POSTER

Tipping Points in Antarctic Climate Components

Identifying thresholds of ocean-induced Antarctic ice loss through idealized ice-sheet simulations

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1. CONTEXT

Commitment of irreversible ice loss from Antarctica under present-day climate

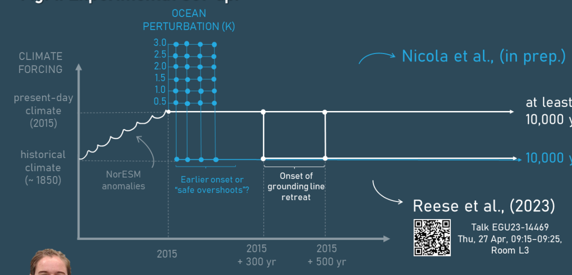
Present-day grounding lines in the Amundsen Sea sector of Antarctica are already committed to retreat if present-day climate is held constant [1]. Reversing the climate forcing to historical conditions can prevent this large-scale grounding line retreat. However, this is only possible for a specific amount of time after which retreat becomes irreversible. Earliest onset of irreversible grounding line retreat is found between 300 and 500 years of present-day climate conditions. We here analyze how the onset of irreversible retreat is influenced by additional ocean perturbations [1].

2. METHODS

How can we determine the onset of irreversible retreat for different ocean perturbations?

- Experimental design summarized in Fig. 1
- Experiments with the Parallel Ice Sheet Model (PISM, https://www.pism.io/) from an initial state representing the present-day Antarctic Ice Sheet at 8 km resolution, including the modelled trend in ice loss from [1], see Fig. 2.
- Present-day ocean temperature and salinity are from [2], atmospheric conditions from [3], historic forcing follows ISMIP6 protocol [4]
- We perform circum-Antarctic extreme ocean temperature perturbations of 1 to 3 K for 25, 50, 75 and 100 years
- Then we reverse back to historical (1850-1900) climate and continue the run for 10,000 years to analyze if grounding lines recover or continue to retreat
- Our simulations are no projections but allow us to identify the onset of irreversible retreat (e.g. driven by the marine ice-sheet instability)

Fig. 1: Experimental set-up.



Meet me at the poster on Mon, 24 Apr, 14:00–15:45

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3. PRELIMINARY RESULTS

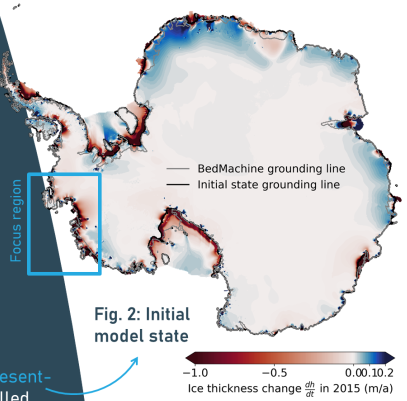


Fig. 2: Initial model state

- Short perturbations of 25 years do not trigger irreversible retreat ("safe overshoots"), except for a perturbation of 2.5 K above present-day, see Fig. 2.
- Overshoots of > 75 years cause long-term irreversible grounding line retreat; a "safe overshoot" of 50 years exists for 0.5 and 1.0 K ocean perturbation
- The committed sea-level rise from the Amundsen Sea region mounts to ~ 1.3 m SLE (sea-level equivalent), if irreversible ice loss is triggered, see Fig. 3.
- Three clusters of long-term grounding line positions are found, one close to present-day positions, one with a loss of 2-7 x 10^4 km^2 and one with 9-13 x 10^4 km^2 of grounded area lost in Thwaites, see Fig. 4.
- Exact threshold (of perturbation strengths leading to irreversible losses) depends on exact model configuration; for a slightly less sensitive initial state, the overshoot window extends to < 3 K < 100 years (not shown)

Fig. 4: Timeseries of sea-level rise from the Amundsen Sea region.

