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Linking the isotopic composition of monthly precipitation, cave drip water and tree ring cellulose – 15 years of monitoring and data-model comparison

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The isotopic composition of proxies used for palaeoclimate reconstruction, like tree ring cellulose or speleothem calcite, is controlled to a large extent by the isotopic composition of precipitation. In order to calibrate and interpret these proxies in terms of climate, it is necessary to study water isotopes in rainfall and their link with the proxies' source water. We present 10 to 15-year series of stable hydrogen and oxygen isotopes in monthly precipitation from three sites in the south of France, along with corresponding REMOiso model simulations, a monitoring of cave drip water from two of these sites (Villars cave the south-west and Chauvet cave in the south-east), as well as measurements of oxygen isotopes in tree ring cellulose from oak trees growing in the same area.
The isotopic composition of monthly precipitation at the three sites displays a typical annual cycle. At the south-west sites, under Atlantic influence, the interannual variability is much more pronounced during the winter months than during the summer, whereas the south-eastern Mediterranean site shows the same variability throughout the year. The model simulations are able to reproduce the annual cycle of monthly precipitation δ^{18}O as well as the intra-seasonal variability. Compared to the data, however, the modelled average isotopic values and the seasonal amplitude are overestimated. Correlations between temperature and precipitation δ^{18}O are generally weak at all our sites, on both the monthly and the annual scale, even when using temperature averages weighted by the amount of precipitation. Consequently, a proxy which is controlled by the δ^{18}O of precipitation cannot be directly interpreted in terms of temperature in this region.
The isotopic composition of cave drip water in both caves remains stable throughout the monitoring period. By calculating different weighted averages of precipitation δ^{18}O for time periods ranging from months to years, we demonstrate that the cave drip water isotopic composition is the result of several years of rainfall mixing. The precipitation of every month must be considered in order to attain the drip water values, which means that rain water infiltrates throughout the year. There is no modification of the soil water isotopic composition by evaporation and no seasonal bias introduced by transpiring plants; they use water from reserves which represents several months or years of mixing. For the interpretation of tree ring cellulose δ^{18}O, this implies that – at least for the monitoring period of 15 years – the source water signal is more or less constant. Therefore, the variability of cellulose δ^{18}O must be mainly due to evaporation at the leaf level, which is strongly dependent on summer temperature.
Insights on the variability and temperature correlations of stable isotopes in precipitation and on the origin and composition of cave drip water are important for the interpretation of proxies. Long-term monitoring is needed for model validation, and the locally validated and corrected model can provide longer time series for a reliable proxy calibration.