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

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Rutherford et al. (2010a, hereinafter R10) 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 described by *Smerdon et al.* (2010, hereinafter S10). We believe that this is the principal information of note in R10 and it serves to underscore the necessity of our efforts to correct previous results in the public record. Nevertheless, the authors advance several additional arguments that require further detailed responses herein.

R10 initially assert that two more recent papers (*Mann et al.* 2009a; *Rutherford et al.* 2010b) do not suffer from the errors discussed in S10. They argue that this information was not adequately addressed by S10, but the presence or absence of errors in these papers could not have been determined by S10 because the data for these experiments are not publicly archived. The argument given by R10 for why these later studies do not suffer from the same problems is also insufficient. R10 imply (pg. 4) that the application of an instrumental data mask is the only problem created by the incorrect geographic orientation of the CCSM field, but S10 also demonstrated that the locations of the sampled pseudoproxies were also erroneously affected by this problem. It therefore is still ambiguous as to whether the employed pseudoproxies in these later studies were compromised.

R10 also make a distinction 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 (hereinafter RegEM-TTLS) is a better climate field reconstruction (CFR) method than RegEM using ridge regression (hereinafter RegEM-Ridge); and (2) implying that only error corrections in published papers about RegEM-TTLS are important, while errors in the peer-reviewed literature about

RegEM-Ridge are presumably not. Leaving aside more detailed arguments about comparisons between the two forms of regularization in RegEM, suffice it to say that any CFR method could have been adequately applied to describe the errors discovered by S10, making methodological distinctions in this context unnecessary. Moreover, a distinction as applied in (2) is certainly wrong. Clearly every statement and number published in the peer-reviewed literature is either correct or in need of correction, regardless of its methodological provenance.

R10 subsequently insist that the problems with the M07 regridded GKSS model field were previously addressed in a Comment/Reply exchange (*Smerdon et al.* 2008b; *Rutherford et al.* 2008) and that "*all GKSS experiments have been re-executed and reinterpreted as necessary, and the results published in Rutherford et al. (2008)*." The incompleteness of the exchange in question was clearly discussed by S10, who demonstrated that the source, scale and character of the problem with the regridded GKSS field were not correctly identified, nor was the complete set of GKSS results from M07 corrected. Furthermore, no corrections were made to the publicly available 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).

Some of the GKSS results in M07 that notably were not corrected by *Rutherford et al.* (2008) are the reconstruction statistics for the Niño3 region. R10 dismiss the significance of the Niño3 statistics by arguing that "*they were not discussed*" in M07 and therefore "*not significant in terms of the published discussions and conclusions*." We first of all challenge the claim that these numbers were not discussed; a simple text search of the M07 paper reveals that Niño3 is mentioned fourteen times (not including table and figure captions).

It is also surprising that results making up one-third of a table (the only table in M07) that spans the majority of a journal page are now deemed insignificant by the authors. Much more importantly, however, is the fact that reconstructed Niño3 indices are used by M07 as one of two diagnostics for assessing the spatial skill of RegEM-TTLS. 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. Moreover, both of these studies involve calculations or interpretations explicitly dependent on the Niño3 region as estimated by the RegEM-TTLS method. The Niño3 reconstruction statistics in M07 therefore cannot be called insignificant, because these are in fact the only published pseudoproxy results that specifically evaluate the skill of the RegEM-TTLS method in reconstructing the Niño3 index.

R10 also offer an explanation for the incorrect processing of the GKSS field in the M07 paper by claiming that a "bug" exists in the Generic Mapping Tools (GMT) software (*Wessel and Smith* 1991). This purported bug produces erroneous fields when the GMT *surface* function, which fits a continuous curved surface to randomly-spaced data, is employed using its default tension setting. If this observation is correct, it would be a valuable piece of information for a wide community of GMT users. Nevertheless, we cannot confirm any signs of such a bug in our own experiments with the GMT *surface* function and the peculiar nature of the error affecting the M07 processed GKSS field – namely the selective smoothing of a single hemisphere – makes the claim by R10 seem untenable. In fact, our own experiments provide a simpler and more plausible explanation. We illustrate our findings using the GKSS annual surface temperature mean from 1880-1990 C.E., in keeping with S10. Figure 1a shows this field averaged by S10 onto a 5° spatial grid, but still in its native longitude range (0°–

