Sub-shelf melt parameterization assessment from an ocean/ice sheet coupled model

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Motivations

- Ocean melt beneath ice shelves is the main driver of Antarctic ice mass loss.
- Our goal is to assess parameterizations of sub-shelf melting that are used in stand-alone ice sheet modelling, in regards to a new framework of ocean-ice sheet coupling.

19 Melting parameterizations

- Linear, local dependency to thermal forcing* (TF) : ***Mlin = α (To-Tf)*** [1]
- Quadratic, local dependency to TF* : ***Mquad = α (To-Tf)²*** [e.g., 2]
- Quadratic, local/non local dependency to TF* : ***M+ = α (To-Tf) <To-Tf>***

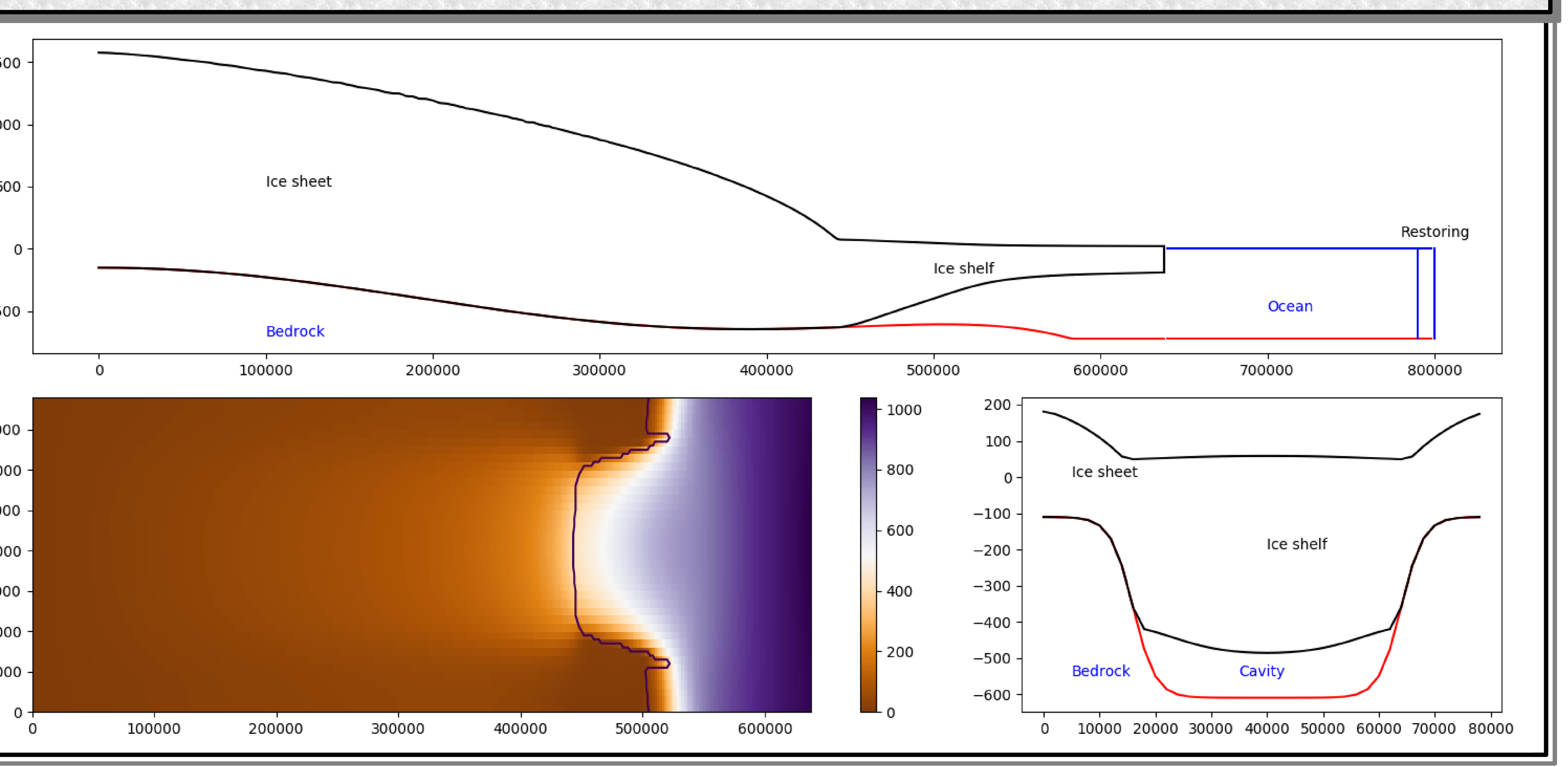
(**To, So taken at 500 or 700m depth, or varying depths, e.g., M+, M+_500, M+_700)*

- 2D plume model emulator (***PMEi***), 4 different implementations [3]
- Box model (***Bmi_..***), at 500 or 700m depth, and with 2, 5, 10 boxes [4]

