear in the exchange, nor had the complete set of GKSS results from M07 been corrected. Additionally, no corrections were made to the incorrectly regridded GKSS data at the M07 supplemental website until after S10 was submitted to the *Journal of Climate*, almost two years after *Rutherford et al.* (2008) was published. It also must be noted that the impression given by *Rutherford et al.* (2008) was that M07 had correctly applied the *surface* function from the Generic Mapping Tools (GMT) software package (*Wessel and Smith* 1991) to yield an interpolated GKSS model field that was only somewhat different from a bilinear interpolation scheme. We welcome the fact that R11 have now offered an explanation for the real cause of the problem: it was "*an apparent error in the longitude files*," and not a regular feature of the GMT *surface* function. Nevertheless, given the relative vagueness of the R11 explanation, further clarification is needed.

Here we use the GKSS annual surface temperature mean from 1880-1980 C.E. (in keeping with S10) to demonstrate the presumed source of the error in M07. Figure 1a shows this field averaged by S10 onto a 5° spatial grid, but still in its native longitude range (0°–360°). We apply the GMT *surface* function to the field shown in Figure 1a, obtaining the correctly gridded version of the field shown in Figure 1c with the longitudinal range changed to -180°–180° (we do not endorse the use of the *surface* function for the purpose of regridding fields in general, but we employ it here to reproduce the M07 regridding problem). This result was accomplished using an *-fg* flag in the call of the *surface* function to ensure that the spatial grid was interpreted as geographic coordinates and not as regular numbers. In the absence of the *-fg* flag, the latter interpretation is made and the *surface* function attributes no input data to the grid points with negative longitudes because the input data range from 0° to 360°. Consequently, the Western Hemisphere (WH) is interpolated with a continuous bi-harmonic surface anchored only by the points on its eastern boundary. The resulting field is shown in Figure 1d and has a striking resemblance to the M07 product shown in Figure 1b. Figure 2 replots Figures 1b and 1d over the range 0°–360° and illustrates, in both cases, the effect of the anchoring of the WH on its eastern boundary and the resulting discontinuity of the global field at 180° longitude. This example identifies the likely source of the problem in the M07 regridded GKSS field as a mismatch between the ranges of the input and output longitude values that presumably occurred as a result of the "*error in the longitude files,*" to which R11 refer. While we have used the *-fg* flag for simple demonstration purposes, the root of the M07 error does not hinge on the use of any specific flag – it is principally associated with a failure to match input and output longitudes.

R11 go on to make several arguments related to the use of the CCSM field and pseudo-

proxies in general. We do not contest the point that their incorrect sampling of the CCSM field constitutes an experiment that can be reinterpreted (this point was made by S10), nor do we disagree that other sampling schemes could be intentionally used in pseudoproxy experiments. We nevertheless fail to understand the relevance of these points with regard to correcting previous errors in the literature or the need to accurately report experimental designs.

A final point on which we disagree with R11 is the importance of the Niño3 statistics reported in M07. These statistics have not been corrected for the CCSM or ECHO-g pseudoproxy experiments in M07, in spite of the insistence by R11 that all of the M07 experiments were corrected by *Rutherford et al.* (2008). R11 dismiss the significance of the Niño3 statistics by arguing that the M07 paper "*focused on the Northern Hemispere mean and the overall field reconstruction*," but fail to acknowledge that the reconstructed Niño3 index was one of only two diagnostics used by M07 to assess the spatial skill of the RegEM-TTLS method. This method has subsequently been used by *Mann et al.* (2009a) and *Mann et al.* (2009b) to derive real-world CFRs in which the spatial skill of the RegEM-TTLS method is fundamentally important, including reconstructions of the Niño3 region that are specifically used for calculations and dynamic interpretations. In both studies, the pseudoproxy tests of M07 are used as important methodological validation. *Mann et al.* (2009a), for instance, specifically cite M07 as the study in which their employed CFR method (RegEM-TTLS) "*has been rigorously tested with synthetic "pseudoproxy" networks generated from forced climate model simulations.*" The Niño3 reconstruction statistics in M07 therefore cannot be considered insignificant because they are in fact the only published pseudoproxy results to date that specifically purport to evaluate the skill of the RegEM-TTLS method in reconstructing the

Niño3 index in a global CFR context.

