# Impact of relative sea-level change on sub-shelf melt

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Sharing is encouraged

## 1. Basic Idea

- Relative Sea Level (RSL) = water column thickness
- Changes through Glacial Isostatic Adjustment (GIA):
  - Mass redistribution (ocean & ice sheets)
  - rotational & gravitational adjustment
  - deformational (visco-elastic) processes
- ΔRSL: O(100m) on glacial time scales
- Strong vertical temperature profiles in ocean can lead to changes in thermal forcing of ice sheets

**goal: Estimating the order of magnitude that RSL change can influence sub-shelf melt rates at maximum.**

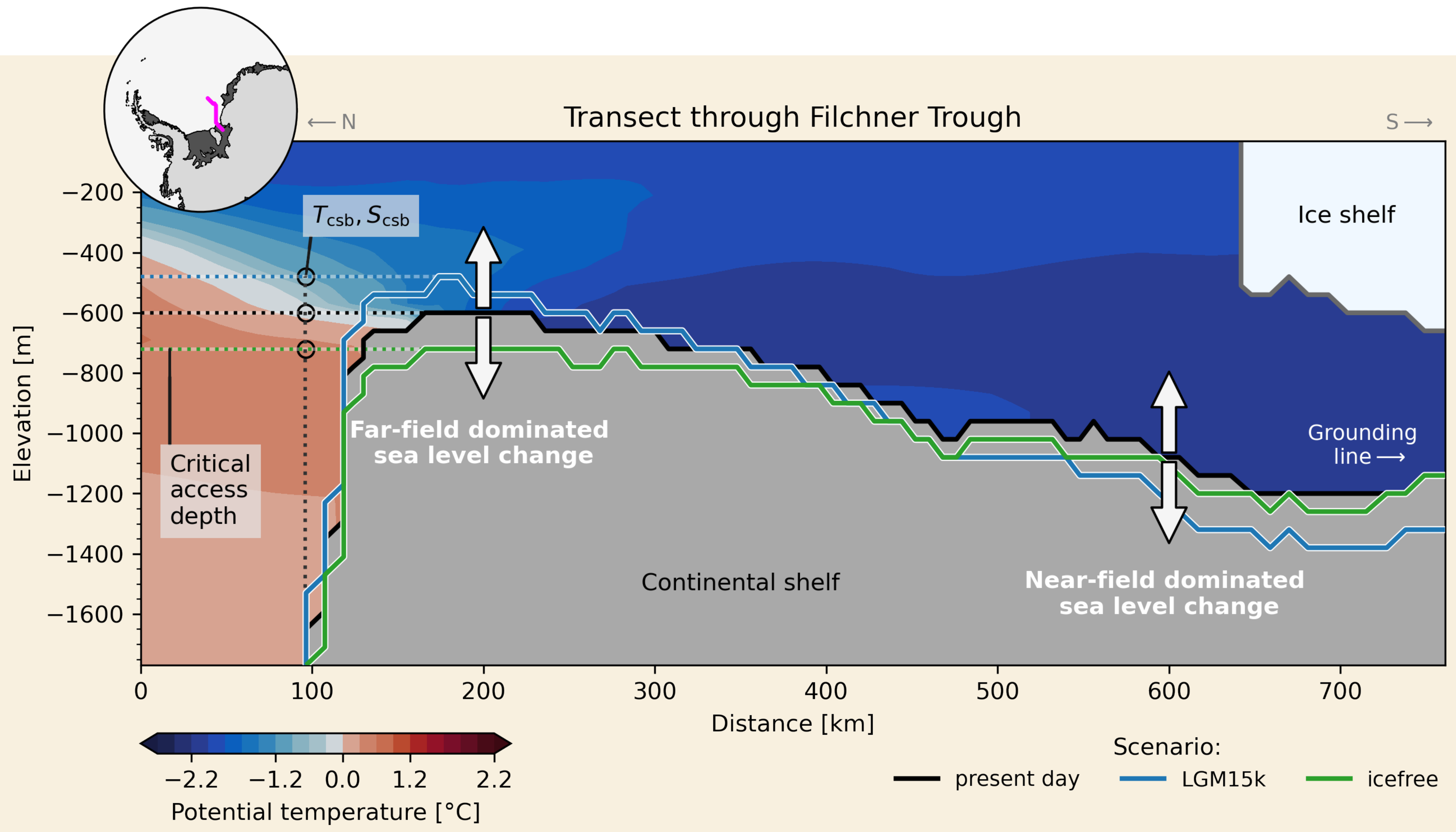


*Figure 1 Cross section through Filchner Trough showing topographic overflow feature and corresponding critical access depths at sill (dotted lines). Changes in Relative Sea Level compared to present-day are shown for LGM and icefree configurations as shifts In bathymetry. Ocean temperature (T) and Salinity (S) are inferred at the continental shelf break (CSB) [data: Jourdain (2020)].*

