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Increased millennial-scale monsoonal circulation amplitude across the mid-Pleistocene transition revealed via speleothem records

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The Asian summer monsoon (ASM) represents a significant and expansive element within the global climate system. While speleothem $\delta^{18}O$ records offer robust characterization of millennial-scale ASM variations over the last 640 ka (thousand years), limited data exists regarding the ASM's behavior preceding the U-Th dating limit of approximately 640 ka. This includes periods such as the mid-Pleistocene Transition (MPT, ~800-1200 ka) and the pre-MPT era. In this study, we present two meticulously calibrated high-resolution speleothem $\delta^{18}O$ records sourced from central China. These records span three distinct periods: 640–615, 690–660, and 1,360–1,310 ka BP (thousand years before present, the present defined as 1950 CE). The absolute dating of these records is accomplished via laser ablation and isotope dilution U-Pb methods. Our meticulous tuning aligns these records with the summer insolation (690–660 and 1,360–1,310 ka BP) and the preceding record (640–615 ka BP). Our findings indicate a close association between millennial-scale weak ASM occurrences and North Atlantic stadials and Antarctic warming events within the period of 685–675 ka BP, similar to previously established connections within the last 640 ka. Furthermore, millennial-scale ASM variations occurred prior to the MPT, specifically during the period of 1360–1310 ka BP, albeit with relatively smaller amplitudes in comparison to those observed after the MPT in the last ~690 ka. We hypothesize that reduced freshwater forcing in the North Atlantic and/or altered freshwater routing to the Gulf of Mexico through the Mississippi drainage system might have resulted in a less pronounced weakening of the Atlantic Meridional Overturning Circulation (AMOC) before the MPT, thereby leading to smaller amplitudes in millennial-scale ASM variations observed during 1360–1310 ka BP.