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Requirements for a reliable millennium temperature reconstruction

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Quantitative temperature reconstructions are hampered by several problems. Proxy records are sparse which is witnessed by the fact that roughly half of all available high-resolution millennia-long proxy data have been published in the last five years. Moreover, proxies are inhomogeneously distributed around the globe and they often have coarse temporal resolution. The period of overlap between proxies and instrumental observations - the calibration period - is brief and dominated by a strong warming trend. Furthermore, proxies are often only weakly correlated to temperature and it is common that some form of screening procedure is applied to select only informative proxies.

We study the influence of these limitations on the reliability of temperature reconstructions for the previous millennium. This influence depends on the spatial and temporal correlation structure of the surface temperature field. It also depends on the reconstruction methodology. We use gridded surface temperature data from GISTEMP and HadCRUT4 to investigate the geographical distribution of the spatial decorrelation length and of the temporal decorrelation time. The spatial decorrelation length varies with more than a factor of 5 with the largest values in the region dominated by the El Nino-Southern Oscillation. The temporal decorrelation time varies less with typical values of 1-2 years over land and 2-5 years over ocean. We also investigate the correlations between proxies and local temperatures (using the 91 proxies from Christiansen and Ljungqvist 2012) and between local temperatures and the NH mean temperature. These correlations have typical values around 0.3 but cover a wide range from weakly negative to larger than 0.8.

The results outlined above allow us to identify regions where the effect of the lack of proxies is most important. They also inform us on the consequences of the short calibration period and on the influence of the recent trend. Finally, we demonstrate the effect of a weak proxy/temperature relationship on three different simple reconstruction methodologies. We show that the size and strength of this effect depends strongly on the chosen methodology.