EGU2020-1340
https://doi.org/10.5194/egusphere-egu2020-1340
EGU General Assembly 2020

Land ice distribution suggests an irregular pattern of interglacials across most of the Quaternary

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From the combination of orbital theory with benthic $\delta^{18}O$ it has been suggested which obliquity cycles led to interglacials during the Quaternary (e.g. Tzedakis et al., 2017). Here, we define interglacials, as deduced for the last 800 kyr (Past Interglacials Working Group of PAGES, 2016), by the absence of substantial northern hemispheric land ice outside of Greenland. When applied to land-ice distribution derived from a 3D-ice-sheet model-based deconvolution of the LR04-benthic $\delta^{18}O$ stack into its temperature and sea-level components (de Boer et al., 2014) we find an irregular pattern of interglacials not only, as suggested so far, in the late Pleistocene but across most of the last 2.6 Myr. In the early Pleistocene eight obliquity cycles miss the onset of new interglacials, therefore increasing the average interglacial periodicity to 60 kyr. Both prolonged glacials (due to skipped terminations) and prolonged interglacials (so-called continued interglacials) are the reasons for these new irregularities. This finding adds new irregularities to the already known glacial/interglacial pattern during the last 1 Myr that include eleven obliquity cycles without new interglacials. Only in the Mid-Pleistocene in-between interglacials reappear regularly once in each obliquity cycle (every 41 kyr) with an exception around 1.1 Myr BP in which the onset of two successing interglacials is more than 100 kyr apart. This finding suggests that the notation of the Quaternary as an obliquity driven period with a growing influence of ice volume on the timing of deglaciations is too simple, or that our definition of interglacials, that seems to be suitable for the last 1.6 Myr, is not applicable to the whole Quaternary.

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