Geophysical Research Abstracts
Vol. 12, EGU2010-9840, 2010
EGU General Assembly 2010

Analysis of trend changes in Northern African palaeo-climate by using Bayesian inference

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Climate variability of Northern Africa is of high interest due to climate-evolutionary linkages under study. The reconstruction of the palaeo-climate over long time scales, including the expected linkages (> 3 Ma), is mainly accessible by proxy data from deep sea drilling cores. By concentrating on published data sets, we try to decipher rhythms and trends to detect correlations between different proxy time series by advanced mathematical methods. Our preliminary data is dust concentration, as an indicator for climatic changes such as humidity, from the ODP sites 659, 721 and 967 situated around Northern Africa.
Our interest is in challenging the available time series with advanced statistical methods to detect significant trend changes and to compare different model assumptions. For that purpose, we want to avoid the rescaling of the time axis to obtain equidistant time steps for filtering methods. Additionally we demand an plausible description of the errors for the estimated parameters, in terms of confidence intervals. Finally, depending on what model we restrict on, we also want an insight in the parameter structure of the assumed models. To gain this information, we focus on Bayesian inference by formulating the problem as a linear mixed model, so that the expectation and deviation are of linear structure. By using the Bayesian method we can formulate the posteriori density as a function of the model parameters and calculate this probability density in the parameter space. Depending which parameters are of interest, we analytically and numerically marginalize the posteriori with respect to the remaining parameters of less interest.

We apply a simple linear mixed model to calculate the posteriori densities of the ODP sites 659 and 721 concerning the last 5 Ma at maximum. From preliminary calculations on these data sets, we can confirm results gained by the method of breakfit regression combined with block bootstrapping ([1]). We obtain a significant change point around (1.63 – 1.82) Ma, which correlates with a global climate transition due to the establishment of the Walker circulation ([2]). Furthermore we detect another significant change point around (2.7 – 3.2) Ma, which correlates with the end of the Pliocene warm period (permanent El Niño-like conditions) and the onset of a colder global climate ([3], [4]). The discussion on the algorithm, the results of calculated confidence intervals, the available information about the applied model in the parameter space and the comparison of multiple change point models will be presented.

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