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Simulating a dynamic Antarctic ice sheet in the early to middle Miocene

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A variety of sources of geological data suggest that there were major variations in Antarctic ice sheet volume and extent during the early to middle Miocene. Simulating such large-scale changes is problematic due to a strong hysteresis effect, which results in limited retreat of the terrestrial ice sheet once it has reached continental size. A relatively narrow range of atmospheric CO_2 concentrations shown by proxy records exacerbates this problem. Here we use a new asynchronous climate-ice sheet coupling method, using a high-resolution atmospheric component, to account for ice sheet-climate feedbacks. Accounting for these processes results in increased retreat when compared with standard offline simulations. Combined with recently proposed mechanisms for ice retreat into deep subglacial basins, we are able to simulate large-scale variability of the Miocene Antarctic ice sheet. This variability is equivalent to a seawater oxygen isotope signal of 0.52 – 0.66 ‰ or a sea level equivalent change of 30 – 36 m, for a range of atmospheric CO_2 between 280 – 500 ppm and a changing astronomical configuration. This result represents a substantial advance in resolving the long-standing model-data conflict of Miocene Antarctic ice sheet and sea level variability, and provides a mechanistic explanation for new ice-proximal records emerging from sedimentological drill cores.