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Response of Late-Eocene warmth to incipient glaciation on Antarctica

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The Eocene-Oligocene Transition is marked by a sudden $\delta^{18}O$ excursion occurring in two distinct phases: a precursor event at 34.15±0.04 Ma and the Earliest Oligocene oxygen Isotope Step at 33.65±0.04 Ma. These events signal a shift from the warm Late-Eocene greenhouse climate to cooler conditions, with temperature decreases of 3-5 °C, and the emergence of the first continent-wide Antarctic Ice Sheet (AIS). Despite clear evidence from proxy data, general circulation models (GCMs) struggle to replicate this Antarctic transition accurately, failing to capture the shift from warm, ice-free to cold, glaciated conditions. Even with unrealistically low pCO_2 levels, Late-Eocene Antarctic summers in GCMs remain too warm and moist for snow or ice to survive. This study evaluates CESM1.0.5 simulations conducted by Baatsen et al. (2020), using a 38 Ma geo- and topographical reconstruction, considering different radiative (4 pre-industrial carbon levels (PIC) and 2 PIC) and orbital (present-day insolation and low Antarctic summer insolation) forcings. The climate is found to be highly seasonal, characterised by hot and wet summers and cold and dry winters. While reduced radiative and summer insolation forcing weaken this seasonality, the persistent atmospheric circulation still impedes ice sheet growth by limiting summer snow survival. For that reason, a new simulation is conducted with regional, moderately-sized ice sheets imposed on the continent, in order to investigate their stability and their influence on the atmospheric circulation. These ice sheets demonstrate self-sustaining and even expansion potential under 2 PIC and low summer insolation conditions. However, correlating resulting temperature and precipitation patterns with proxy data proves challenging, given the absence of terrestrial proxies. Extended simulations with coupled GCM-ISM models are therefore recommended, allowing for more dynamic atmosphere-ice-ocean-vegetation feedback mechanisms and dynamic radiative and orbital forcing.