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Antarctic Ice Dynamics - From Deep Past to Deep Future

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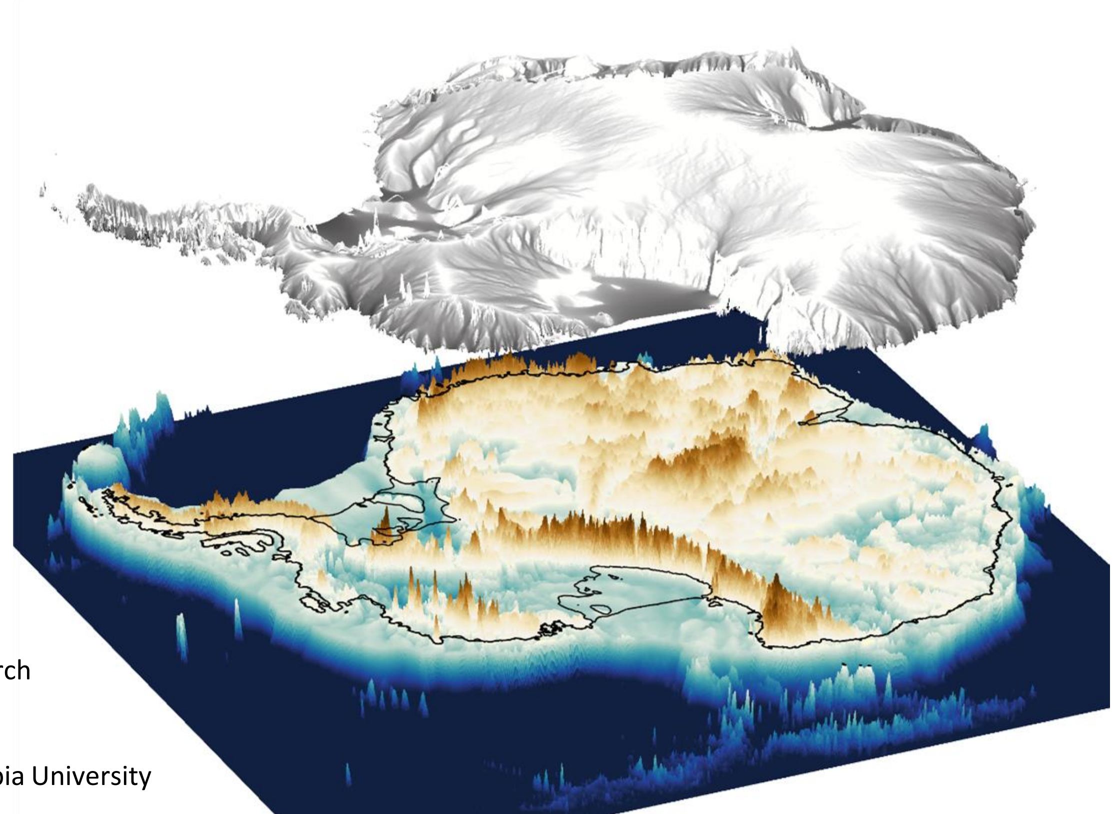

