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Comparison of isotopic signatures in speleothem records and model simulations for the past millennium

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Global changes in climate, especially in mean temperature, receive increasing public as well as scientific attention under the current warming trend. However, the probability of extreme events and their societal impact is also governed by changes in climate variability. Improving the understanding of changes in both and their relationship is crucial for projecting reliable climate change scenarios. Model-data comparisons between general circulation models and speleothem paleoclimate archives, with $\delta^{18}O$ as a temperature and precipitation proxy, have been suggested to test and validate the capability of different climate models.

Speleothems are precisely date-able and provide well preserved (semi-)continuous climate signals in the lower and mid-latitudes, providing a suitable archive to assess a model's capability to simulate climate variability on time scales longer than those observable. However, the $\delta^{18}O$ measured in speleothem calcite does not directly represent temperature or precipitation but results from multivariate, non-linear processes on top of the dominant meteoric controls on $\delta^{18}O$ in precipitation.

Here, we evaluate correlations and networks between different records and power spectral densities across a speleothem database for the past millennium (850-2000CE), testing for representativity of individual records for the time period. Similarity measures are applied to proxy records and to the local climate variables obtained from three isotope-enabled HadCM3 simulations to evaluate simulation biases across different parameters and to distinguish main climate drivers for individual records or regions. The proxy records show strong damping of variability on shorter time scales compared to simulations down-sampled to record-resolution, acting like simple filter processes with realistic time scales for karst transit times.

Based on the evidence from proxies and models for the past 1000 years, we test for realistic parameter constraints and sufficient complexity of a speleothem proxy system model to represent low-latitude changes in climate variability on interannual to centennial timescales.