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A comparison of climate field reconstruction methods using millennial pseudo-proxy experiments

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Pseudo-proxy experiments derived from the NCAR CSM 1.4 millennial integration are used to investigate the spatial skill of climate field reconstructions (CFRs) derived from three techniques. Reconstructions performed with Canonical Correlation Analysis (CCA) and the Regularized Expectation Maximization (RegEM) method are evaluated, the latter of which has been recently favored for millennial CFRs. In the case of RegEM, two regularization approaches have been discussed in the literature – regularization by ridge regression or truncated total least squares (TTLS) – and reconstructions derived with both of these regularization approaches are investigated. The skill of each reconstruction is shown to vary spatially and can be quite poor over important regions such as the equatorial Pacific Ocean. These regions of reduced skill appear most notably associated with the distribution of the proxy network. Widespread variance losses are also noted, resulting in significant underestimates of variability in many regions of the reconstructed field. Furthermore, the spectral fidelity of the reconstructed climatic fields is shown to have altered ratios of high (annual to decadal) and low (multi-decadal and lower) frequency variability. Comparisons between the CFRs show CCA and RegEM-Ridge to compare most closely, while the field characteristics of RegEM-TTLS are unique among the three. The spatial correlations of the latter method are in fact the lowest of all three tested approaches and, unlike CCA and RegEM-Ridge, its variance is preserved predominantly in regions of lowest skill. These results demonstrate the importance of performing field validation experiments for CFRs and suggest that contemporary methods and proxy distributions may not yet

be adequate for skillful reconstruction of hemispheric or global temperature fields.