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1 Brief Summary

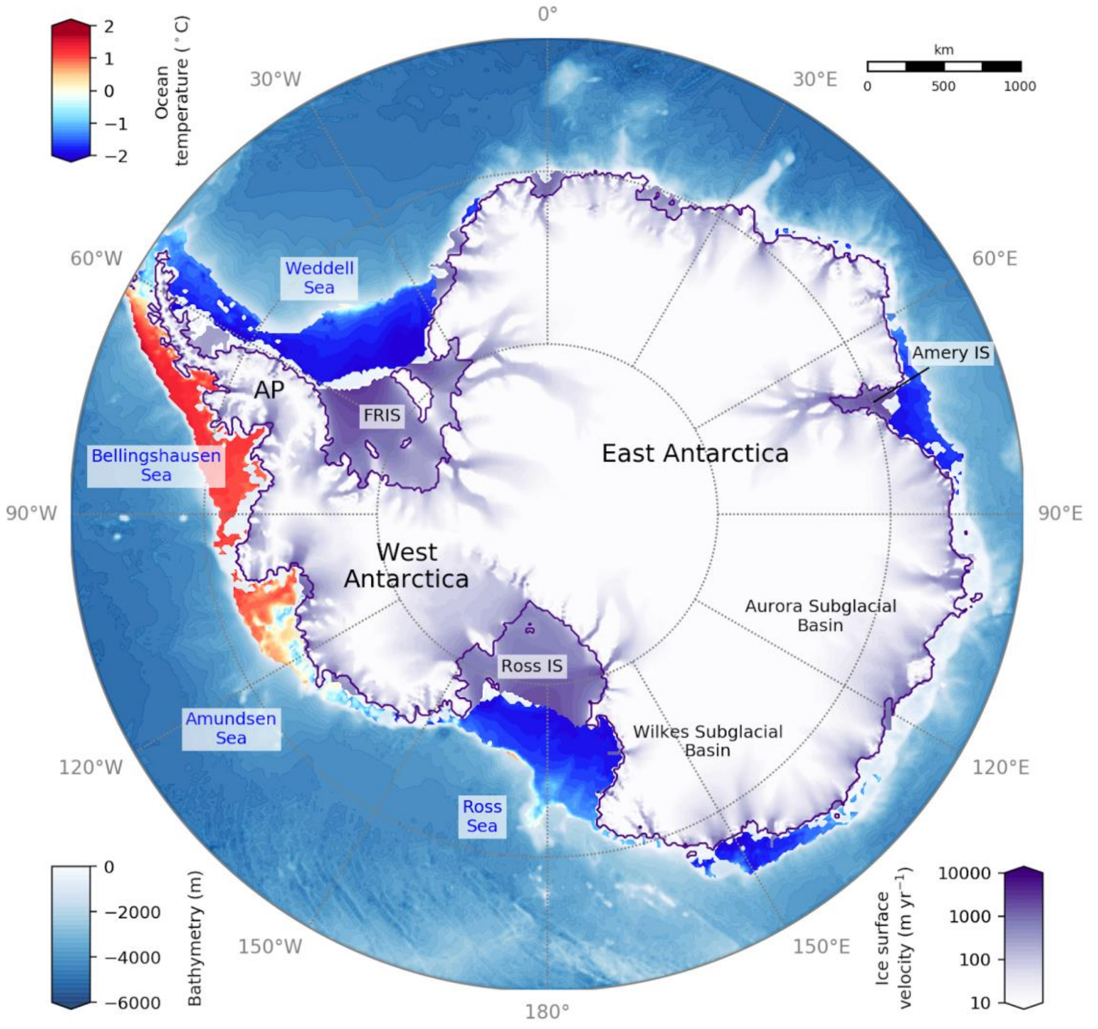
Main finding 1: Past glacial cycles

- Successful simulation of past two glacial cycles with the Parallel Ice Sheet Model PISM
- Sensitivity analysis to model parameterizations and boundary conditions (see also display EGU2020-15081)

Main finding 2: Future long-term stability

- Antarctic Ice Sheet exhibits a multitude of temperature thresholds beyond which ice loss into the ocean is irreversible
- Marine ice sheet instability is triggered in West Antarctica at global warming levels around 1 to 2 °C above pre-industrial temperatures
- Between 6 to 8 °C of warming, the loss of half of the present-day ice volume is triggered, mainly due to the surface melt-elevation feedback
- These thresholds give rise to hysteresis behavior

2 PARALLEL ICE SHEET MODEL PISM



Present-day Antarctica as simulated with PISM
(Garbe et al., in review)

- **Open source:** http://pism-docs.org
- **Ice dynamics**: hybrid of Shallow Ice Approximation (SIA) and Shallow Shelf Approximation (SSA) *(Bueler and Brown 2009)*
- **Grounding line and calving front** can freely evolve (on sub-grid scale) *(Feldmann et al. 2014; Levermann et al. 2012)*
- **Visco-elastic bed deformation** by modified Lingle-Clark model *(Lingle and Clark 1985; Bueler et al. 2007)*
- **3D polythermal enthalpy** conservation *(Aschwanden et al. 2012)*
- **Sub-shelf melting** simulated using the Ice-shelf Cavity mOdel PICO *(Reese et al. 2018)*
- **Surface mass balance** via positive-degree-day scheme based on parameterized air temperature and scaled RACMO precipitation *(van Wessem et al. 2018)*

3 Past Two Glacial Cycles

Forcing:

- surface temperature anomaly $dT(t)$
- ocean temperature anomaly $dT_o(dT)$
- precipitation scaling $dP(dT)$
- sea-level anomaly $dS(t)$

