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SINOMA - A new iterative statistical approach for the identification of linear relationships between noisy time series

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In paleoclimatology, reconstructions of environmental conditions play a significant role. Such reconstructions rely on the relationship between proxies (e.g. tree-rings, lake sediments) and the processes which are to be reconstructed (e.g. temperature, precipitation, solar activity). However, both of these variable types in general are noisy. For instance, ring-width is only a proxy for tree growth and further determined by several other environmental signals (e.g. precipitation, length of growing season, competition). On the other hand, records of process data that are to be reconstructed are mostly available for too short periods (too short in terms of calibration) at the particular site at which the proxy data have been sampled. The resulting 'spatial' noise (e.g. by using climate station data not situated at the proxy site) causes additional errors in the relationship between measured proxy data and available process data (e.g. Kutzbach et al., 2011).
If deriving models from such noisy data, Thees et al. (2009) and Kutzbach et al. (2011) could show (amongst others), that model slopes (the factor with which the one variable is multiplied to predict the other variable) in most cases are misestimated – depending on the ratio of the variances of the respective variable noises. Despite these facts, many recent reconstructions are based on ordinary least squares regressions, which underestimate model slopes as they do not account for the noise in the predictor variable (Kutzbach et al., 2011). This is because there yet only are few methodological approaches available to treat noisy data in terms of modeling, and for those methods additional information (e.g. a good estimate of the error noise ratio) which often is impossible to acquire is needed.
Here we introduce the Sequential Iterative NOise Matching Algorithm - SINOMA - with which we are able to derive good estimates for model slopes between noisy time series. The mathematical background of SINOMA is described accompanied by a successful application to a pseudo-proxy dataset of which the error noise conditions and true model parameters are known. Further examples on its successful application are intended for presentation in another contribution to this EGU session (Buras et al., 2014) which aims at representing SINOMAs range of applicability rather than its theoretical background which is the focus of the herewith submitted contribution.
Given the features of yet published paleoclimatological reconstructions (mostly ordinary least squares regression) and the generally noisy characteristics of process and proxy data, SINOMA has the potential to change our understanding of past climate variability. This is because the magnitude of amplitudes in reconstructed climate parameters may change significantly as soon as comparably precise slope estimates (as acquired by SINOMA) are used for reconstructions. Therefore, SINOMA has the potential to reframe our picture of the past.

References

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