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Recurrence network-based time series analysis for identifying tipping points in Plio-Pleistocene African climate

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The analysis of paleoclimate time series is usually affected by severe methodological problems, resulting primarily from non-equidistant sampling and uncertain age models. As an alternative to existing methods of time series analysis, the statistical properties of recurrence networks are promising candidates for characterizing a system's nonlinear dynamics and quantifying structural changes in its reconstructed phase space as time evolves. The results of recurrence network analysis are robust under changes in the age model and are not directly affected by non-equidistant sampling of the data. Specifically, we investigate three marine records of African climate variability during the Plio-Pleistocene. We detect several statistically significant dynamical transitions or tipping points and show that the obtained results are qualitatively robust under changes of the relevant parameters of our method, including detrending, size of the running window used for analysis, and embedding delay. Finally, relating the identified tipping points in paleoclimate-variability to speciation and extinction events in the available fossil record of human ancestors contributes to the understanding of climatic mechanisms driving human evolution in Africa during the past 5 million years.