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Pseudo-proxy tests of the regularized expectation maximization (RegEM) method and their implications for real-world climate field reconstructions of the last millennium

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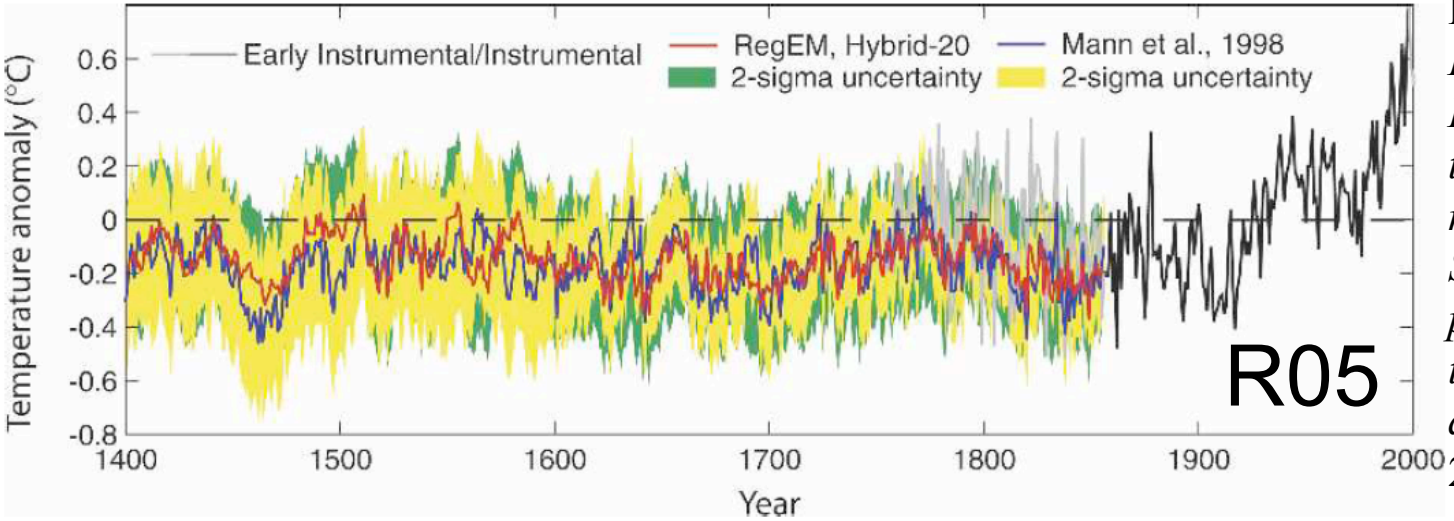
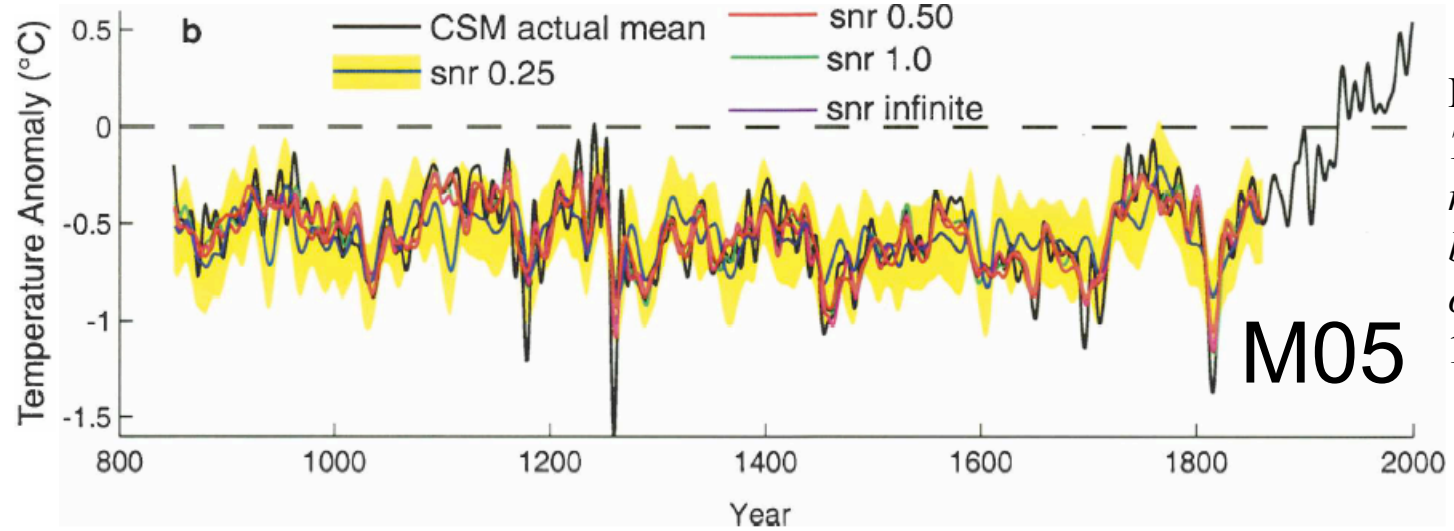
RegEM Climate Field Reconstructions

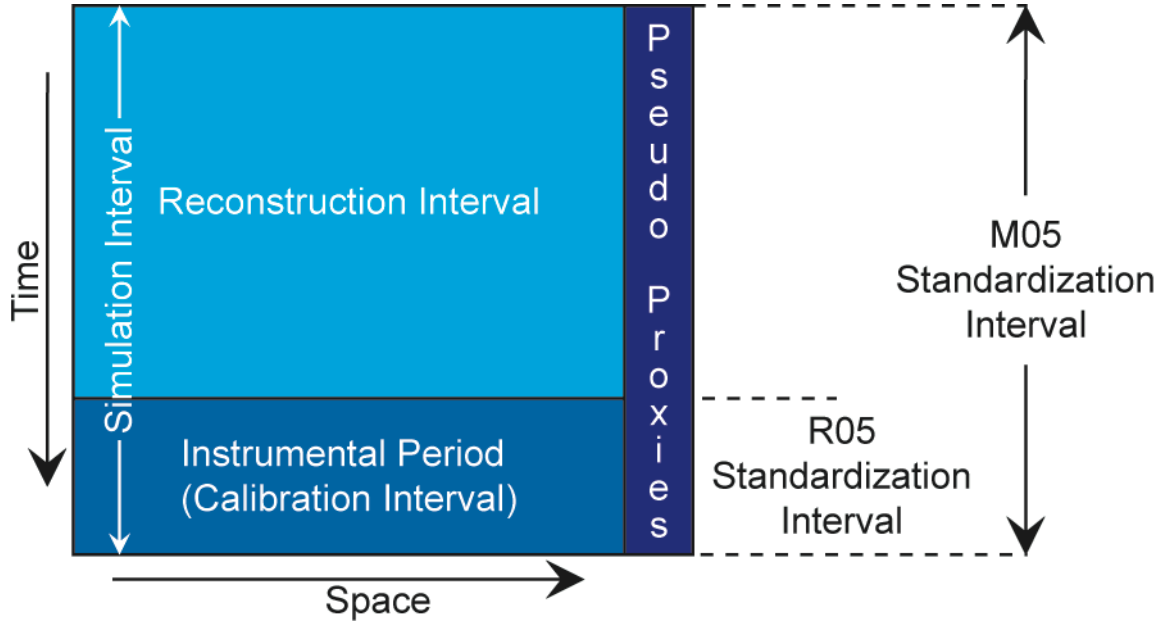


Rutherford et al., 2005: *Proxy-based Northern Hemisphere surface temperature reconstructions: Sensitivity to method, predictor network, target season and target domain*, *J. Clim.*, 18, 2308-2329.



