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Robustness of Well-Verified, Spatially-Explicit High Resolution Climate Reconstructions: Characterization of Issues and Potential for Their Resolution

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High-resolution, spatially-explicit reconstructions of climate over the past 1-2 millennia offer the potential to achieve two key goals of paleoclimatology: 1) joining the instrumental and paleo records in a systematic way, to facilitate an extended synoptic-scale perspective on climate variability at regional scales; and 2) elucidating spatial patterns of the response to forcing changes over much longer time spans than possible with instrumental data, allowing for a greater range of responses to be included in composite analyses of forcings impacts on climate. A suite of spatially-explicit reconstruction methods coupled with experimental examination of long-term reconstruction performance in climate model simulation environments now provide a rich set of resources with which to move towards these goals, and also to examine likely situations of good and poor performance.

A key concern of all paleo-reconstruction methods is that even well-calibrated and well-verified models of the same phenomenon over the same spatial and temporal domains can diverge outside of the calibration and verification periods. Divergence can occur simply by altering proxy data richness within the same reconstruction model. This suite of problems is relatively well characterized for regional, hemispheric, and global average temperature time series, and even has a well-known visual representation – the so-called "spaghetti diagrams". These issues also exist in spatially-explicit reconstructions, but are not as well characterized as they are for spatially-averaged time series; their potential impacts on achieving the goals described above are also not as well understood.

We present examples of these issues from our current work in western North America and the South Asia/Indian Ocean region, along with ways to better characterize and deal with them. An intensive empirical approach is taken that examines a large variety of reconstruction situations for a given spatial-temporal domain – using the criterion of reconstruction robustness to gauge how well specific time periods and regional features can be reconstructed. In this approach, features in well-verified reconstructions that are robust across the situations examined are considered likely to be realistically reconstructed, whereas characteristics that differ significantly across reconstruction situations are considered to be uncertain in terms of their realism and of limited usefulness for synoptic and forcings response analyses. Examining differing reconstructions in terms of their dynamical realism has the potential to help resolve cases in which such uncertainty occurs, but must be employed with caution to avoid logical circularity, especially when the reconstructions are intended for use in forcings response analysis.