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Hypothesis testing and uncertainty propagation in paleo climate proxy data evidencing abrupt climate shifts

Keno Riechers¹, Niklas Boers^{1,2,3}, Jens Fohlmeister¹, and Norbert Marwan¹

¹Potsdam Institute for Climate Impact Research, Complexity Science, Germany (riechers@pik-potsdam.de)

²Department of Mathematics and Computer Science, Free University Berlin, Germany

³Global Systems Institute and Department of Mathematics, University of Exeter, UK

Reconstruction of ancient climate variability relies on inference from paleoclimate proxy data. However, such data often suffers from large uncertainties in particular concerning the age assigned to measured proxy values, which makes the derivation of clear conclusions challenging. Especially in the study of abrupt climatic shifts, dating uncertainties in the proxy archives merit increased attention, since they frequently happen to be of the same order of magnitude as the dynamics of interest. Yet, analyses of paleoclimate proxy reconstructions tend to focus on mean values and thereby conceal the full range of uncertainty. In addition, the statistical significance of the reported results is sometimes not or at least not accurately tested. Here we discuss both, methods for rigorous propagation of uncertainties and for hypothesis testing with applications to the Dansgaard-Oeschger (DO) events of the last glacial interval and their varying timings in different proxy variables and archives. We scrutinized the mathematical analysis of different paleoclimate records evidencing the DO events and provide results that take into account the full range of uncertainties. We discuss several possibilities of testing the significance of apparent leads and lags between transitions found in proxy data evidencing DO events within and across different ice core archives from Greenland and Antarctica.