Mann, M.E. et al., 2005: *Testing the fidelity of methods used in proxy-based reconstructions of past climate*, *J. Clim.*, **18**, 4097-4107.

Two Standardization Choices



Standardization: The normalization of a time series by it's standard deviation and the centering of a time series by the subtraction of it's mean, both over a given interval.

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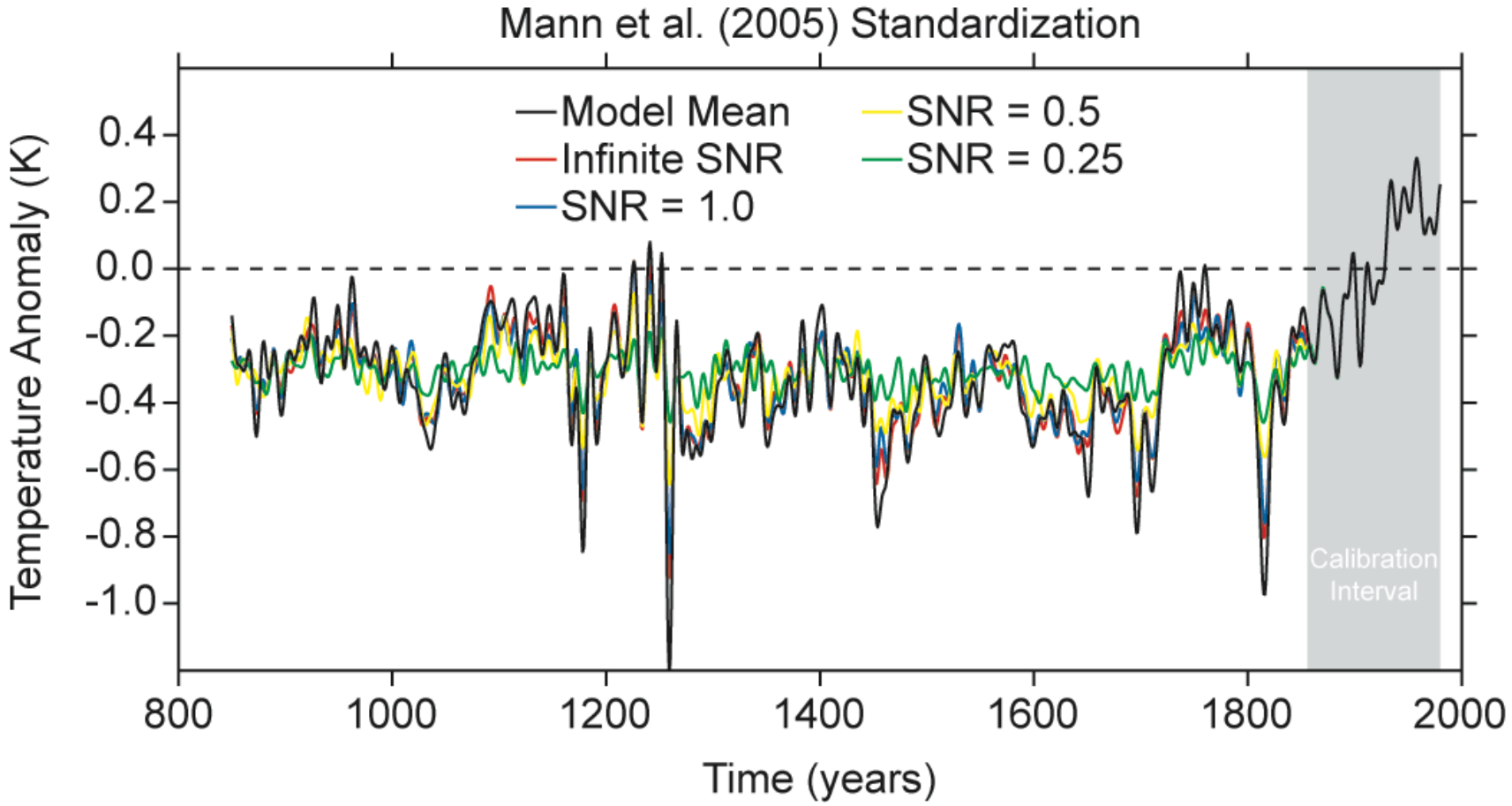
Pseudo-Proxy Test with NCAR CSM Millennial Simulation



Smerdon, J.E., and A. Kaplan, Comment on "Testing the fidelity of methods used in proxy-based reconstructions of past climate": The role of the standardization interval, *Journal of Climate*, in press.

