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Construction and evaluation of age-depth models for large numbers of speleothems

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The SISAL database v1 [1] is a comprehensive quality-controlled global compilation of oxygen and carbon isotope records from speleothems spanning large parts of the late Pleistocene compiled as a community effort supported by Past Global Changes (PAGES). The stable isotope records provide information on past changes in climate and the environment, both for reconstruction, as well as for comparison to climate model output.
The chronology of the majority of the records is based on precise ^{230}Th/U-dating, and speleothems are palaeoclimate archives with generally good chronological control. However, various types of age-depth modelling with different degrees of complexity (e.g., linear interpolation, etc.) have been used to construct the chronologies, and most of the records provide no estimates of age uncertainty. Some data sets have no age model at all. This limits the suitability for assessing abrupt transitions as well as the synchronicity of events across space.
Here we apply six different age-depth modeling approaches to a representative subset from the SISAL database, to compare and evaluate their suitability as final SISAL chronologies for the next version of the database. The methods include linear models (linear regression, linear interpolation), fitting approaches (StalAge), ensemble-based methods (COPRA), as well as Bayesian models (OxCal, Bacon, Bchron). The subset of records from the SISAL database is representative in a sense that they include speleothems with "well-behaved" constant and continuous growth, variable growth rates, age outliers as well as growth interruptions.
We find that for many speleothems, age models can be established, and that there is an overall consensus on the median, or most likely, age-depth trajectory. Not all methods are applicable in all situations, however, and the resulting confidence intervals differ. We compare and evaluate the methods also by applying them to virtually grown speleothems.
We discuss challenges that arise (data inconsistencies, missing hiatuses, duplicated sample depths, multi-model integration) and the format we intend for the final chronologies. The new chronologies will allow to consider the impact of age uncertainty on analyses in the SISAL working group consistently across the database.

[1] Atsawawaranunt *et al*., The SISAL database: a global resource to document oxygen and carbon isotope records from speleothems, Earth Syst. Sci. Data, 10, 1687-1713, https://doi.org/10.5194/essd-10-1687-2018, 2018.