Ice volume and insolation forcing of abrupt strengthening of East Asian winter monsoon during glacial inceptions

By : Li, Tao ; Li, Gaojun ; Chen, Tianyu ; Sun, Youbin ; **Yin, Qiuzhen** [UCL] ; **Wu, Zhipeng** [UCL] ; Chen, Jun **et al.**
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The East Asian winter monsoon (EAWM), a major component of the East Asian monsoon circulation, is characterized by prevailing low-level northwesterly winds tightly linked to the high-northern-latitude climate via the Siberian-Mongolian High.Our current understanding of the EAWM dynamics during the glacial-interglacial cycles is mostly based on loess records on the Chinese Loess Plateau (CLP), which suggest that the EAWM intensity is closely linked to the volume of the Northern Hemisphere ice sheets (NHIS) on orbital timescale. However, unlike the 'sawtooth' pattern of global ice volume that shows a gradual build-up of the ice sheets (in ~9000 years) followed by rapid deglaciation (in ~1000 years) since the middle Pleistocene transition as documented by the benthic δ18O records, the loess records of EAWM show distinct glacial and interglacial modes, with the transitions between them generally being quick. This dissimilar evolution pattern between the EAWM and the global ice volume (and NHIS) at the interglacial-glacial transitions means that some key information is missing regarding the dynamics of the EAWM during the glacial inceptions. By generating an independent chronology framework and integrating multi-proxy records from the loess sections on the central CLP, here we show that the rapid intensifying of the EAWM during glacial inceptions, previously demonstrated as a direct response to the build-up of NHIS, actually reflects millennial perturbations in the large-scale atmospheric circulation in East Asia caused by insolation-triggered abrupt North Atlantic cooling when NHIS reaches a critical large size. The role of NHIS is reinterpreted as preconditioning the teleconnection between North Atlantic and East Asia during glacial inceptions instead of directly controlling the intensity of EAWM. Our integrated multi-proxy records thus highlight the key role of ice volume in modulating the response of the EAWM to insolation-triggered North Atlantic cooling during the interglacial-glacial transitions.