## Related Talks

- Lena Nicola: Oceanic gateways to Antarctic grounding lines - Impact of critical access depths on sub-shelf melt
  Wed 17:27, OS1.6
- Torsten Albrecht: Feedback mechanisms controlling Antarctic glacial cycle dynamics simulated with a coupled ice sheet–solid Earth model
  Tue 9:25, CR2.2

## 5. Take Home Messages

- **Relative sea level changes have an influence on basal melt rates**
- **Magnitude of temperature changes are comparable to other mechanisms like warm water intrusions or climatic changes over paleo time scales**

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## 2. Relative Sea Level configurations

- Upper bound of plausible changes:
  - **LGM15k:** Last Glacial Maximum 15ka before present, GMSL= -93m, grounding line advance close to continental shelf break
  - **Icefree:** all continental ice transformed into liquid ocean water, GMSL= +70m
- Computed with coupled ice - GIA model (PISM-VILMA)
  - solving sea-level equation self-consistently (Albrecht, in discussion)

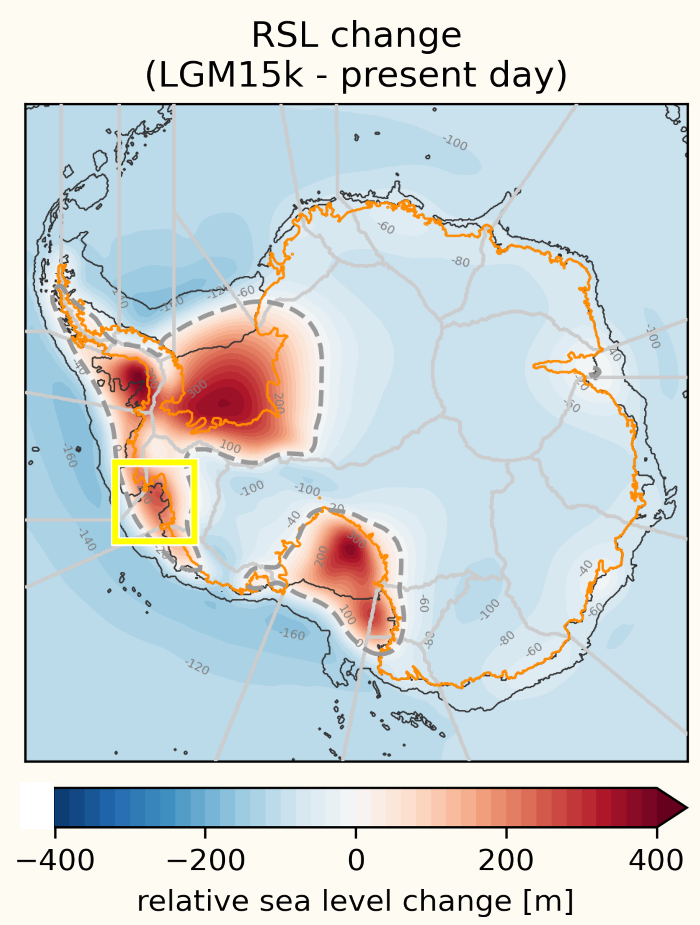


*Figure 2 RSL change for LGM configuration.
Dashed grey line: transition between positive and negative ΔRSL, gold contour: present-day grounding line. Black line confines region between continental shelf break and present-day ice shelves.*

## Preprint (The Cryosphere)

Kreuzer et al.: *Oceanic Gateways in Antarctica – Impact of relative sea-level change on sub-shelf melt*, EGUsphere, 2023