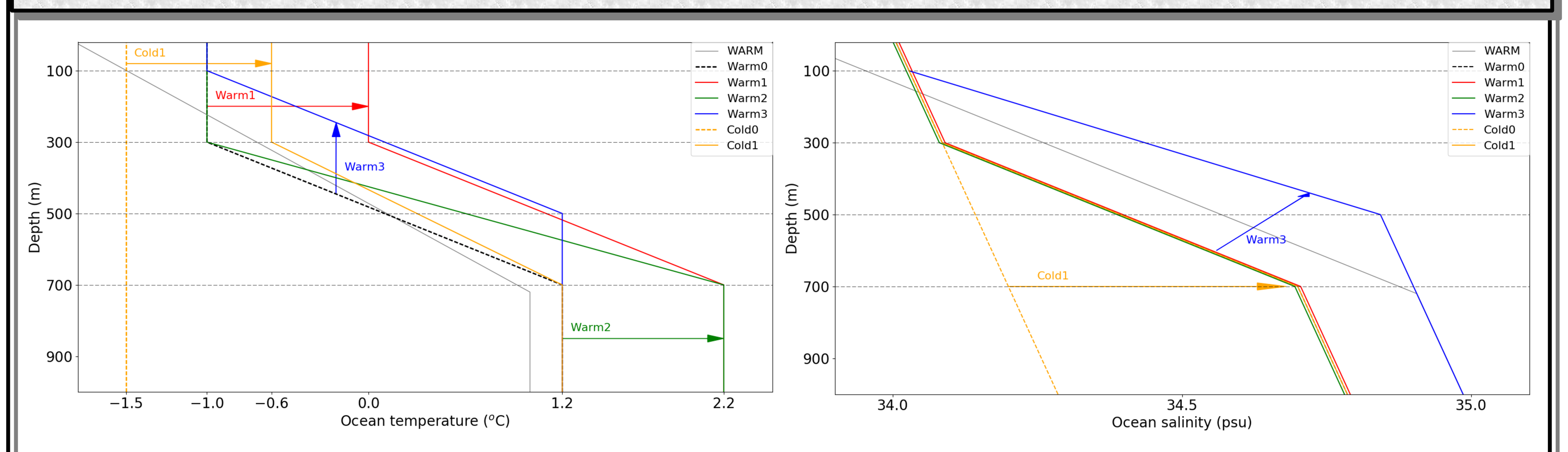
Models

- Elmer/Ice for the ice sheet (SSA* and Schoof friction law)
- NEMO for the ocean (no tides, no sea ice, no atmo forcing)
- Asynchronous coupling of Elmer/ice and NEMO

Geometry : MISOMIP framework [8]



6 TF (To - Tf freezing point) scenarios (To & So in front of the cavity)



Cold0 and Warm0 are static.

- Cold0: cold cavity (e.g., Ross)
- Warm0: inspired by PIG [6]

The others start from the static and evolve in time

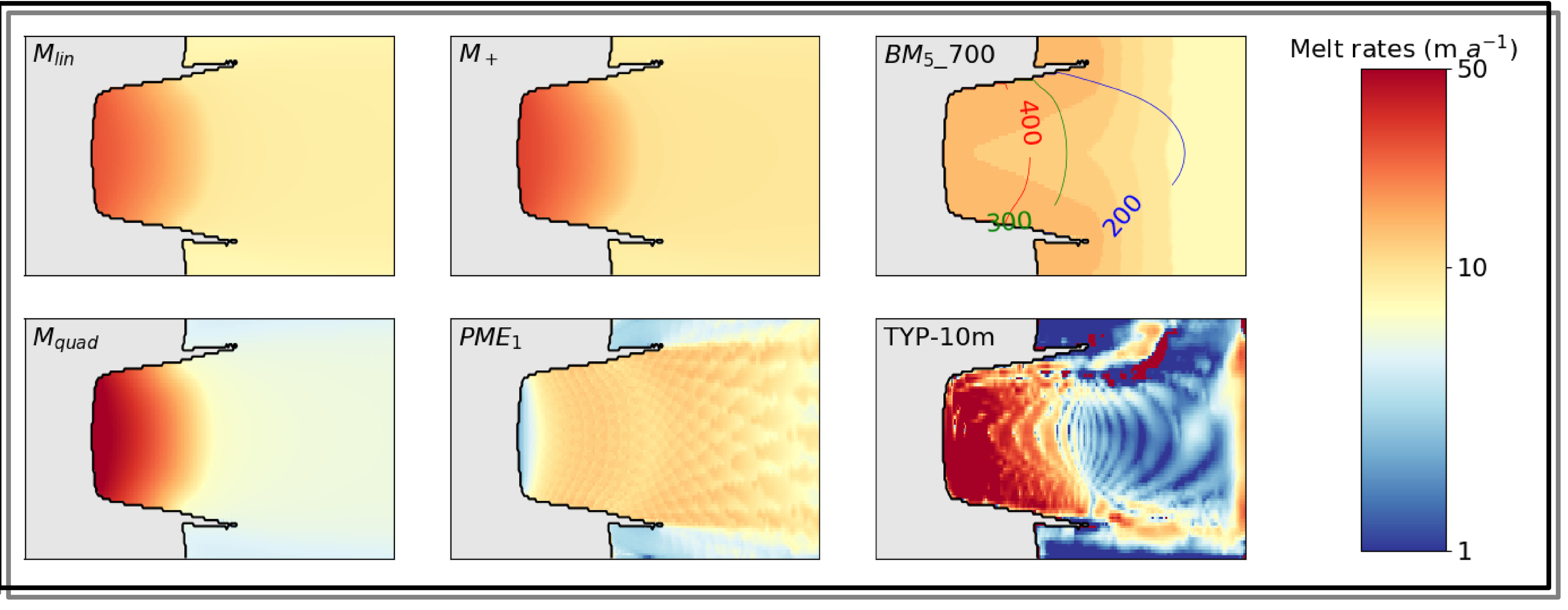
- Cold1: cold to warm [5]
- Warm1: 1°C warming at all depths (CMIP5 models)
- Warm2: 1°C warming at depth
- Warm3: coastal thermocline uplift [7]