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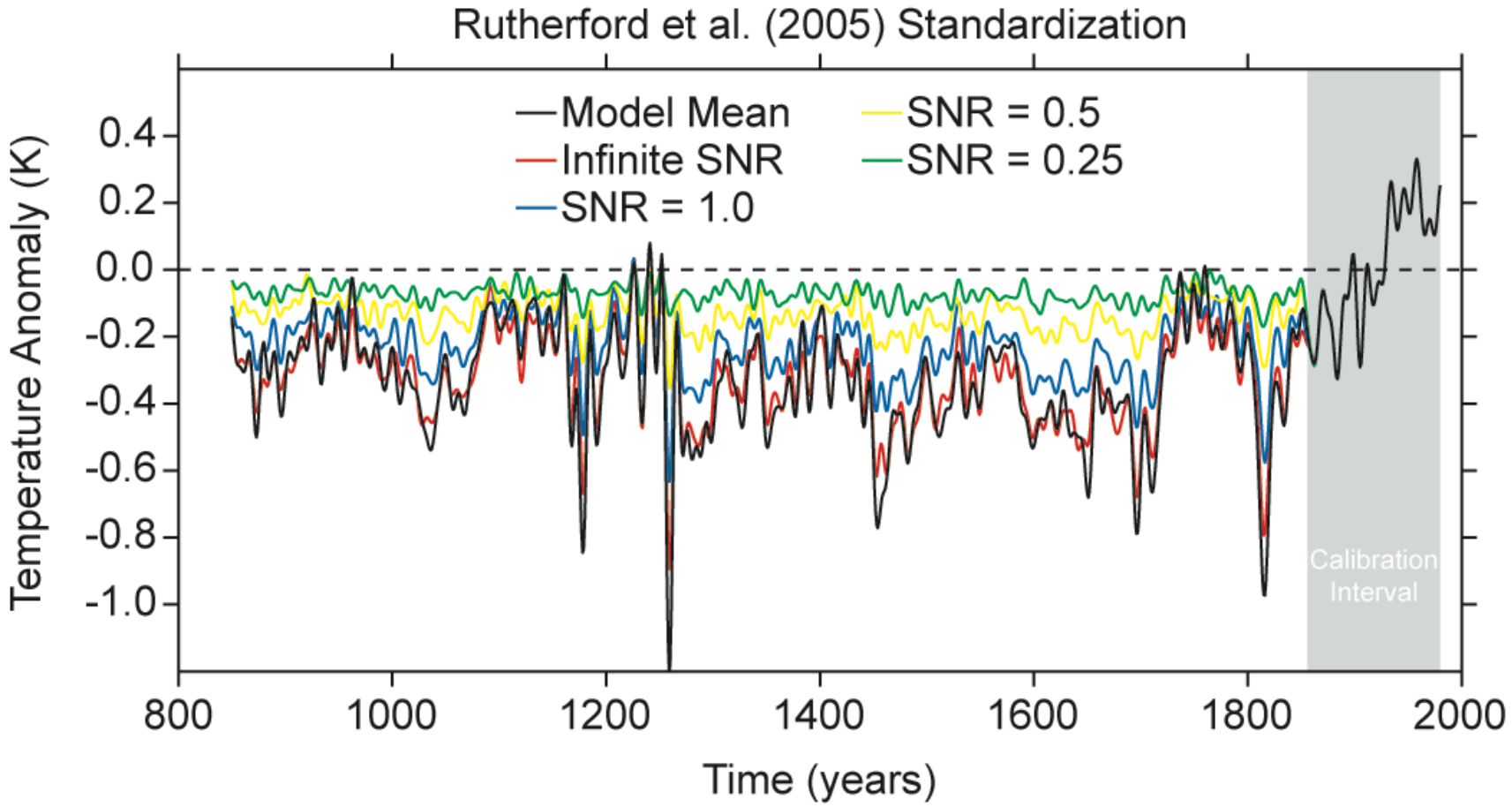

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What is the origin of the standardization sensitivity in RegEM?

- Mann et al.: The standardization sensitivity is associated with ridge parameter selection in RegEM regularized by ridge regression

- Us: The standardization sensitivity IS NOT associated with ridge parameter selection and is instead a result of the additional information included in the Mann et al. (2005) standardization choice

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Some RegEM Basics

Linear Regression Eq:

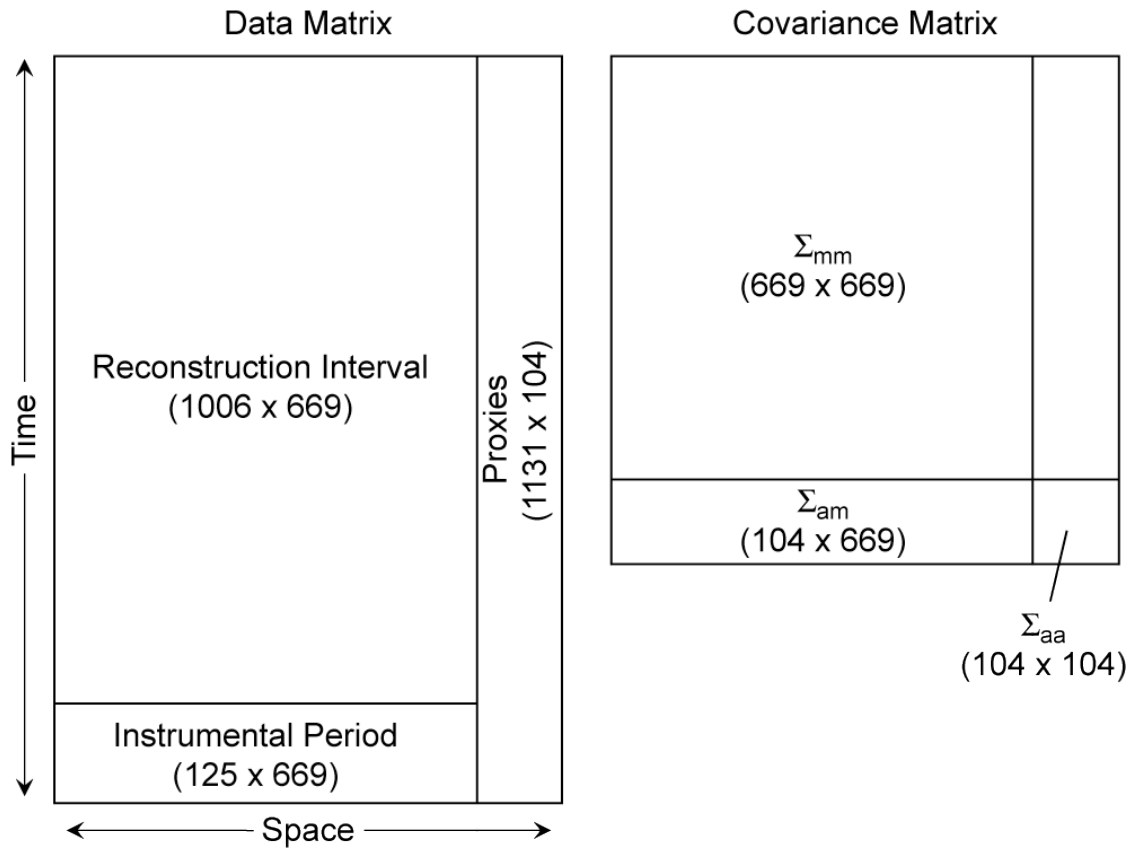
$$\mathbf{x}_m = \mu_m + (\mathbf{x}_a - \mu_a)\mathbf{B} + \mathbf{e}$$

Estimate of B:

$$\hat{\mathbf{B}} = \hat{\Sigma}_{aa}^{-1}\hat{\Sigma}_{am}$$

Regularization by Ridge Regression:

$$\hat{\Sigma}_{aa}^{-1} = \left(\hat{\Sigma}_{aa} + h^2\hat{\mathbf{D}}\right)^{-1}$$



