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Unraveling multiple changes in complex climate time series using Bayesian inference

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Change points in time series are perceived as heterogeneities in the statistical or dynamical characteristics of observations. Unraveling such transitions yields essential information for the understanding of the observed system. The precise detection and basic characterization of underlying changes is therefore of particular importance in environmental sciences. We present a kernel-based Bayesian inference approach to investigate direct as well as indirect climate observations for multiple generic transition events.
In order to develop a diagnostic approach designed to capture a variety of natural processes, the basic statistical features of central tendency and dispersion are used to locally approximate a complex time series by a generic transition model. A Bayesian inversion approach is developed to robustly infer on the location and the generic patterns of such a transition. To systematically investigate time series for multiple changes occurring at different temporal scales, the Bayesian inversion is extended to a kernel-based inference approach. By introducing basic kernel measures, the kernel inference results are composed into a proxy probability to a posterior distribution of multiple transitions. Thus, based on a generic transition model a probability expression is derived that is capable to indicate multiple changes within a complex time series.
We discuss the method's performance by investigating direct and indirect climate observations. The approach is applied to environmental time series (about 100 a), from the weather station in Tuscaloosa, Alabama, and confirms documented instrumentation changes. Moreover, the approach is used to investigate a set of complex terrigenous dust records from the ODP sites 659, 721/722 and 967 interpreted as climate indicators of the African region of the Plio-Pleistocene period (about 5 Ma). The detailed inference unravels multiple transitions underlying the indirect climate observations coinciding with established global climate events.