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New insights of the East Asian summer monsoon variability over the past 800 kyr from a transient simulation with CLIMBER-2

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The East Asian summer monsoon (EASM) is a major component of the global climate system with its variability closely associated with regional changes of rainfall, impacting the lives of over one sixth of the global population strongly. Understanding the periodicities of summer rainfall influenced by the EASM is beneficial to its future projections. However, the mechanism of the response of the EASM associated summer rainfall fluctuations to orbital-scale forcing during the late Pleistocene remains far from being well understood. Here, we provide an 800-kyr long series of EASM rainfall variations by extracting data from multiple transient simulations of CLIMBER-2 over the past 3 million years. Despite a coarse model resolution, the CLIMBER-2 captures a realistic spatial distribution and magnitude of present-day summer (June-July-August) rainfall, especially in East Asia. The CLIMBER-2 model simulates correct magnitude and timing of the last eight glacial cycles in respect to both global ice sheet volume (expressed in δ18O) and CO_2 concentration. Both the simulation and reconstructions reveal predominant 100-ky and 41-ky cycles of global ice sheet volume and CO_2 concentration, although precession (23- and 19-kyr) bands dominate high-latitude summer insolation. The EASM intensity is traditionally measured by the monsoonal circulation, i.e. the low-level southerly winds in summer over East Asia. Cross-spectral analysis confirms high coherence between model and proxy at 19-kyr and 41-kyr bands implying a strong low-latitude process modulated by precession. Unlike the EASM circulation from the CLIMBER-2, simulated boreal summer rainfall in East Asia, denoted as “EASM rainfall” shows pronounced 41- and 100-kyr cycles, resembling the loess record over the past 800 kyr. The simulation results reveal a decoupling between EASM rainfall and EASM circulation, which probably is a reasonable explanation for the conflicts in proxy records, and also reflects complicated mechanisms of the EASM system on glacial–interglacial timescales.