One forcing alone cannot explain glacial cycle history of sea-level relevant ice volume (reference in grey)

Without sea-level forcing there is no significant ice-sheet growth and decay

Find out more

EGU General Assembly

Display EGU2020-15081

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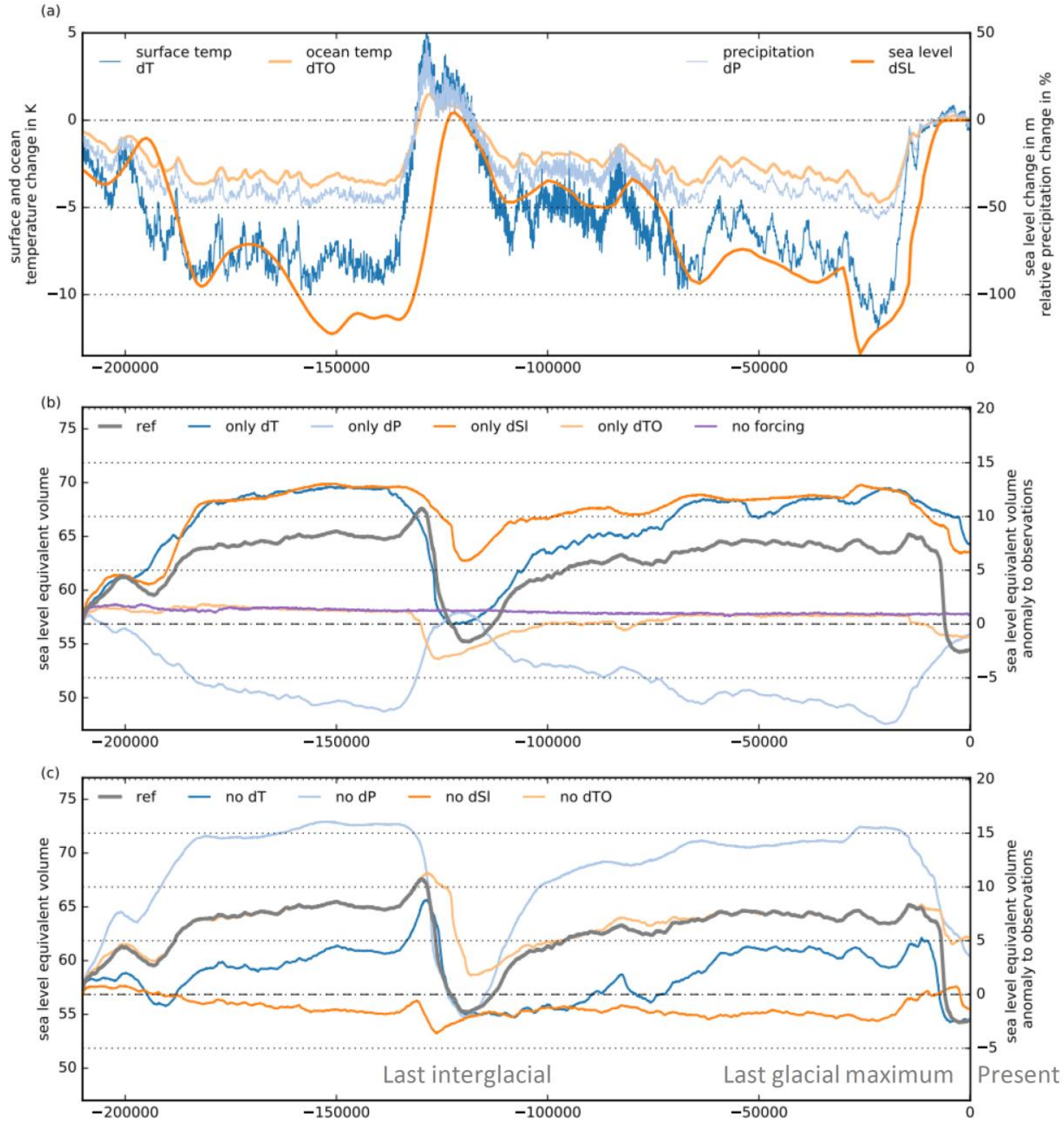
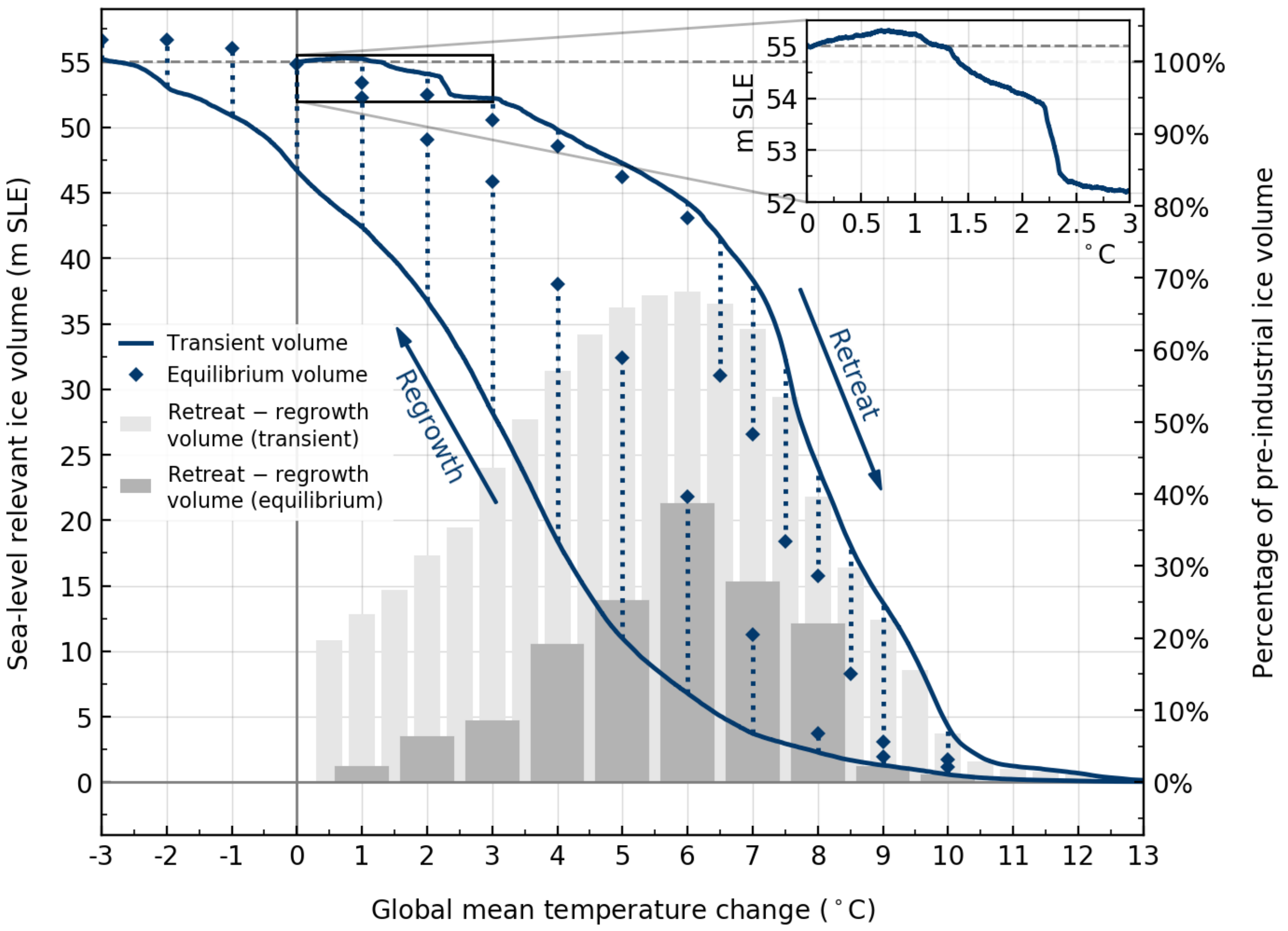
Albrecht et al. 2020a