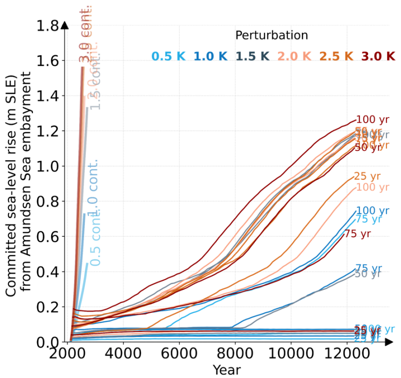


Fig. 3: (Ir)reversible retreat in the Amundsen Sea depending on ocean forcing strength and duration. Dark red shows regions that unground within 10,000 years after reversing to historic climate conditions. Where regions unground, grounding lines retreat become irreversible during the perturbation (red). When grounding lines recover, retreat is reversible (grey).

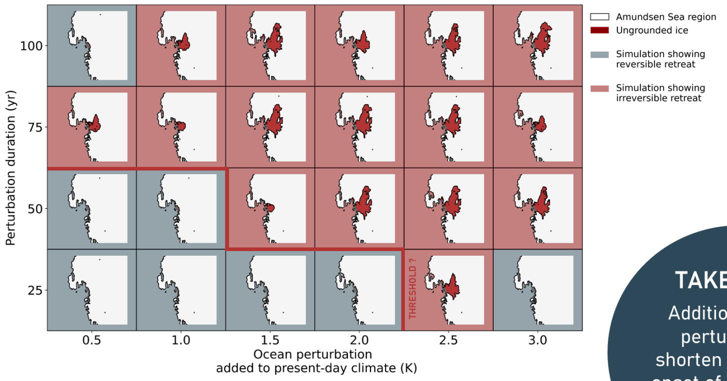
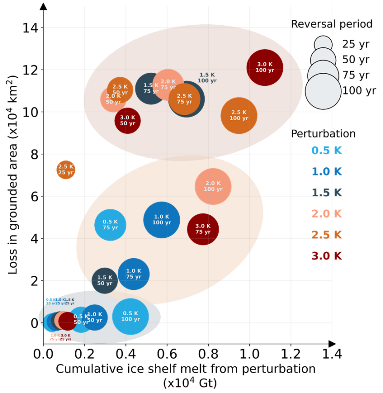


Fig. 5: Changes in grounded area for different forcing strengths (cumulative ice-shelf melt in perturbation period).



TAKE HOME

Additional ocean perturbations shorten window for onset of irreversible retreat in the Amundsen Sea region.

REFERENCES

[1] Reese et al., *The Cryosphere Discussions* (2023)
[2] Schmidtko et al., *Science* (2014)
[3] RACMO2.3p2, van Wessem et al., *The Cryosphere* (2018)
[4] Seroussi et al. , *The Cryosphere* (2020)

ACKNOWLEDGEMENTS

This work received funding from the European Union's Horizon 2020 programme (grant no. 820575) and the Studienstiftung des Deutschen Volkes e.V.

Identifying thresholds of ocean-induced Antarctic ice loss through idealized ice-sheet simulations

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TiPACCs – Tipping Points in Antarctic Climate Components

