Geophysical Research Abstracts
Vol. 13, EGU2011-2018, 2011
EGU General Assembly 2011

Reconstructing pre-historic temperatures from natural proxies: statistical methods in paleoclimate research

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Reconstructing the spatial pattern of a climate field through time from incomplete instrumental and climate proxy time series poses both scientific and statistical challenges. Over the last two decades, the statistics community has made major advances in the modeling and analysis of space-time processes. Many of these advances have not yet been applied to the paleoclimate reconstruction problem, and doing so has the potential to improve understanding of the climate of the past.

I outline a unifying, hierarchical space-time modeling framework for reconstructing past climate. Within this framework, the modeling assumptions made by a number of published methods can be understood as special cases, and the distinction between modeling assumptions and analysis or inference choices becomes more transparent. In addition, Bayesian inference allows for uncertainty propagation through the various levels of the hierarchy, and provides uncertainty estimates for any function of the inferred field.

As a demonstration of the power of hierarchical space-time models in this context, I present an analysis of a 600-year temperature proxy data set based on simple data-level and process-level assumptions.