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Correcting speleothem oxygen isotopic variations for growth-rate controlled kinetic fractionation effects

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The oxygen isotopic signature may be the most widely used climate indicator in stalagmites, but recent experimental and theoretical studies indicate the potential for kinetic fractionation effects which may be significant, especially in situations where the primary signal from rainfall isotopic composition and cave temperature is limited to a few permil. Here we use a natural set of stalagmites to illustrate the magnitude of such effects and the potential for deconvolving kinetic signals from the primary temperature and rainfall signals. We compare isotopic records from 6 coeval stalagmites covering the interval 140 to 70 ka, from two proximal caves in NW Spain which experienced the same primary variations in temperature and rainfall d18O, but exhibit a large range in growth rates and temporal trends in growth rate. Stalagmites growing at faster rates near 50 microns/year have oxygen isotopic ratios more than 1 permil more negative than coeval stalagmites with very slow (5 micron/year) growth rates. Because growth rate variations also occur over time within any given stalagmite, the measured oxygen isotopic time series for a given stalagmite includes both climatic and kinetic components. Removal of the kinetic component of variation in each stalagmite, based on the dependence of the kinetic component on growth rate, is effective at distilling a common temporal evolution among the oxygen isotopic records of the multiple stalagmites. However, this approach is limited by the quality of the age model. For time periods characterized by very slow growth and long durations between dates, the presence of crypto-hiatus may result in average growth rates which underestimate the instantaneous speleothem deposition rates and which therefore underestimate the magnitude of kinetic effects. We compare the composite corrected oxygen isotopic record with other records of the timing of glacial inception in the North Atlantic realm.