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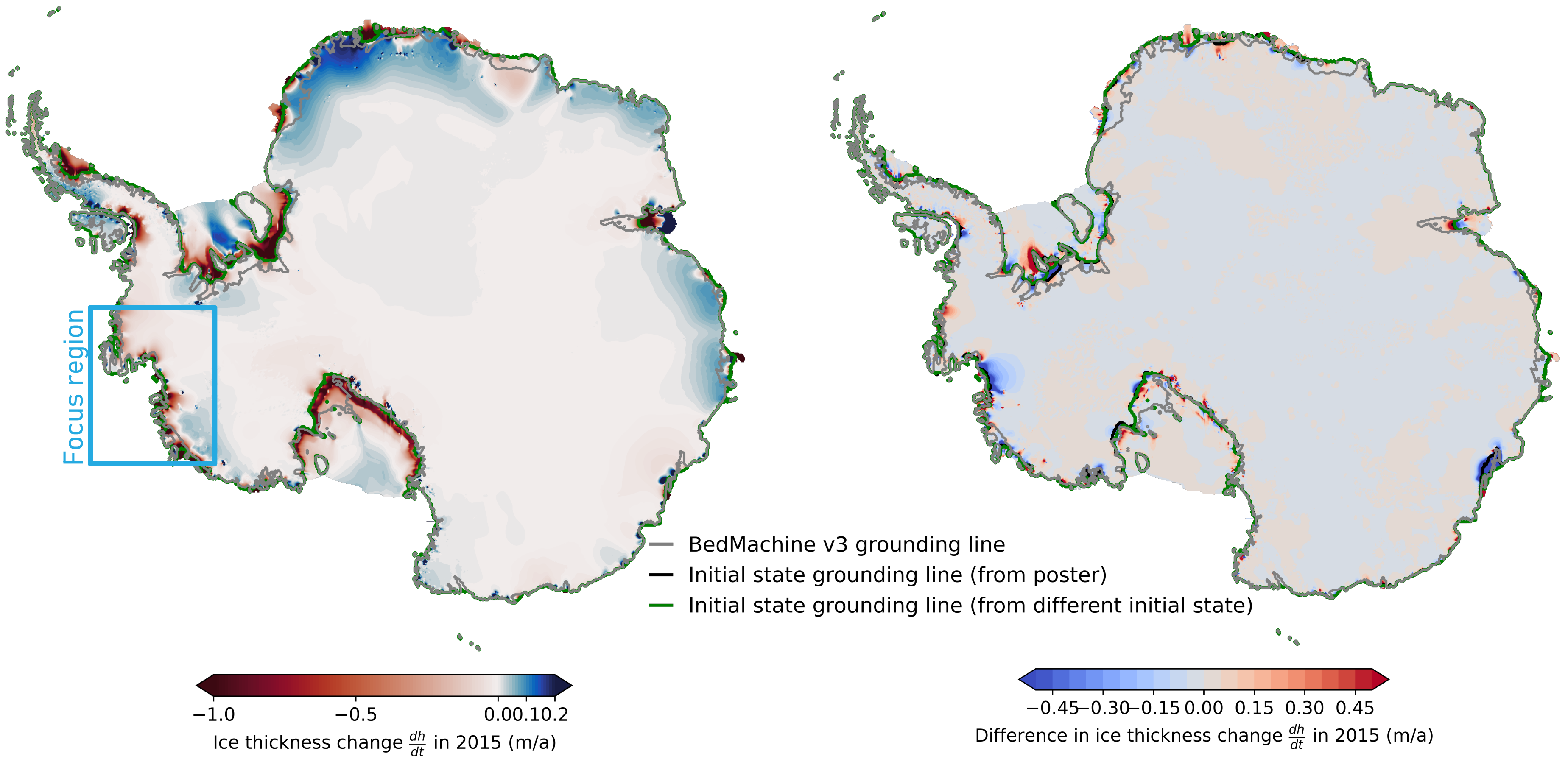
SUPPLEMENT

For a different member of the initial state ensemble, Reese et al., 2023 (The Cryosphere Discussions) found that irreversible grounding line retreat starts > 1000 yr after present-day, when climate is held constant.

Same as Fig. 2 from poster, but with different ensemble member (from Reese et al., 2023.)