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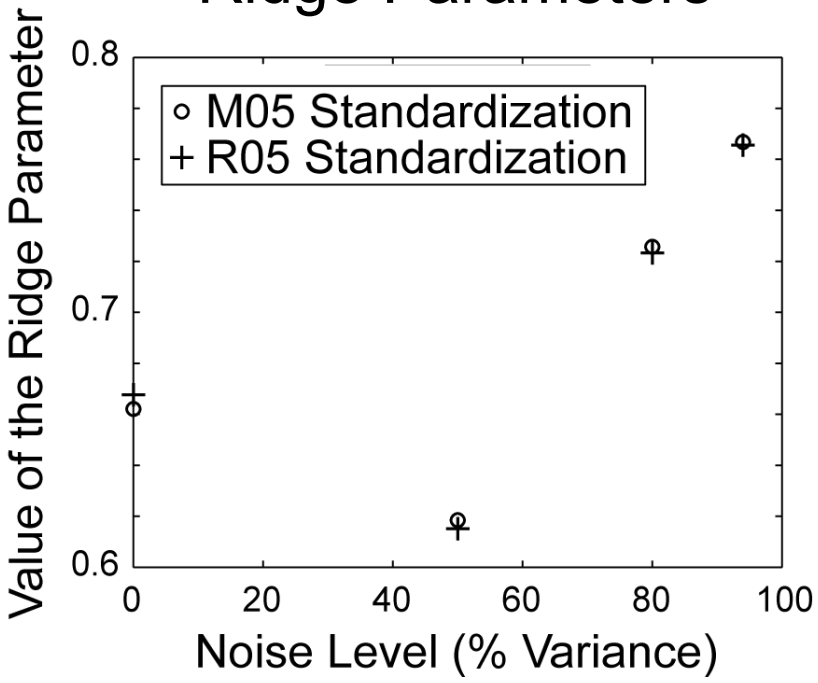
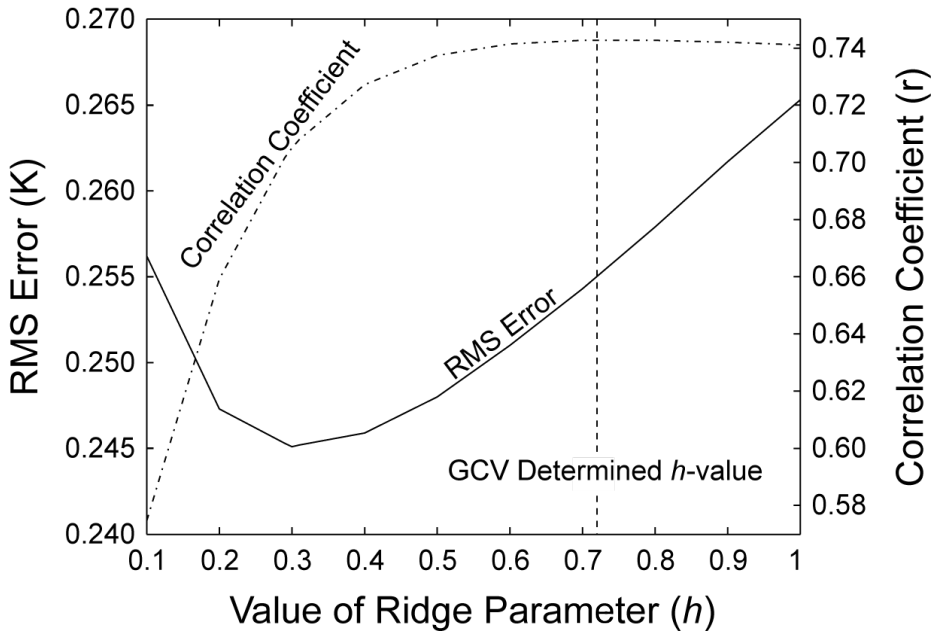
Ridge Parameter Selection

GCV Selected Ridge Parameters



Alternative Optimization Results



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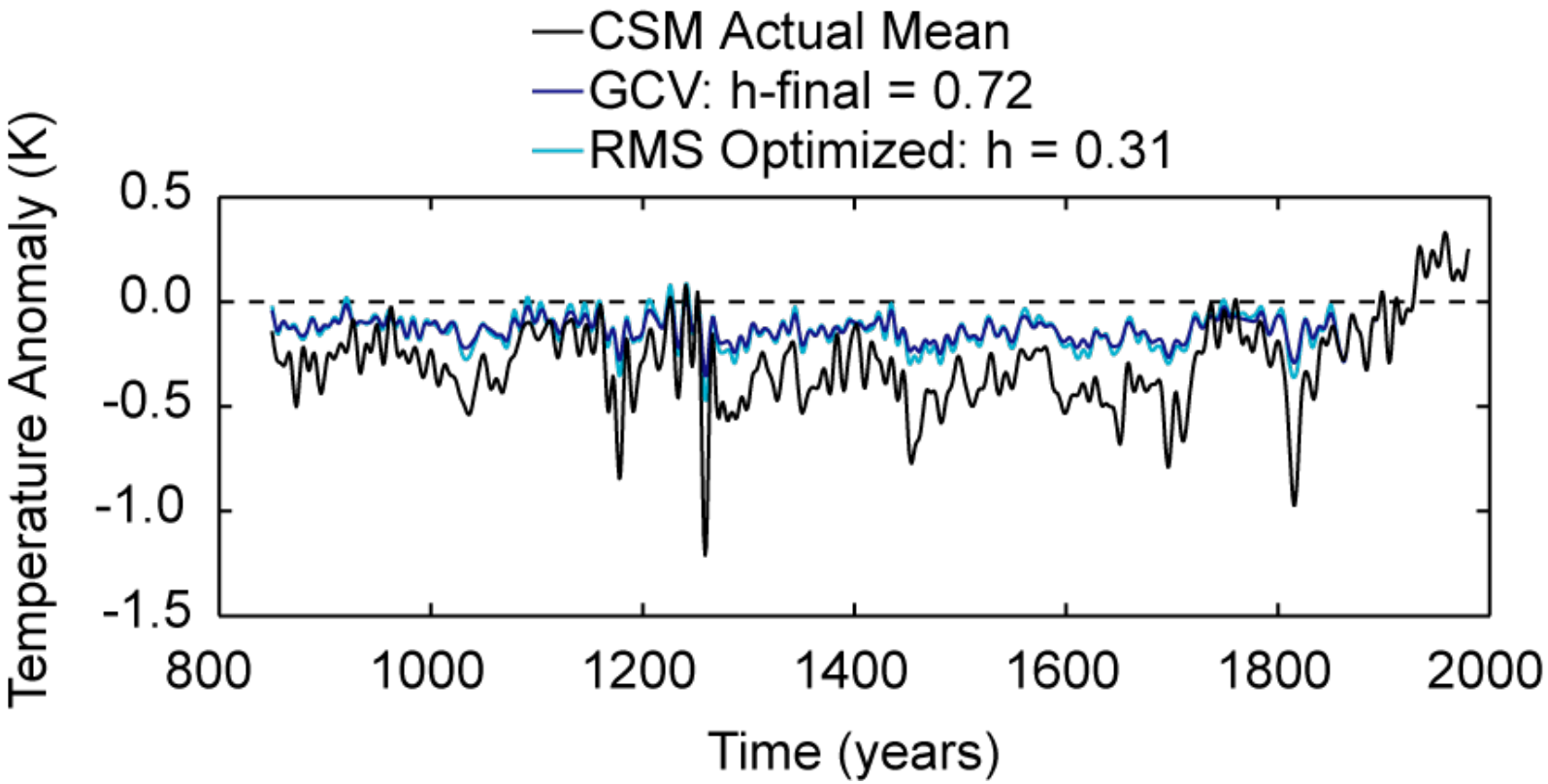
Reconstructions with Different Ridge Parameters