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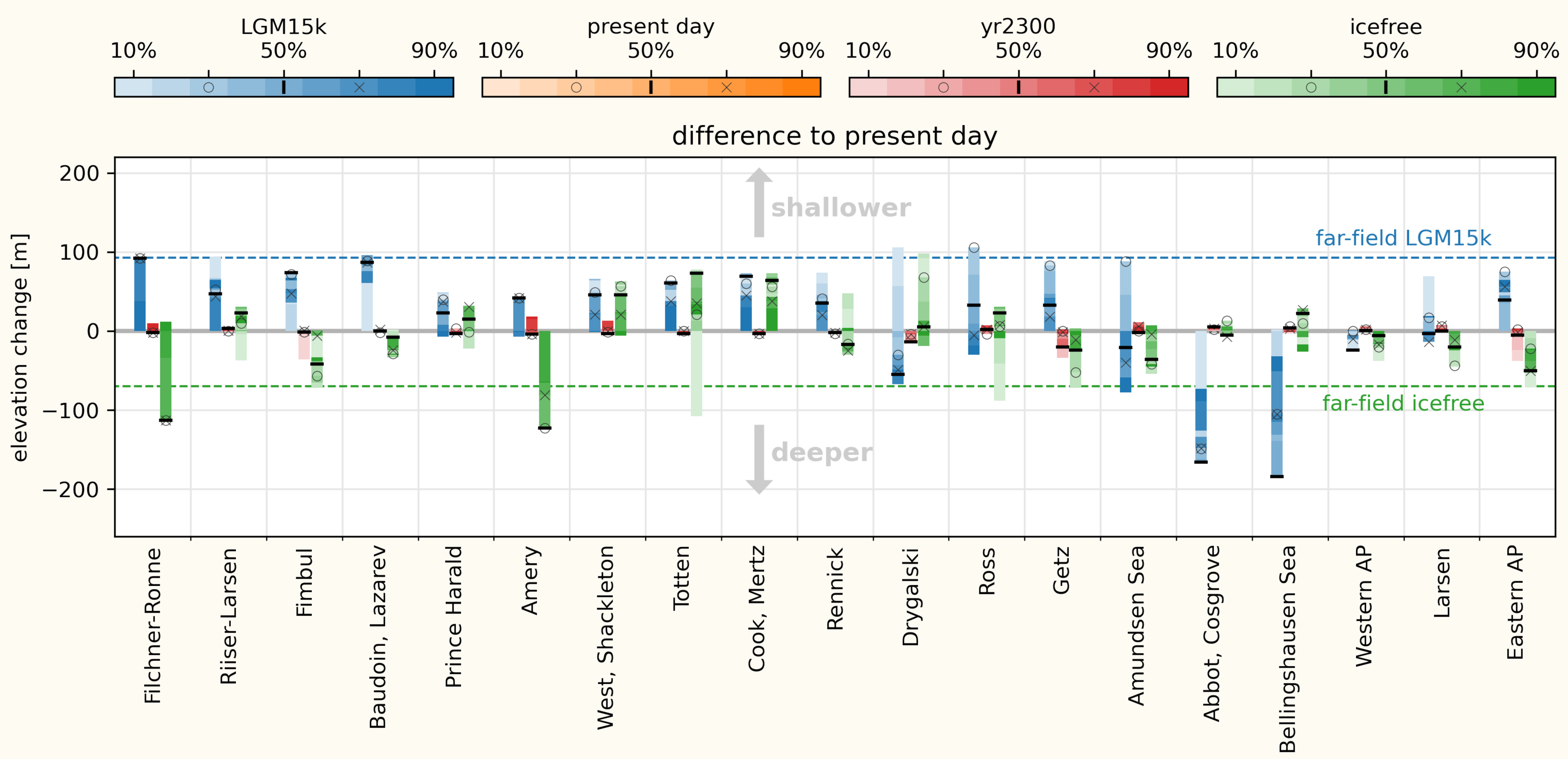
## 3. Changes of critical access depths




- Computing critical access depth like in Nicola (in discussion)
- Deviations from far-field signal (dotted lines in Fig. 3): deformational solid-Earth response to changing ice load
- *LGM15k*: shallowing in East Antarctic and Peninsula basins, deepening in West Antarctica
- *Icefree:* regionally heterogeneous pattern

*Figure 3 Critical access depth changes to present day. The colour shade indicates the percentage of grounding line reached by the specific critical access depths. Far-field sea-level changes are indicated by dashed horizontal lines for LGM15k and icefree scenario.*

## 4. Changes of ocean temperature and sub-shelf melt

- Shallower critical access depth: colder temperatures → reduced basal melt
- Deeper critical access depth: warmer temperatures → enhanced basal melt
- *LGM:* ΔT = +/- 0.7 °C → Δm = +/- 100%
- *Icefree:* ΔT = +/- 0.5 °C → Δm = - 100% to +260%