We conclude by reiterating the importance of maintaining consistent and correctly documented pseudoproxy experiments for testing CFR methods. The advantage of such experiments lies in their ability to provide an objective and common testbed on which reconstruction methods can be systematically evaluated and compared. This advantage is lost if pseudoproxy experiments are inaccurately described or incorrectly executed. The purpose of S10 was to correct errors affecting or confusing discussions in at least seven published papers (*Mann et al.* 2005, 2007a,b; *Smerdon and Kaplan* 2007; *Smerdon et al.* 2008a,b; *Rutherford et al.* 2008). Such corrections are fundamentally important for avoiding the perpetuation of these errors in the published literature and to improve testing and development of methods for reconstructing climate fields during the Common Era.

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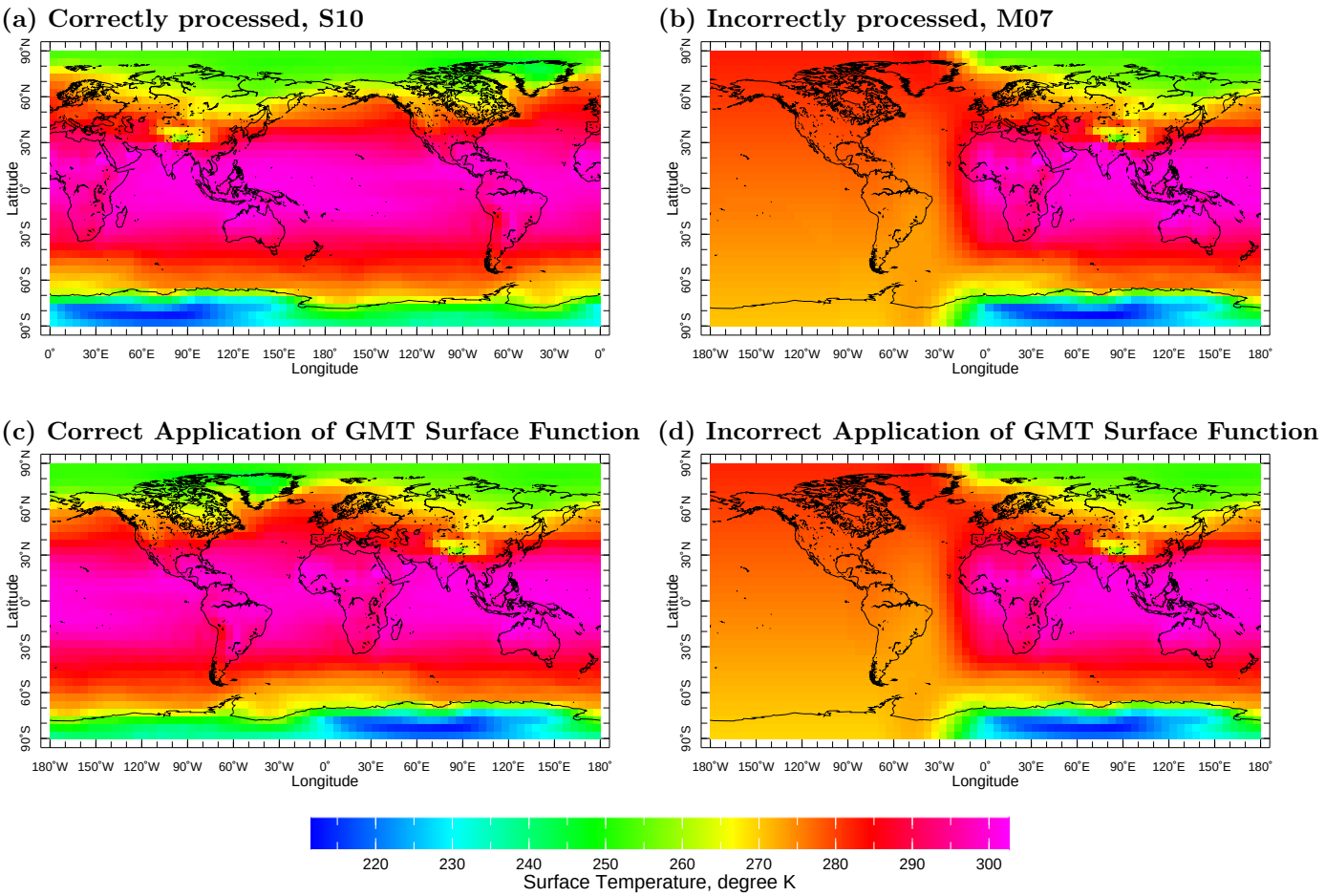