360°). For simple illustration purposes, we apply the GMT *surface* function to the field shown in Figure 1a using a default tension setting (tension = 0; this setting can range from 0 to 1), which yields the correctly gridded version of the field shown in Figure 1c with the longitudinal range changed to -180°–180° (note that we do not endorse the use of the *surface* function for the purpose of regridding fields in general, but we consider it here because it is at the heart of the M07 regridding procedure). This result was accomplished using a flag *-fg* in the call of the *surface* function to ensure that the spatial grid was interpreted as geographic coordinates and not as regular numbers. If the latter interpretation is made due to the absence of the *-fg* flag, however, the *surface* function will regard the input points with longitudes <0° as unavailable because the input data range from 0° to 360°. Consequently, the Western Hemisphere (WH) will be interpolated with a continuous curved 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 clearly illustrates, in both cases, the effect of the anchoring of the WH on its eastern boundary and the discontinuity of the boundary at 180°). Furthermore, we find no evidence to support the dependence of these results on the tension setting of the *surface* function. In Figures 1e and 1f, we plot correct and incorrect results for a prescribed tension setting (0.5) that do not differ from their respective counterparts using the default tension in any substantial way. These findings thus suggest a misuse of the GMT *surface* function by M07 as the origin of the errors in the regridded GKSS field, rather than the existence of a hypothetical bug that only occurs at the default tension setting and only affects one hemisphere.

If our assertion that the true reason for the problems in the regridded GKSS model field is correct, the false claim by R10 that a bug exists in the GMT software should be roundly rejected. The GMT software has been developed by two committed scientists and able volunteers from around the world into a widely used open-source geophysical software of the highest quality and reliability (*Wessel and Smith* 1995, 1998). Due to the open-source nature of the project, the reputation of this software is its principal capital. For this reason alone, claims of bugs in GMT should not be made or taken lightly. Nevertheless, if we are incorrect in our assertion that the true source of the problems in the regridded GKSS field stems from a misuse of the GMT software by M07, then we ask R10 to make public the script that was used to process the GKSS field and to demonstrate unambiguously that the existence of the bug in GMT causes the errors observed in the M07 version of the field (a script producing our own experiments and the related data files are available in the Supplementary Materials for this Reply).

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 testbed on which to systematically evaluate and compare reconstruction methods. 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 literature and to improve testing and development of methods for reconstructing climate fields during the Common Era.

