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Holocene hydrologic conditions in the Central Mediterranean recorded in highly resolved speleothem stable oxygen and carbon isotopes from Frasassi Caves, Italy

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Climate change scenarios suggest that Mediterranean ecosystems could plunge into aridity as a consequence of shifting temperature and precipitation patterns in response to anthropogenically induced global warming with a considerable impact on society. It is essential, thus, to shed light on past hydrologic changes to gain a better understanding on timing, dynamics and causes of arid episodes. During the Holocene, insolation gradients between low and high latitudes increased due to changes in Earth's obliquity and precession. Modelling studies infer a response of the Hadley-cell termini and mid-latitude storm tracks, which makes the Mediterranean hydroclimate, which is situated between the temperate and tropical zones, particularly sensitive to such changes.
Here we present a new high-resolution stable oxygen and carbon isotope (δ^{18}O and δ^{13}C) record obtained from speleothem FR-18. Stalagmite FR-18, a candle-shaped stalagmite composed of white columnar fabric, was sampled from Frasassi Caves, Italy (42.4°N, 12.97°E; 420 m.a.s.l). Frasassi Caves are located in Central Italy on the Eastern side of the Apennines, 40 km from the Adriatic Sea, located in a strategic position to unravel climate dynamics in the Central Mediterranean, given its location midway between the Alps and the central Mediterranean.
The chronology is based on 31 high precision U-series ages, which revealed two growth phases (GP). Carbonate deposition started at 18.40±0.37 ka BP and continued through the deglaciation until 5.10±0.07ka BP, when a 3 ka-long hiatus occurred (median Holocene growth rate during GP-I 68 μm/a). GP-I is characterised by alternating compact columnar and open columnar calcite fabric. Subsequently, FR-18 continued growing at 1.99±0.10 ka BP until the present at roughly half the previous accumulation rate (GP-II: 29 μm/a) and is characterised by compact columnar calcite fabric.
The δ^{13}C values progressively decrease during the Holocene from -3.0 to -6.0 ‰ and from -4.8 to -7.2 ‰ during GP-II. In contrast, the δ^{18}O values show only moderate changes during the early Holocene (until about c. 8.2 ka BP) from c. -8.0 to -7.5 ‰ and then reach a steady value in the mid-Holocene. Throughout GP-II, the δ^{18}O values decrease from -7.0 to -8.0 ‰ . During the initial growth phase, the δ^{13}C and δ^{18}O values of GP-I are uncorrelated; while a significant correlation (r^2=0.62) is observed during GP-II possibly indicating kinetic isotope fractionation.
These new observations are compared to speleothem as well as lake and marine records along a north-south transect in the central Mediterranean and its surroundings to improve our understanding of the dynamics of Mediterranean hydroclimate in response to changing insolation gradients.