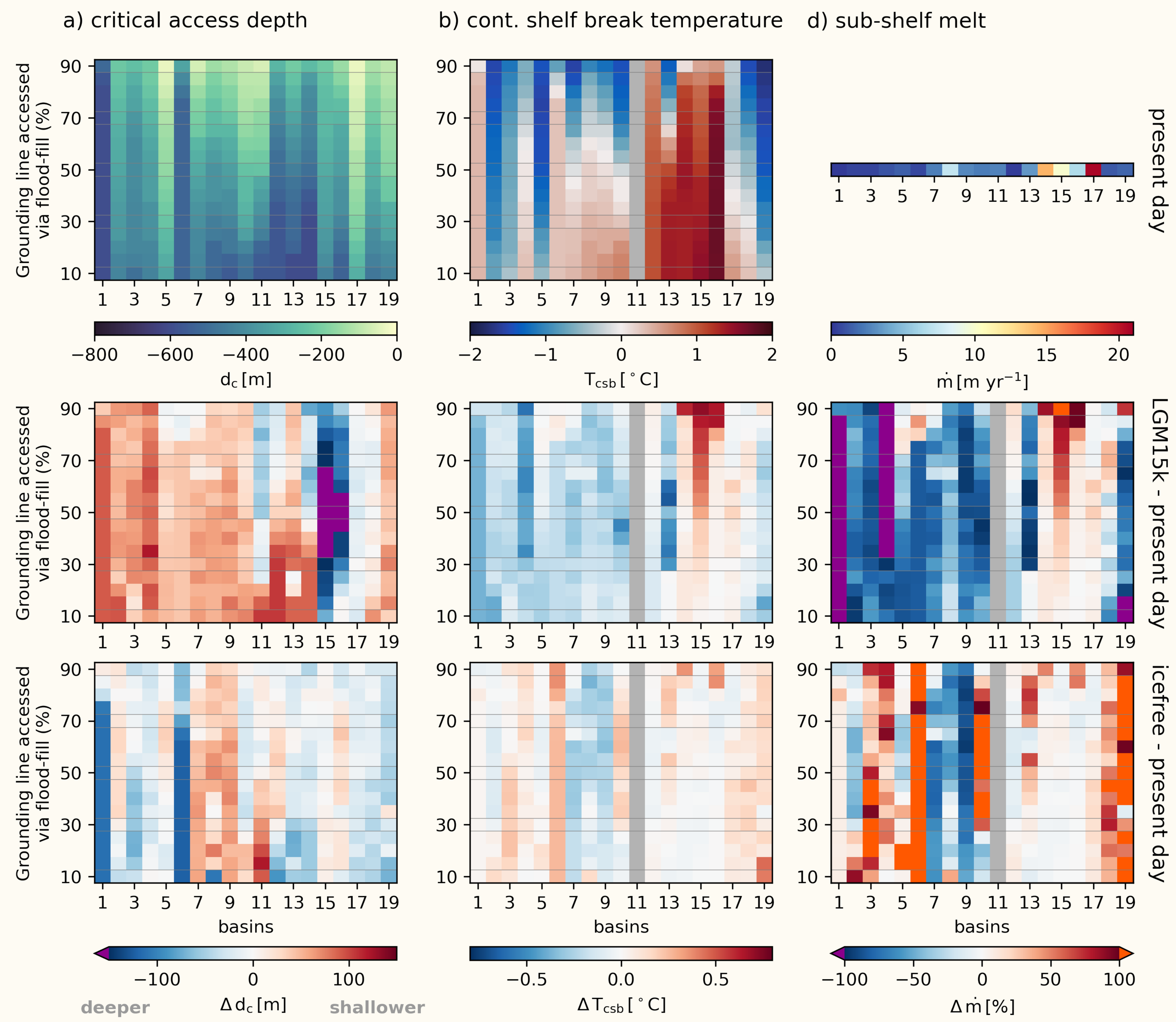



*Figure 4 Overview of derived critical access depths, ocean temperatures and basal melt rates for present-day conditions (upper row) and their changes in the LGM15k (middle row) and icefree (lower row) RSL configurations.*

References:
Albrecht et al.: Feedback mechanisms controlling Antarctic glacial cycle dynamics simulated with a coupled ice sheet–solid Earth model, EGUsphere [preprint], 2023.
Jourdain et al.: A protocol for calculating basal melt rates in the ISMIP6 Antarctic ice sheet projections, The Cryosphere, 14, 3111–3134, 2020.
Nicola et al.: Oceanic gateways to Antarctic grounding lines – Impact of critical access depths on sub-shelf melt, EGUsphere [preprint], 2023.