Geophysical Research Abstracts
Vol. 13, EGU2011-4077, 2011
EGU General Assembly 2011

Inference of abrupt changes in noisy data records using Bayesian transdimensional changepoint models

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We present a method to quantify abrupt changes (or changepoints) in data series, represented as a function of depth or time. These changes are often the result of climatic or environmental variations and can be manifested in multiple data sets as different responses, but all data sets can have the same changepoint locations/timings.
The method we present uses transdimensional Markov chain Monte Carlo to infer probability distributions on the number and locations (in depth or time) of changepoints, the mean values between changepoints and, if required, the average level of noise (or uncertainty) associated with each dataset being considered. This latter point is important as we generally will have estimates only of measurement uncertainty, and in most cases it is not practical to make repeat sampling/measurement to assess other contributions to the variation in the data.
We present the main features of the approach, and demonstrate its validity using synthetic datasets, with known changepoint structure (number and locations of changepoints) and distribution of noise for each dataset. The method recovers the input changepoint structure and the noise distribution well in all cases. We show that when using multiple data, we can achieve better resolution of the changepoint structure than when we use each dataset individually. This is conditional on the validity of the assumption of common changepoints between different datasets.
We apply the method to two sets of real geochemical data, both from peat cores, taken from NE Australia and eastern Tibet, used a proxy for climate change. Under the assumption that changes occur at the same time for all data sets, we recover solutions consistent with those previously inferred qualitatively from independent data and interpretations. However, our approach provides a quantitative estimate of the relative probability of the inferred changepoints, allowing an objective assessment of the significance of each change.