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Eurasian ice sheet reinforces East Asian summer monsoon 500 000 years ago

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Deep-sea and Antarctica ice-core records show a significant reduced amplitude of the climate variations before about 450,000 years ago, with less warm (more glaciated) interglacials and less cold glacials than after. In this context, the recent discovery of evidences for extremely abundant rainfall in China as early as Marine Isotope Stage (MIS) 13 (about 500 000 years ago), in fact more abundant than during the present interglacial, was very unexpected. The evidences were coming from the loess in northern China, the sedimentary core in the eastern Tibetan Plateau and the palaeosols in southern China. These three sites are under the influence of the East Asian Summer Monsoon (EASM), which is why abundant rainfall was attributed to intense monsoon activity. The possibility of intense monsoon at an epoch where the Northern Hemisphere was still partially glaciated invites us to revisit our current understanding of monsoon dynamics and in particular its interaction with the ice sheets present at that time..

To understand a strong EASM occurring during the relatively "cool" MIS-13, we investigate the response of LOVECLIM, an Earth system model of intermediate complexity, to prescribed GHG concentration, astronomical and ice sheet forcings of MIS-13. The results reveal the important but unexpected role played by the Eurasian ice sheet. We expected that the presence of this ice sheet would reduce the EASM because it contributes to cool down the continental mass. In fact, the contrary happened: the ice sheet enhanced the EASM. The mechanism was investigated and turned to be the following one: in summer, the ice sheet forces a topographically induced atmospheric wave. This wave propagates south-eastwards, starting from the Eurasian ice

sheet towards East China, with alternating large scale ascent and subsidence. It ends up with a reinforcement of the ascent over China and consequently of the EASM. The Tibetan plateau was shown to play a role as well because it deflects the wave towards the monsoon area. Sensitivity experiments also revealed that when the Northern Hemisphere (NH) summer occurs at perihelion, EASM is stronger than when Southern Hemisphere summer occurs at perihelion. Both the Eurasian ice sheet and NH summer occurring at perihelion lead to a much stronger EASM during MIS-13 than Pre-Industrial time, in agreement with geological evidences.