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RegEM Reconstruction

$$T_{recon} = \mathbf{m} + \mathbf{P}^*\mathbf{B}^*\mathbf{S}$$

m = Mean Field Matrix
P = Proxy Matrix
B = Regression Coefficient Matrix
S = Scaling matrix

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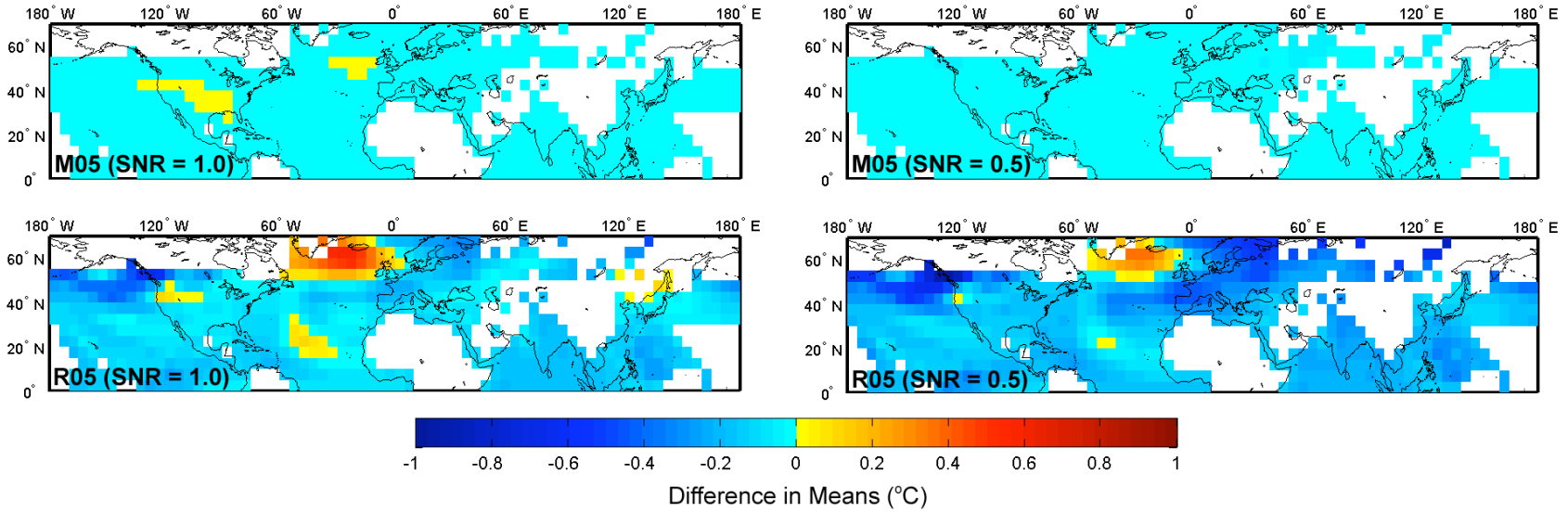
Mean Differences Between Known and Reconstructed Fields



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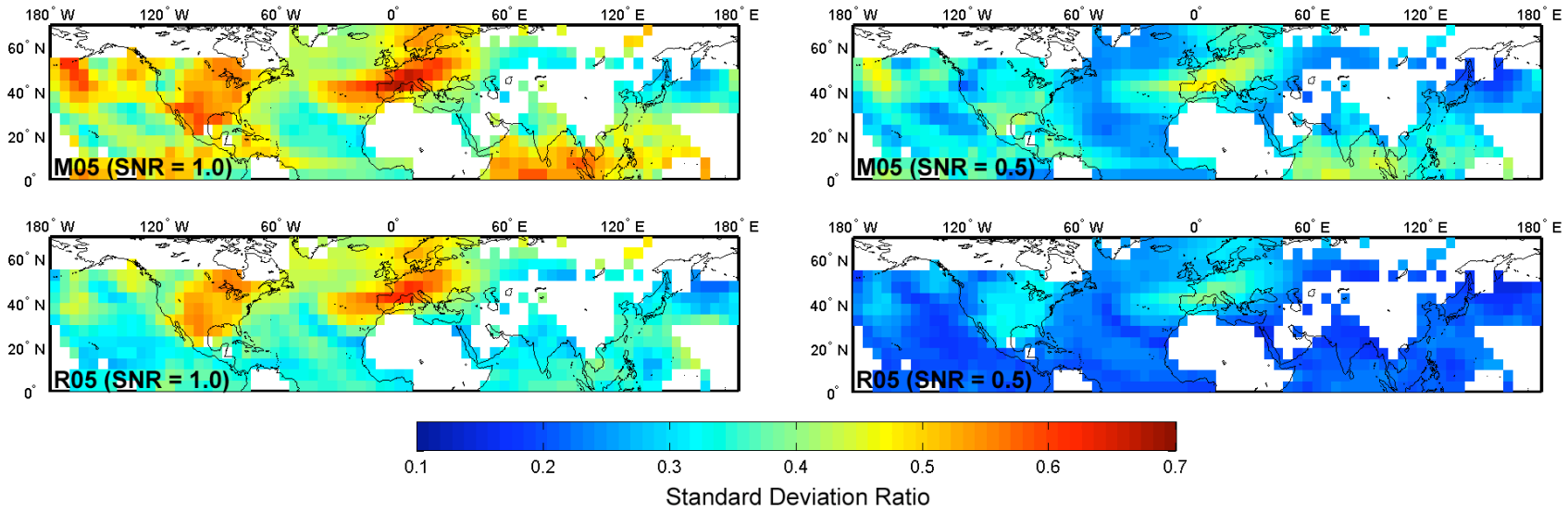
Standard Deviation Ratios Between Reconstructed and Known Fields