a) Modelled trend in ice thickness in 2015

b) Difference between ensemble members



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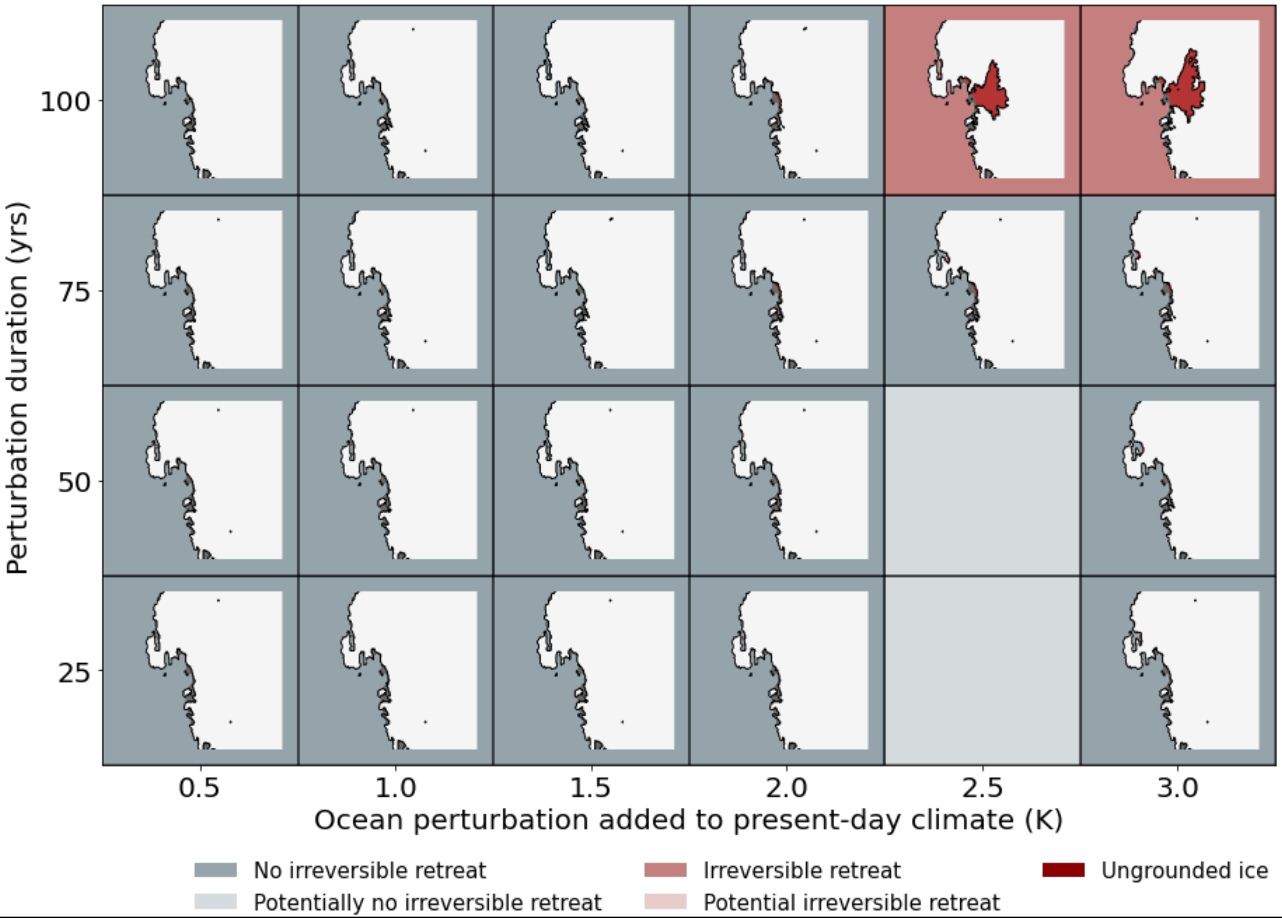
Same as Fig. 3 from poster, but with different ensemble member (from Reese et al., 2023.)



→ "Safe overshoot" window < 3 K and < 100 yrs perturbation length ?

