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Delayed build-up of Arctic ice sheets during 400, 000-year minima in insolation variability confirmed by Chinese loess

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The growth and decay of the Northern Hemisphere ice volume led to alternations of glacial and interglacial climate. Unfortunately, long-term continuous records of ice-sheet variability in the Northern Hemisphere during the Quaternary period only are scarce because benthic δ18O records represent an integrated signal of changes in ice volume in both polar regions. However, variations in Northern Hemisphere ice sheets influence the Siberian High (an atmospheric pressure system), so variations in the East Asian winter monsoon (EAWM)—as recorded in the aeolian dust deposits on the Chinese Loess Plateau—can serve as a useful proxy of Arctic climate variability. Here we present an EAWM proxy record using grain-size variations in two parallel loess sections over the past 900 kyr to address the timing of build-up of Northern hemisphere ice sheets around 413 kyr mimina in eccentricity and precessional variability. These periods are regarded as the astronomical analogues of the present interglacial.

The grain-size-inferred intensity of the EAWM records shows that the wind strength of EAWM increased rapidly after the end of most interglacials. However, during periods of low eccentricity and precessional variability around 400 kyr and 800 kyr ago, EAWM remains weak for up to 20 kyr after the end of the interglacial episodes MIS 11, MIS 19 and MIS 21. We conclude that the delayed increase in wind strength of the EAWM was caused by delayed buildup of Arctic ice sheets at the ends of the interglacials at 400 kyr intervals, which had led to much longer climate of interglacial mode at high northern latitudes than expected from the marine oxygen isotope records. During these times, the less severe summer insolation minima at 65° N (modulated by 413-kyr eccentricity cycles) would have suppressed ice and snow accumulation, leading to a weak Siberian High and, consequently, weak EAWM winds. Astronomically driven insolation during the present interglacial and in the near future is characterized by its low-amplitude variability. The close similarity between future insolation and that 400 kyr ago leads us to speculate that the future climate may still remain in interglacial mode for more that ~40 kyr, even in the absence of anthropogenic greenhouse gases.

The difference in timing of the onset of glaciations inferred from the EAMW records and marine δ18O records in this study could not be attributable in chronology uncertainty. We argue that the changes in marine δ18O records at 400 kyr and 800 kyr ago mainly reflect the changes in glaciation in Antarctic regions, as supported by temperature records in the EPICA ice core. The much earlier onset of glacial climate in Antarctic suggests that austral summer insolation in high southern latitudes may also play an important role in driving the alternations of glacial and interglacial at some special orbital configurations, e.g. 400 kyr and 800 kyr ago.