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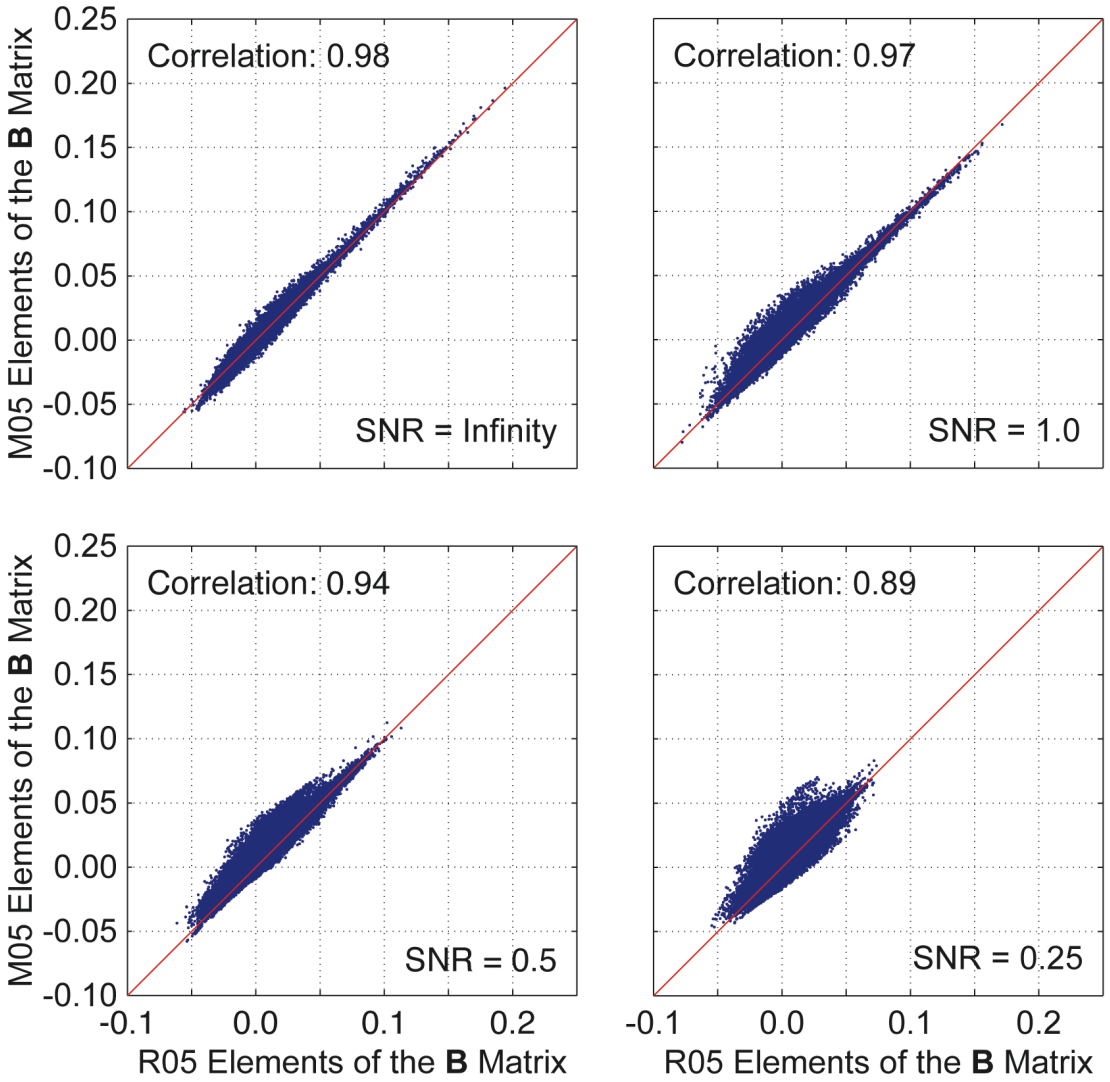

Regression Coefficient Comparisons

Smerdon, J.E., A. Kaplan, and D. Chang, 2007: On the origin of the standardization sensitivity in RegEM climate field reconstructions, *J. Clim.*, in review.

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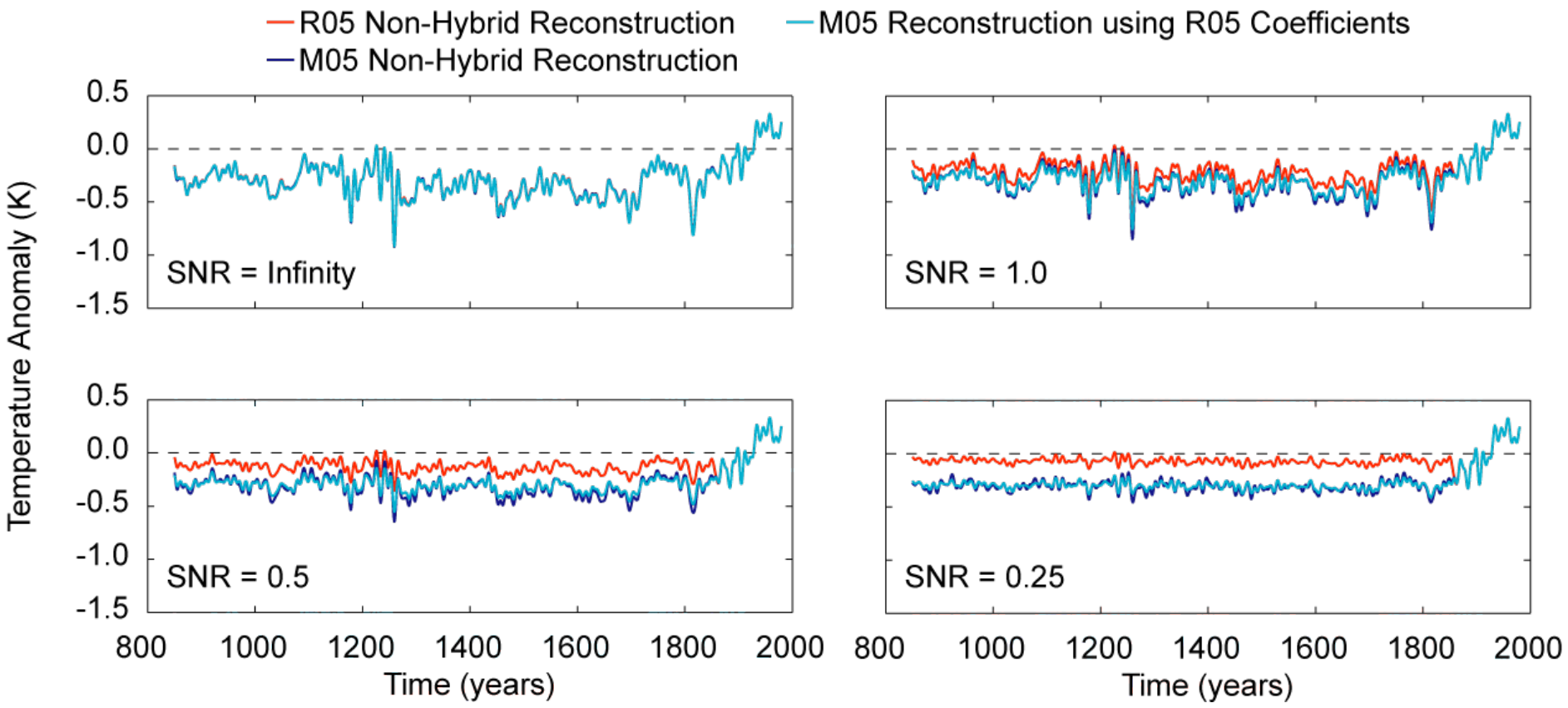
Mixed-Operator Reconstructions