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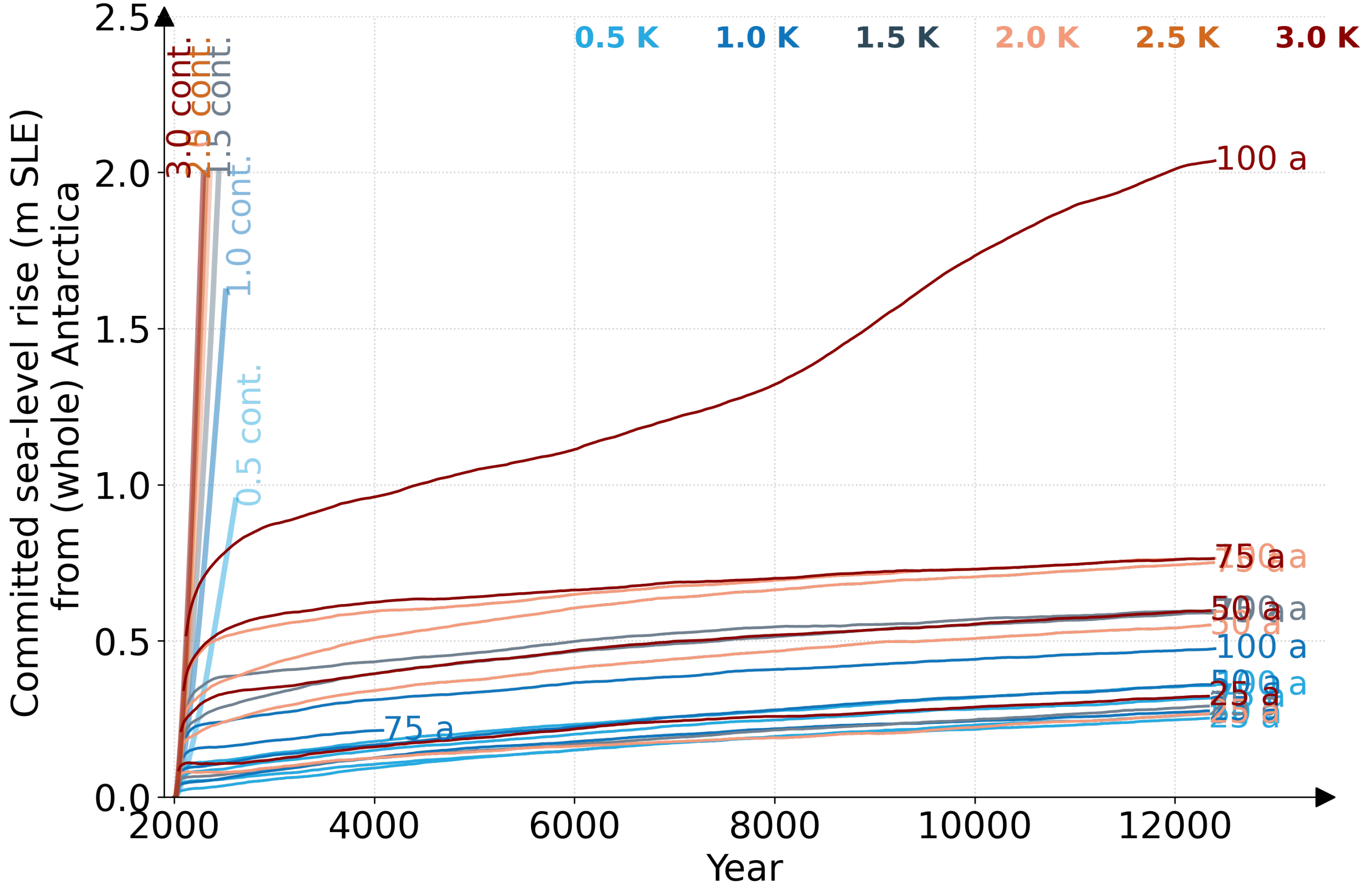

