Reconstruction of Indian summer monsoon variability during the last 1,460,000 years

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Monsoon is an atmospheric phenomenon dominant in low and mid-latitudes and determines the temporal and spatial distributions of rainfall that govern vegetation. A classical model assumes that monsoon responds to precession-controlled changes in seasonal insolation. Speleothem records show a precession cycle in oxygen isotope variation consistent with this model, but marine and loess records generally do not show strong precession variation. This mismatch has long been debated. Key approach is the precipitation reconstruction to understand past changes in summer monsoon. In this study, we generated an Indian summer monsoon (ISM) record by evaluating riverine discharge. We used GDGT indices, i.e., CBT and MBT, as a proxy of soil organic matter contribution and generated a 1,700-year resolution record of Mahanadi River soil discharge in IODP Site U1446 to understand changes in the ISM rainfall during the last 1,460,000 years. The CBT and BIT show a similar variation according to glacial-interglacial cycles. Maxima appeared after the peak of interglacial. Minima appeared during deglaciations. Their variations are reversely correlated with the sea water $\delta^{18}O$ obtained based on *G. ruber* $\delta^{18}O$, global $\delta^{18}O$ and TEX_{86}-based SST. The records are consistent with previously-reported ISM records from marine archives and Borneo speleothems in the overlap periods and different from Chinese speleothem records. Spectral analysis indicates that BIT and CBT show 100,000, 41,000, 30,000, 23,000 and 19,000-year cycles during the last 800,000 years, the variation was out of phase with variation in northern hemisphere summer insolation. This suggests that the ISM did not respond directly to orbital forcing, in contrast to the classical hypothesis, but was driven by internal feedback processes. Orbital cycles were not clearly shown prior to 800,000 years ago. This suggests that the strong response of the ISM to orbital forcing was initiated around 800,000 years ago, which coincided with the onset of glacial 100,000 year cycles.

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