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From local processes to global controls: Disentangling the complexity of carbon isotopes in speleothems using the SISAL database

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Paleoclimate interpretations based on variations in stable-isotope ratios of carbon (δ13C) are still underrepresented in speleothem-based studies, owing mainly to the complexities and uncertainties associated with the precise controls on δ13C with respect to climatic and local conditions. Interpretations of δ18O of speleothem calcite form the foundation of most speleothem studies of paleoclimate, with controls on the δ18O of local rainfall often controlled by far-field climatic conditions. By contrast, δ13C seems to more strongly reflect site-specific aspects, including cave and ground surface processes which are not always well understood, and which may or may not be associated with far-field processes. Until recently a larger scale review of how climatic parameters and vegetation composition is reflected in the δ13C of speleothems globally has not been possible due to the lack of reported and interpreted δ13C speleothem datasets. Undertaking such an effort requires a large amount of unique datasets from various locations to produce sufficient statistics in order to compensate for site-specific effects such as carbonate dissolution or in-cave isotope fractionation.

Here, we present a first review of speleothem δ13C records in light of the recent publication of the Speleothem Isotopes Synthesis and AnaLysis (SISAL) database with the aim of providing a better understanding of this complex climate proxy. We focus on δ13C in speleothems which grew within the last 100 years. Within the SISAL database (version 1) there are 62 records available, which satisfy our constraints. Sample distribution includes locations which span an annual average temperature range between $\sim$1 and 28°C, and an annual precipitation range between 100 and 3000 mm/yr. We compare the mean δ13C values of the records with average climate parameters of temperature and precipitation, as well as with vegetation. We found no major control of precipitation on the δ13C values. By contrast, we found a covariance of speleothem δ13C with vegetation zones and, surprisingly, with temperature. The latter relation is non-linear and is disturbed by site-specific carbon isotope effects as well as by precipitation amount in regions with high rainfall. This first step towards a better understanding of δ13C in speleothems at a global scale for the last century opens new avenues to explore the δ13C proxy at longer timescales.