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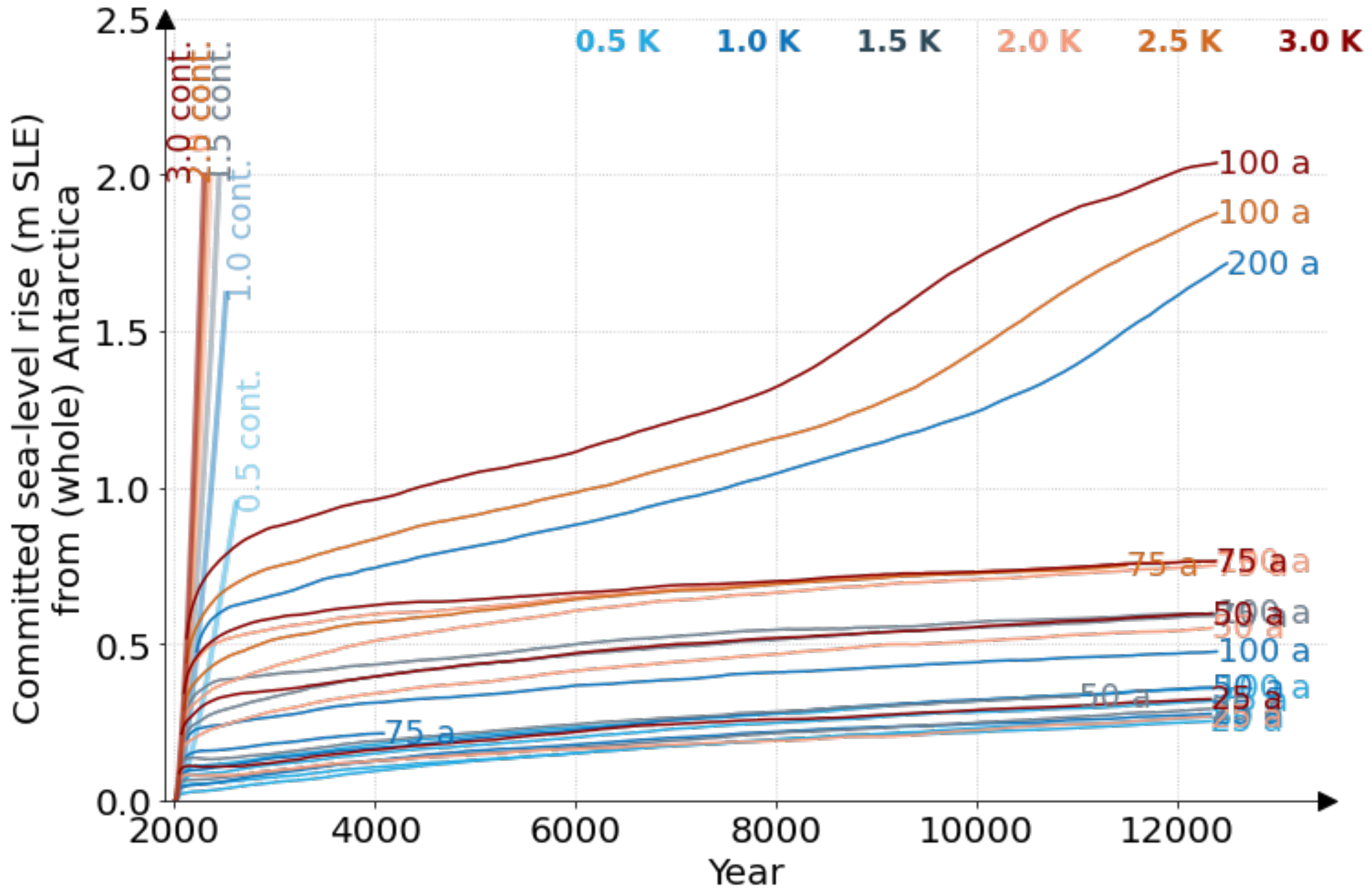

New simulations!

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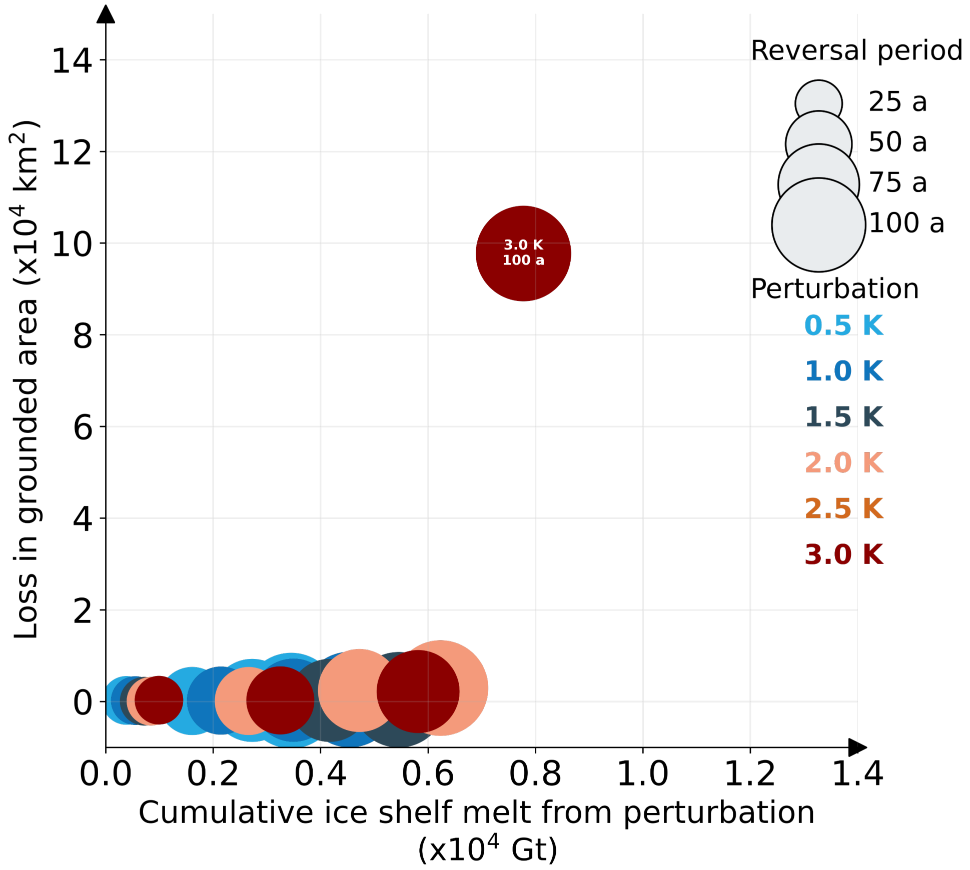

