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Reconciling Eocene Ice with Antarctic Warmth, Implications for the EOT

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For quite some time, there has been a consensus that a widespread glaciation of the Antarctic continent took place at the Eocene-Oligocene transition. However, the exact conditions and mechanism behind this event are still poorly constrained. What's more, large variability during the Oligocene/Miocene and indications of Eocene ice challenge the idea of a single abrupt transition within a system characterised by a strong hysteresis.

Using newly reconstructed middle-to-late Eocene geography reconstructions and adequate model resolution, our simulations can reconcile the seemingly paradoxical existence of ice and warmth on the Antarctic continent. Prior to glaciation, Antarctica featured a monsoonal climate with warm and wet summers altered by cool and dry winters. Inland regions saw extreme seasonal variation ($\sim$40°C), while coastal zones were milder and therefore suitable to sustain temperate to sub-tropical vegetation. Meanwhile, near-coastal elevated regions allowed the formation of localised ice caps mainly thanks to high amounts of precipitation (1-4 m/year). Interestingly, the central Gamburtsev Range is a hostile environment for ice growth in these simulations despite being suggested as an important focus point for Antarctic glaciation.

The results presented here are generally in good agreement with proxies for the middle-to-late Eocene, explaining indications of regional ice as well as abundant vegetation near the coasts. This more regional view of the Antarctic greenhouse climate poses new challenges on the presumed large-scale glaciation at the EOT. While allowing the formation of smaller ice caps, intense summertime melt across the continental interior poses an important inhibitor on further ice growth. The peculiar climate of an ice-free Antarctica proves quite resilient to external forcing, including a global cooling (well below the proposed 2.5–3$\times$ pre-industrial CO_2 threshold), geography changes or a shift in the oceanic circulation (regarding the meridional overturning regime). We therefore suggest that the conventional idea of a mostly CO_2-driven critical transition at the EOT needs to be revisited. A rather noise-induced transition with reduced hysteresis can explain a prolonged period of bi-stability following the EOT as well as failed prior glaciation.