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Speleothem evidence for reoccurring rapid warming events during the fourth glacial cycle

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During glacial periods, millennial-scale climate variability is a well-documented feature in various climate records. Particularly prominent are the Dansgaard – Oeschger (D/O) events during the last glacial cycle, evident as abrupt millennial- to centennial-scale climate oscillations. Synthetic Greenland ice core data suggest that D/O-type millennial-scale climate variability can be expected for all glacial phases of the past 800 ka. However, due to the general sparsity of absolute and precisely dated high resolution climate records beyond the last interglacial, the detection and synchronization of millennial-scale climate oscillations beyond the last glacial cycle remains challenging.

Here we present a new speleothem record from Cueva Victoria (SE Spain), covering MIS (Marine Isotope Stage) 11a and 10. Previous studies showed that speleothems from Cueva Victoria are capable of tracking hydrological changes on both millennial and orbital timescales, and numerous D/O events have been identified in their stable isotope records during the last glacial cycle. This demonstrates the strong interconnection between North Atlantic climate patterns and stable isotope signals recorded in Cueva Victoria speleothems on the millennial timescale.

During MIS 11a, two distinct cooling episodes are evident in the speleothem record, aligning with the previously described Iberian margin stadials (IMS) 4IMS-6 and 4IMS-7. Afterwards, the $\delta^{18}O$ record shows a general cooling trend toward full glacial conditions during MIS 10, interrupted by at least seven rapid warming events, followed by gradual cooling. These rapid warming events mirror the timing, duration, and magnitude of D/O events of the last glacial cycle. The $\delta^{13}C$ generally follows the $\delta^{18}O$ record but reveals longer phases of enhanced soil activity during the warming events, despite temperature is already decreasing. The timing of these climate oscillations agrees with the predicted occurrence of D/O events based on the synthetic Greenland ice core record. This highlights the potential of Cueva Victoria speleothems to reconstruct the timing and duration of past millennial scale climate variability beyond the last glacial cycle.