The formation of the Antarctic Ice Sheet

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Take-home

Our model simulations are consistent with available data and reveal asymmetric glaciation in Antarctica during the Eocene-Oligocene-Transition

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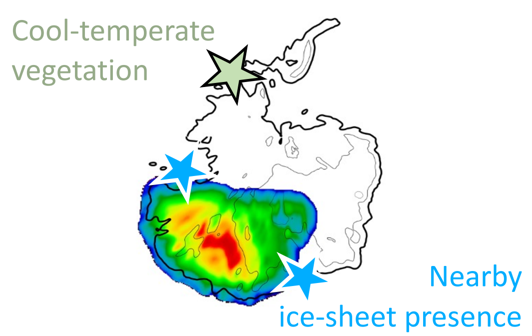
Continental-scale ice sheet in East and cool-temperate climate vegetation in West Antarctica



Motivation and Methods

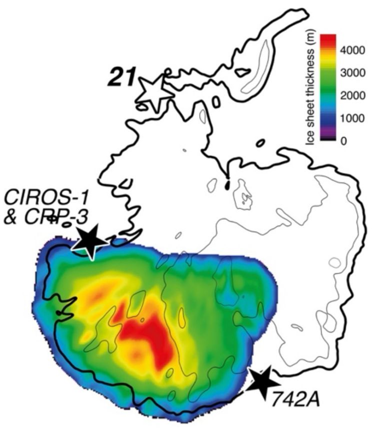
The evolution from greenhouse to icehouse climate conditions during the Eocene-Oligocene Transition (EOT) (~34.4–33.7 Ma) was associated with a drastic cooling of global climate and significant ice sheet build- up. However, extent and location of the such early permanent ice masses are still largely unknown. Here, we coupled the AWI-Earth System Model (Danilov et al.,2017; Stevens et al., 2013; Raddatz et al., 2007) with the Parallel Ice Sheet Model (The PISM authors, 2015) to draw a bigger picture of the relationship between Antarctic ice sheet presence and global climate dynamics during the EOT and the Early Oligocene Glacial Maximum (EOGM) just afterwards.

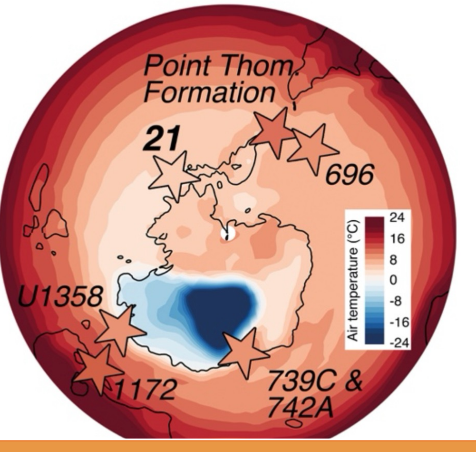
Results

Our climate model simulates warm waters reaching the coast of the strongly uplifting Northern Victoria Land via a yet significantly shallower Tasman gateway. Its associated moist air masses led to increased precipitation and thus formation of an ice sheet nucleus there and not in the dry Antarctic interior in the Gamburtsev Mountains.

Our simulation reveals an asymmetric ice sheet cover during the EOGM (see figure below), and, notably, identifies a CO_2-threshold of <560 ppmv necessary for initiating marine-terminating ice sheet advance onto West Antarctic continental shelves — one major component in Earth's paleoclimatic puzzle. Our Antarctic climate and vegetation simulations match available proxy data well for this period of fundamental change (see figure below).

Therefore, our new simulations significantly contribute to a deeper understanding of Antarctic ice sheet build-up during the EOT and EOGM, revealing the highly differential regional response of the Antarctic ice sheet to past and future climatic change.





Site	Ice presence	Air temp
CIROS1 / CRP-3	Fielling et al., 2001, *Terra Ant.* Galeotti et al., 2012, *Palaeogeogr. Palaeoclimatol. Palaeoecol.*	Raine et al., 2001, *Terra Ant.* Cantrill et al., 2001, *Terra Ant.*
Point Thomas F.		Birkenmajer et al., 1989, *Geol. Soc.*
696		Thompson et al., 2022, *Clim. Past*
U1358		Salzmann et al., in prep
1172		Amoo et al., 2022, *Clim. Past*
739C / 742A	Passchier et al., 2017, *GSA Bulletin*	Tibbet et al., 2021, *Paleoceanography*
21	**Klages et al., in revision, *Science***	
Topography	Paxmann et al., 2019, *Palaeogeogr. Palaeoclimatol. Palaeoecol.*	

Acknowledgements

S.S.R. Jamieson (University of Durham, UK) is thanked for advice on initial ice pre-settings for the model.

Funding

H.K., G.L., J.P.K., L.N., and P.G. were funded by the Helmholtz Association “Changing Earth – Sustaining our future” programme and the AWI PACES II.

Data and materials availability: All data are available online in the Data Base for Earth and Environmental Science (PANGAEA). The source codes of the Alfred Wegener Institute-Earth System Model 2.1 (AWI-ESM 2.1) and the Parallel Ice Sheet Model (PISM) are available online in the Data Base Zenodo