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A multi-archive method for robustly detecting nonlinear regime shifts in palaeoclimate dynamics under consideration of dating uncertainties

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The number of available high-resolution palaeoclimate records, e.g., such as those from speleothems, is currently growing quickly. This wealth of data calls for robust methods of time series analysis that can detect common signals in a set of several records and at the same time cope with dating uncertainties and irregular sampling. In this contribution, a multi-archive method is proposed for identifying nonlinear regime shifts that are common to several palaeoclimate records. In a first step, the COPRA framework (Breitenbach et al., Clim. Past 8, 1765-1779, 2012) is applied to convert each individual irregularly sampled record into an ensemble of regularly sampled time series that are all consistent with the given dating uncertainties. Next, recurrence network analysis (RNA, Donges et al., PNAS 108, 20422-20427, 2011) is used to detect epochs with significant nonlinear deviations from the dominant dynamical regime for all records and ensemble members. Finally, we employ a Monte Carlo approach to identify the relevant time periods during which a significant fraction of all available records shows a regime shift according to RNA. We apply the proposed methodology for revealing continental-scale nonlinear transitions in the Asian monsoon system during the Holocene based on oxygen isotope records from speleothems.