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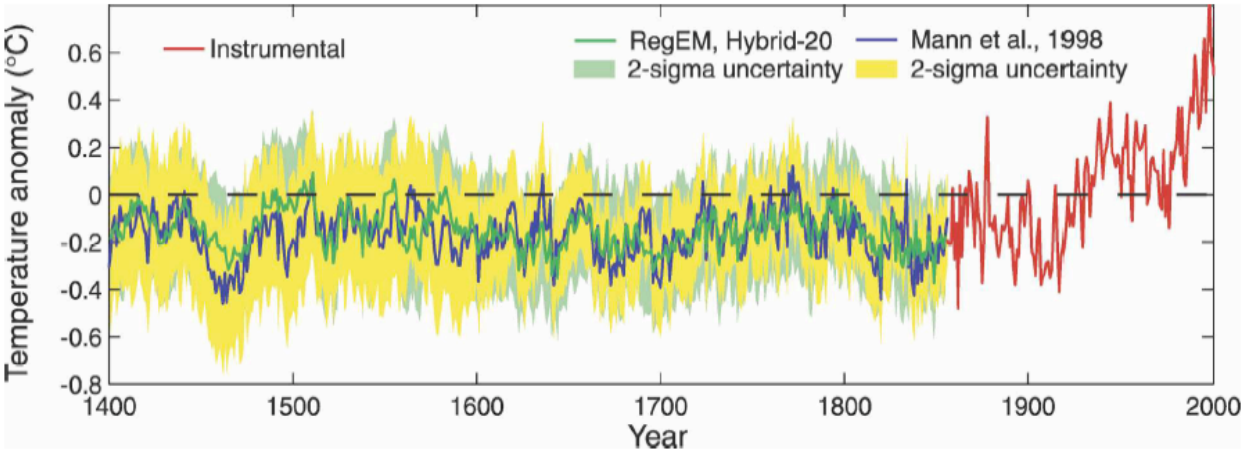
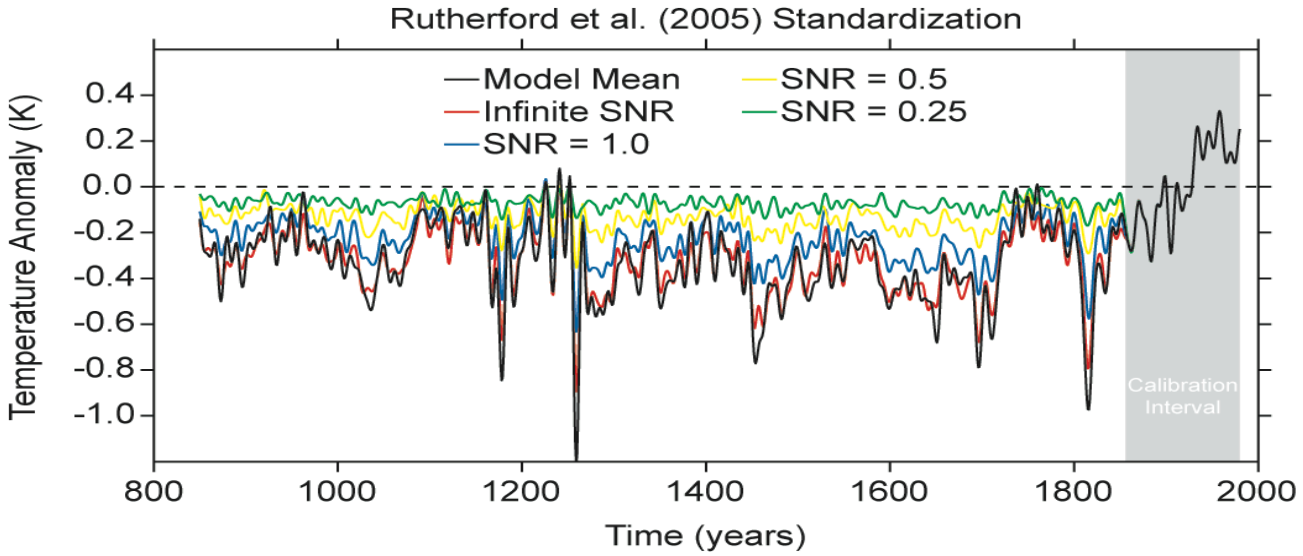
The Rutherford et al. (2005) Reconstruction: Warm Biases and Variance Losses





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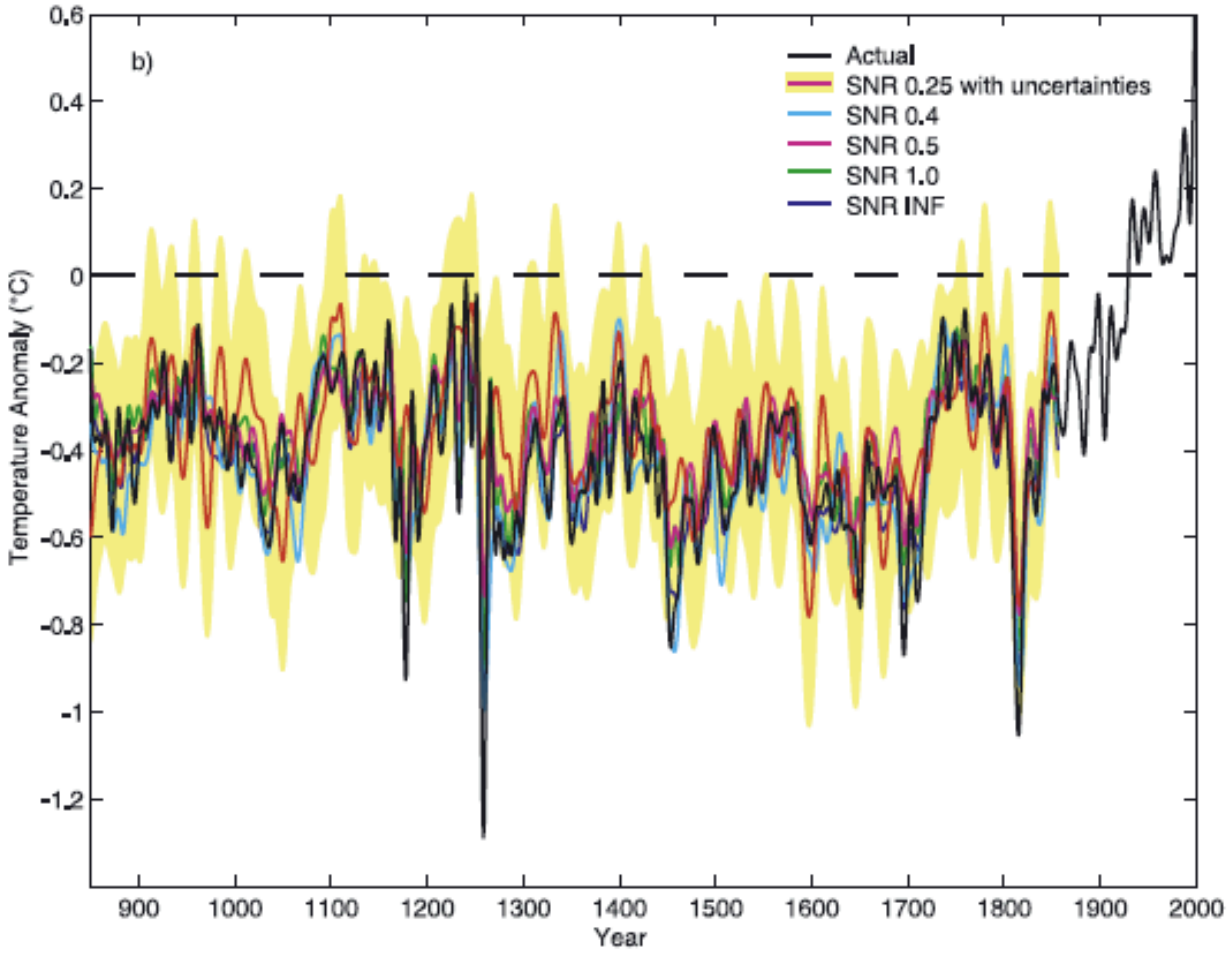
Mann et al. (2007): RegEM with TTLS

