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Simulating the contribution of the Antarctic ice sheet to Miocene benthic $\delta^{18}O$ variability

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Large benthic $\delta^{18}O$ fluctuations, which are caused by deep-ocean temperature and ice-volume changes, are shown on multiple time scales during the early to mid-Miocene (23-14 Myr ago). To understand how these signals are related to orbital changes, it is necessary to disentangle them. Here, we approach this problem by simulating how the Antarctic ice sheet (AIS) responds to typical CO_2 changes during this period. We use the 3D thermodynamical model PISM, forced by climate model output, to conduct both transient and steady-state experiments. Our results indicate that even if equilibrium differences are relatively large (~40 m.s.l.e.), transient AIS variability on orbital time scales (20-400 kyr) still has a much smaller amplitude due to the slow ice-volume response to climatic changes. We analyse our results further using a conceptual model, based on the notion that at any CO_2 level an ice sheet will grow (shrink) by a specific rate towards its smaller (larger) equilibrium size. We show that phases of concurrent ice volume increase and rising CO_2 levels are possible, even though the equilibrium ice volume decreases monotonically with CO_2. When the AIS volume is out of equilibrium with the forcing climate, the ice sheet can still be adapting to a relatively large equilibrium size, although CO_2 is rising after a phase of decrease. A delayed response of Antarctic ice volume to in-sync solar insolation and CO_2 changes can cause discrepancies between Miocene solar insolation and benthic $\delta^{18}O$ variability.