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Detecting abrupt transitions during the Late Quaternary in southern Ethiopia using Recurrence Quantification Analyses

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In many data driven fields of research, categorizing abrupt transitions / regime changes is of high interest. The different aspects of temporal recurrence patterns of previous states can help to identify and characterize subtle changes in systems dynamics. Besides the identification of transitions, recurrence methods can provide a better understanding of the process underlying these transitions by statistically describing the dynamical characteristics, e.g. the predictability, determinism and complexity of the dynamical system. For example, the characteristic block structures in the recurrence plot can be used to identify different types of intermittency. In general, changes between different dynamical regimes are visually well expressed in recurrence plots. The introduction of selected recurrence quantifiers (such as recurrence rate, determinism, or laminarity) together with a running window approach has paved the way for a quantitative recurrence analysis of transitions and therefore should be able to provide a classification of different transition types.

In order to achieve such a classification there is necessity for developing a method which is capable to statistically analyze the behavior of recurrence quantifiers at transitions. In this work, we show how to make statements about the significance of estimated values of recurrence quantifiers using a bootstrap approach. We also highlight the specific technical problems related to that task. The presented method also allows gaining information about the duration of a transition. Here we demonstrate potentials of the proposed approach to detect abrupt transitions in (1) prototypical models of transitions as well as in (2) real data of past climate variations in the Chew Bahir basin (South Ethiopia), investigated within the Hominin Sites and Paleolakes Drilling Project (HSPDP).