FIG. 1. (a) Annual GKSS surface temperature mean field between 1880-1980 C.E., as in S10; (b) same as (a) but for the version regridded, used, and archived by M07; (c) same as (a) but after correctly applying the GMT *surface* function (the longitude range has been changed to -180°–180° as in panel (b)); (d) same as (c) but without the *-fg* flag in the call of the *surface* function, resulting in large-scale smoothing of the WH due to the loss of all WH data.

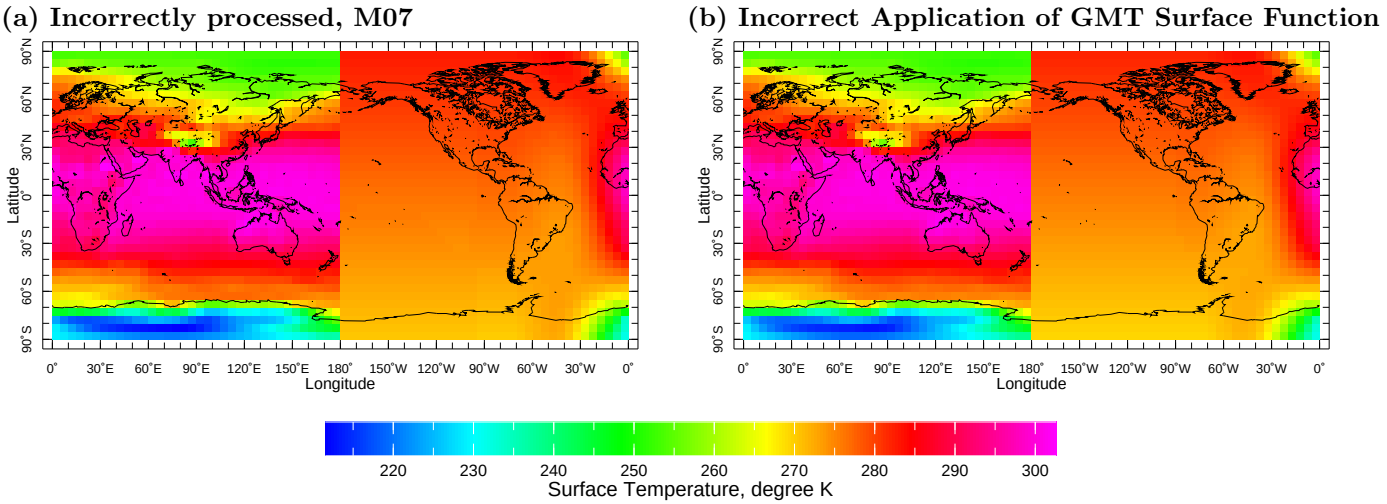

FIG. 2. Panels (a) and (b) are for the same data as those in panels (b) and (d) in Figure 1, but for the longitudinal range 0°–360° to show the anchoring of the smoothed WH on its eastern boundary and the resulting discontinuity of the global field at 180°: (a) M07 processing; (b) resulting field after applying the *surface* function to the field in Figure 1a while omitting the *-fg* flag.