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A 3-million-year reconstruction of climate, ice volume and sea level; identifying mechanisms behind the inception of Northern-Hemisphere glaciation and the mid-Pleistocene transition

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A coupled ice-sheet ocean-temperature model was used to extract three-million-year records of surface air temperature, ice volume, and sea level from deep-sea oxygen isotopes. The results show that a 5 ˚C cooling between 3 and 2.5 million years ago (Ma) initiated Northern Hemispheric glaciation around 2.7 Ma with low amplitude obliquity-scale (41-kyr) glacials – dominated by the sluggish Eurasian ice sheets – prevailing. Prior to about 1 Ma, ice volume lagged behind air temperature by 5 kyr in quasi-linear 41-kyr cycles. Ongoing climate cooling enabled the Corderillan and Laurentide ice sheets to survive insolation maximums, causing them to eventually merge and to expand rapidly during glacial conditions. Once the huge North-American ice sheet reached a certain extent and/or thickness, the subsequent insolation maximum-related warming then initiated deglaciation, presumably through basal sliding related instabilities. The 100-kyr glacials arose gradually between 1.4 and 0.6 Ma, with the different response time and geometrical constraints of the Eurasian and North-American ice sheets being key factors.