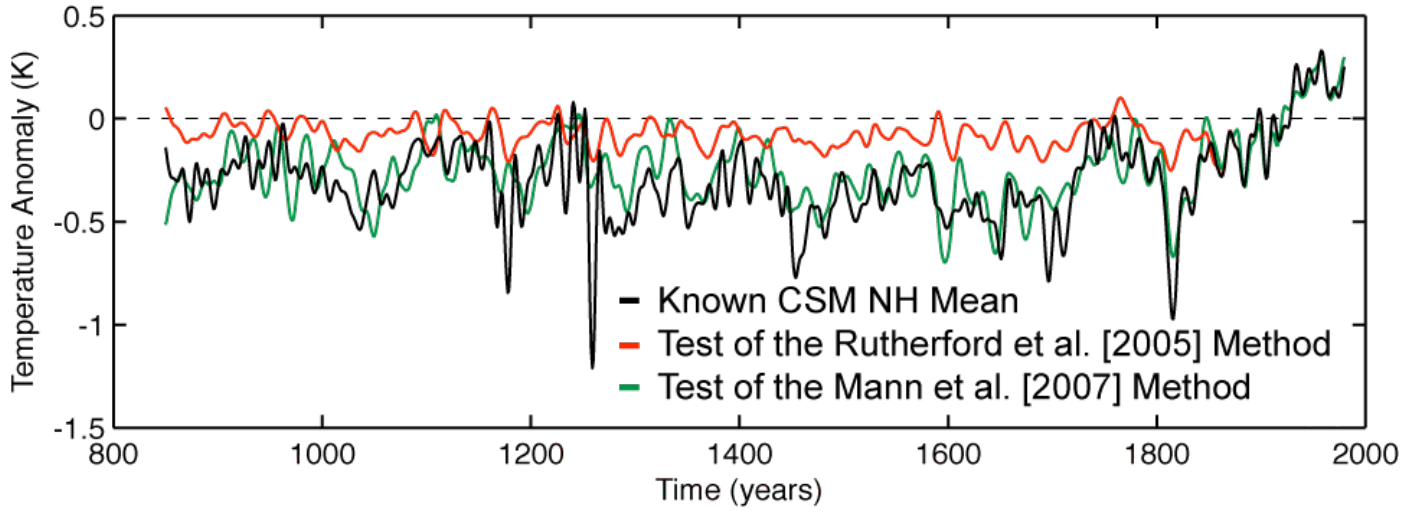


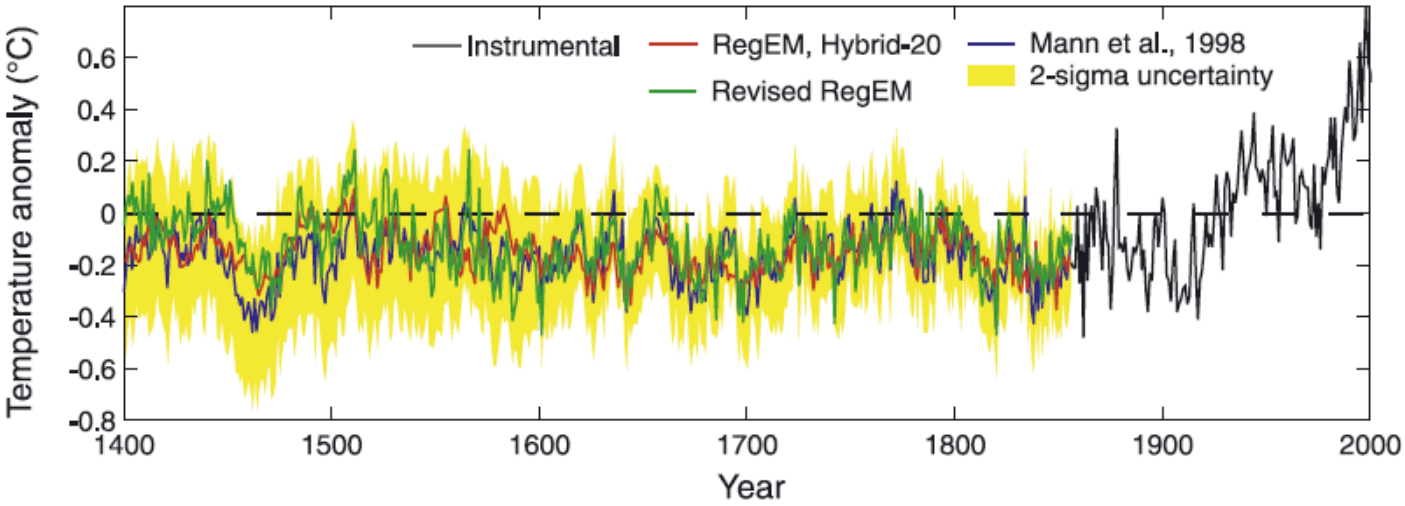
1. Regularization is done using truncated total least squares

2. Only two leading instrumental PCs are reconstructed

Mann et al., 2007: *Robustness of proxy-based climate field reconstruction methods*, JGR, 112.

Inconsistent Results?





Mann et al., 2007: *Robustness of proxy-based climate field reconstruction methods*, JGR, 112.

Conclusions

- The Rutherford et al. (2005) climate reconstruction technique likely suffers from warm biases and variance losses in the reconstruction interval

- Given the close similarity between the Rutherford et al. (2005) and the Mann et al. (1998) reconstructions, it is likely that the latter also underestimates past variability

- The standardization sensitivity of the RegEM method is not associated with a specific regularization scheme and therefore may affect more recent RegEM results

- Current pseudo-proxy tests of the RegEM method and derived historical reconstructions are inconsistent and must be reconciled