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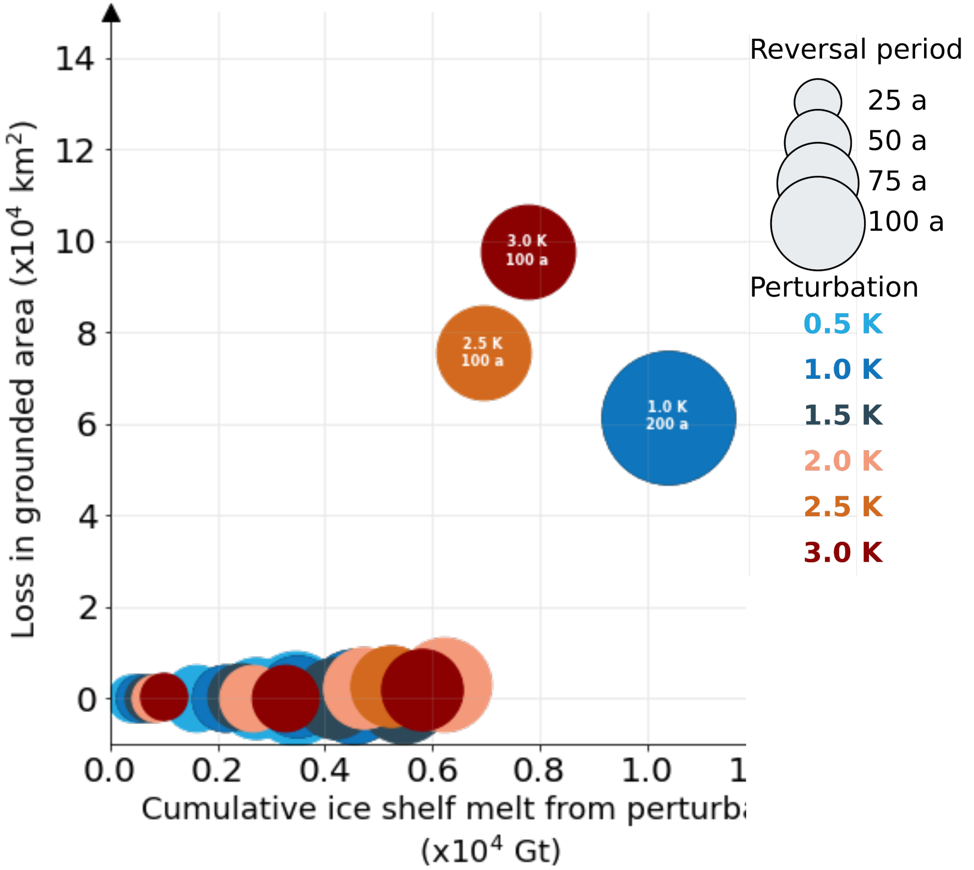

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