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Recovering the vegetation/soil component of d^{13}C variation in speleothem records, despite overprints from in-cave effects

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The carbon isotope ratio of speleothems is routinely measured alongside oxygen isotopes but much less widely utilized for paleoclimate and paleoenvironmental interpretation. The primary carbon isotope ratio imparted to the dripwater by soil and vegetation processes is sensitive to the integrated soil and epikarst $pCO_{2;}$ pCO_2 increases with higher temperature in moisture-replete mid and high latitude regions, and may be stimulated more by increased soil moisture in more arid settings. However, this valuable environmental information on temperature or soil moisture can be hard to recover from speleothem d^{13}C records because the primary signal can be variably and strongly overprinted by in-cave processes of degassing and prior calcite precipitation which differ among stalagmites and over time in a given stalagmite, complicating interpretations and hampering replication.

Here, we describe an approach to recover the trends in the speleothem carbon isotope ratio which arise from the primary vegetation and soil processes, the "initial d^{13}C", using measured speleothem carbon isotope ratios coupled with Mg/Ca or stable Ca isotope measurements on the same sample to remove the influence of in-cave processes. We illustrate the feasibility, advantages and limitations of the approach on a set of 9 stalagmites from the same geographic region which feature common climate and environmental forcing. In coeval samples, we find that the trends in "initial d^{13}C" are more similar than those of measured initial d^{13}C, and in the interval 94 to 82 ka we show that the initial initial d^{13}C records illustrate a common positive anomaly during a stadial cooling event consistent with depressed soil pCO_2 from slowed respiration under cold temperatures. During deglacial warmings, the increase in soil respiration rates and soil pCO_2 is recovered by the more negative calculated "initial d^{13}C", despite the tendency for the more oversaturated dripwaters to suffer greater prior calcite precipitation. This approach offers a clearer path to interpretation of the speleothem carbon isotope ratios and their environmental signal.