Albrecht et al. 2020b



4 FUTURE LONG-TERM STABILITY

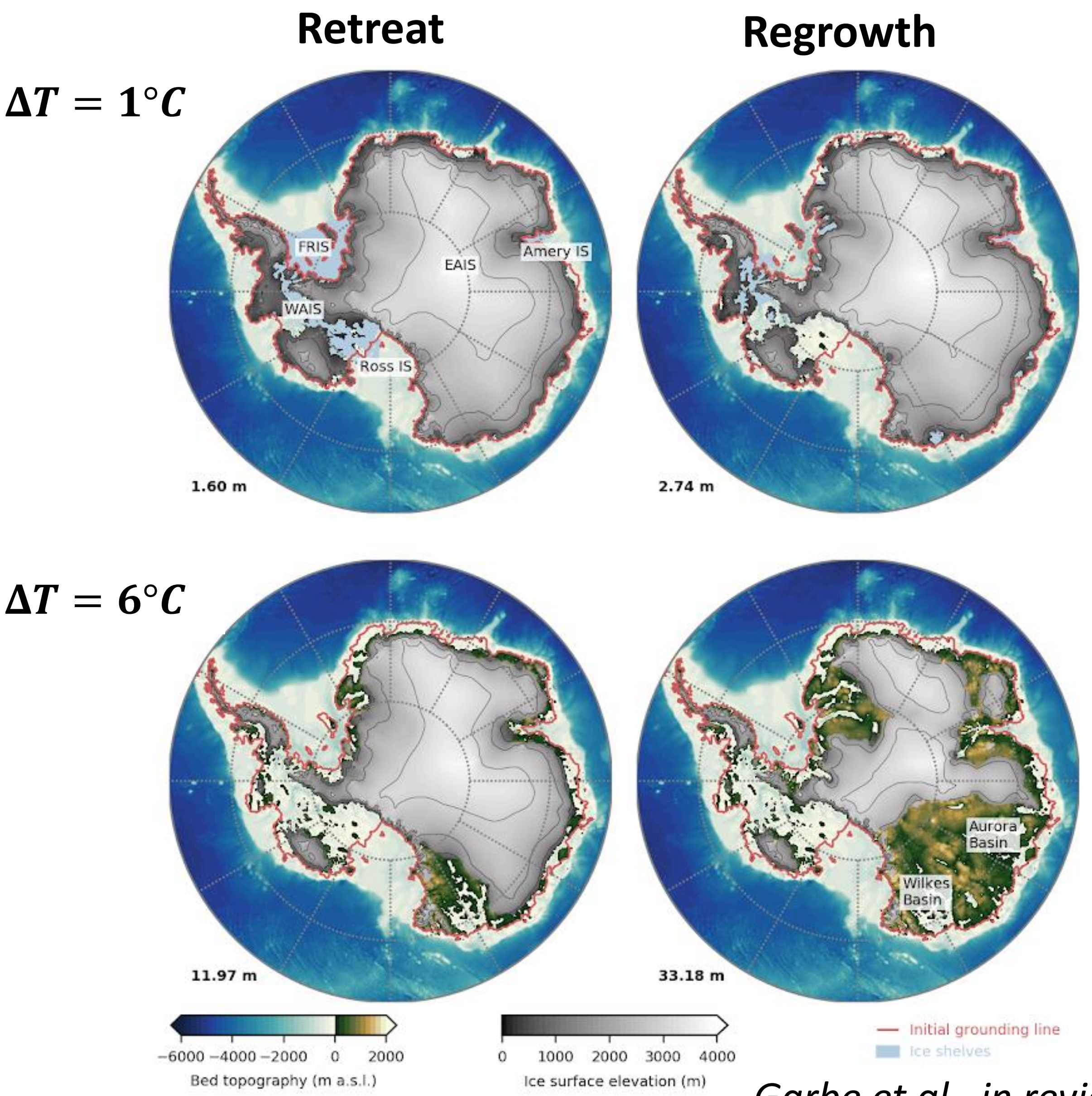


Garbe et al., in review

- Quasi-equilibrium simulations with PISM: forcing rate slower than typical response times of ice-sheet, monitoring ice-sheet retreat and regrowth
- Marine ice sheet instability in West Antarctica triggered around 1 to 2 °C above pre-industrial temperatures
- Loss of half of present-day ice volume between 6 to 8 °C of warming, mainly due to the surface melt-elevation feedback
- Bar charts indicate ice volume difference between the retreat and regrowth branches

5 Antarctic Ice-Sheet Hysteresis

- Significant differences between retreat and regrowth ice-sheet configurations at same temperature levels
- Currently observed ice-sheet configuration is not regained even if temperatures are reversed to their present-day levels
- West Antarctic Ice Sheet does not regrow to its modern extent until temperatures are at least -1 °C colder than pre-industrial levels



Garbe et al., in review