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List of Figures

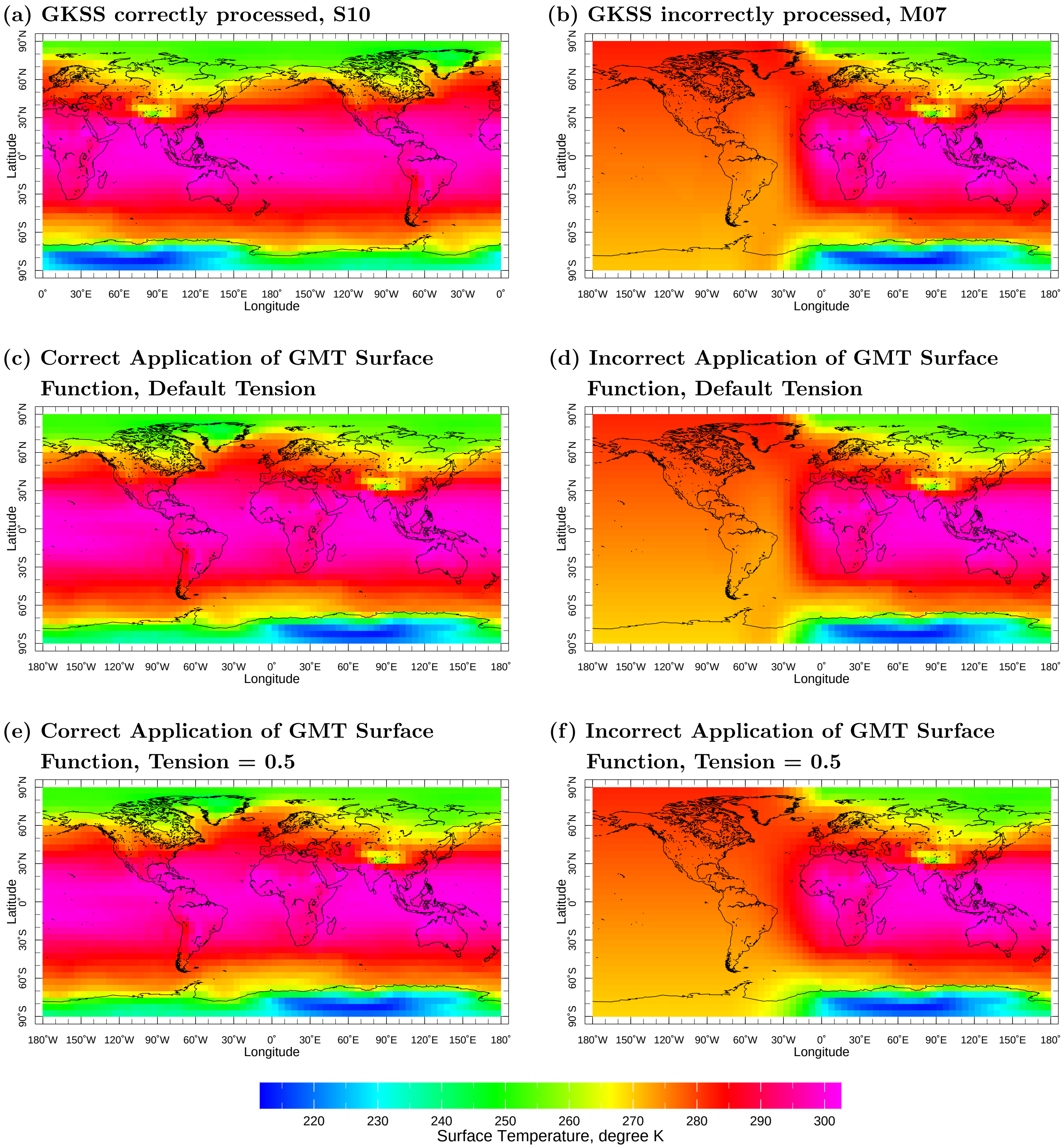

FIG. 1. (a) Average of the mean annual GKSS surface temperature field for the 1880-1980 C.E. period from S10; (b) same as (a) but for the version regridded, used and archived by M07; (c) GKSS surface temperature field derived by correctly applying the GMT *surface* function using the default tension setting of 0 (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; (e) and (f) are the same as (c) and (d) respectively, but for a tension setting of 0.5 (the tension can range between 0 and 1).

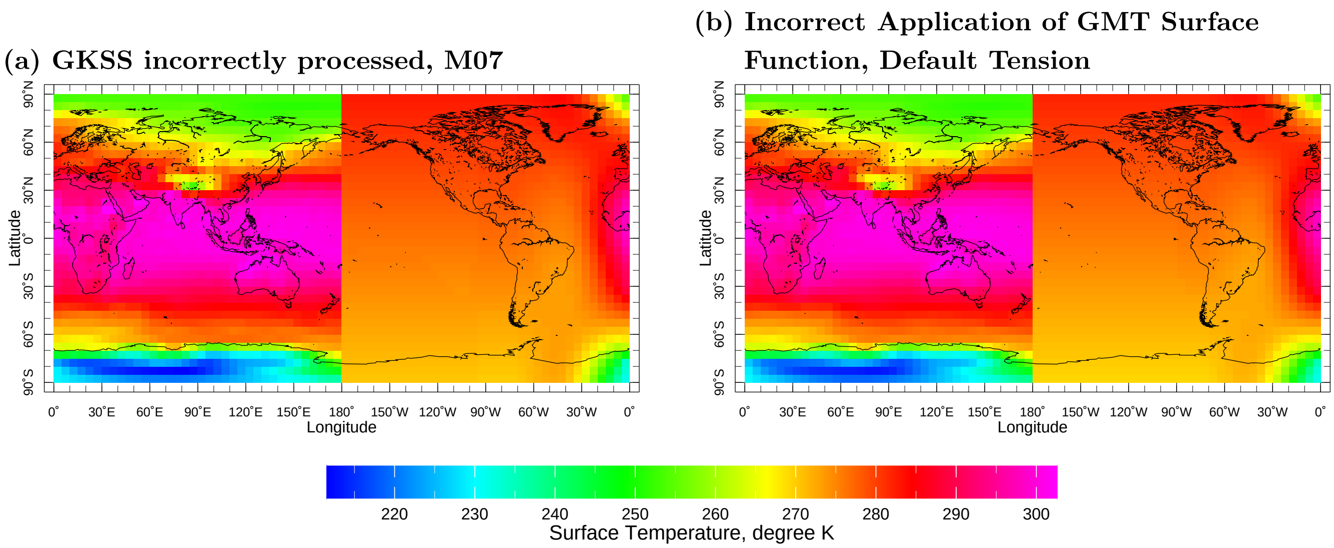

FIG. 2. Panels (a) and (b) are for the same data as those in panels (b) and (d) in Figure 1, but for the longitudinal range 0°–360° to show the anchoring of the smoothed WH on its eastern boundary and the discontinuity of the field at 180°: (a) M07 processing; (b) resulting field after application of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