Calibration

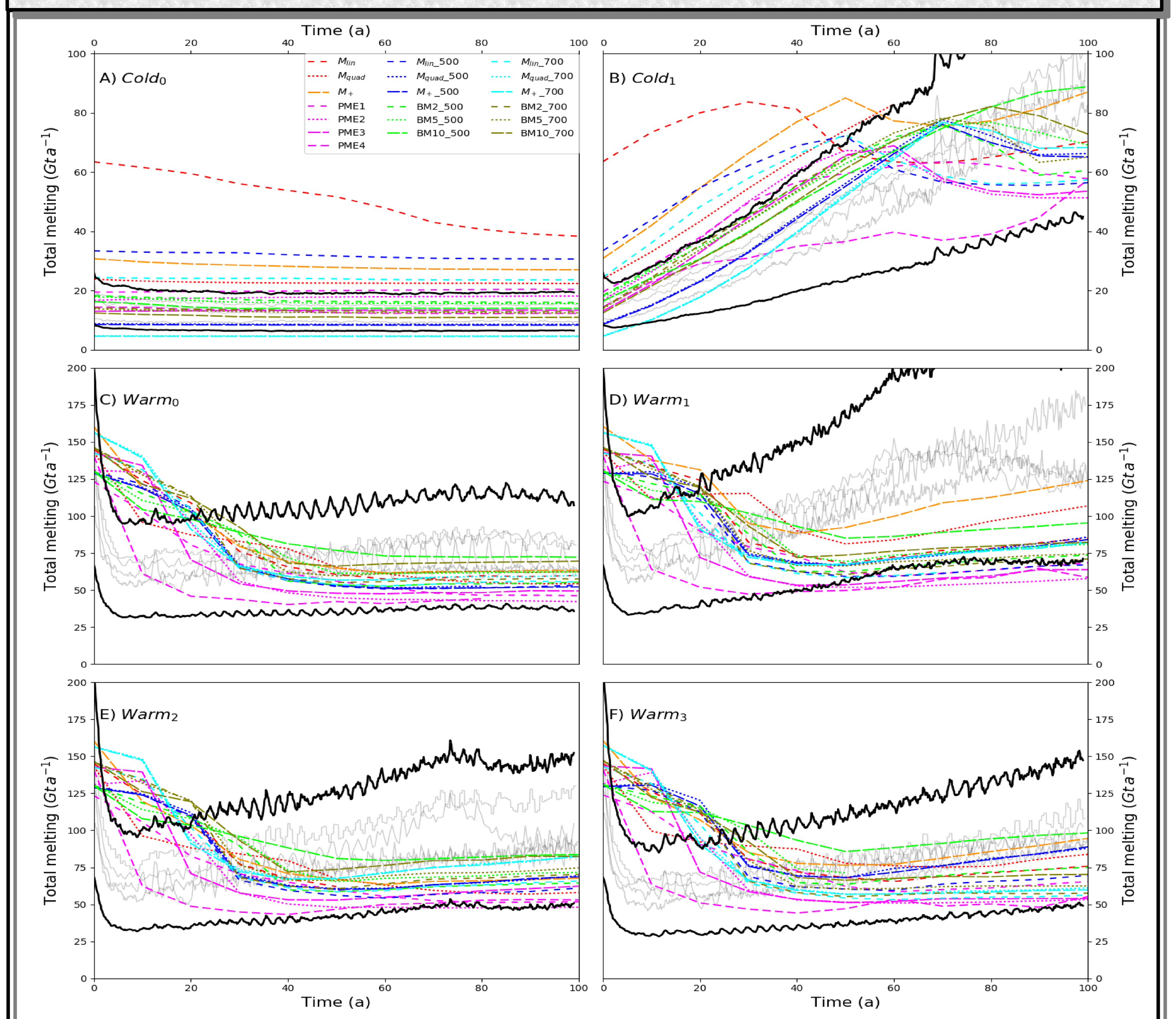
- Stand-alone ice-sheet and coupled configurations are calibrated (done by tuning the α in params) before simulations so they all have similar melt average obtained with the WARM scenario from MISOMIP [8]*

(*some of the calibrated patterns are shown to the right side)

- The targeted melt rates is the average of 4 coupled configurations
- Then the simulations are performed with the various thermal forcings

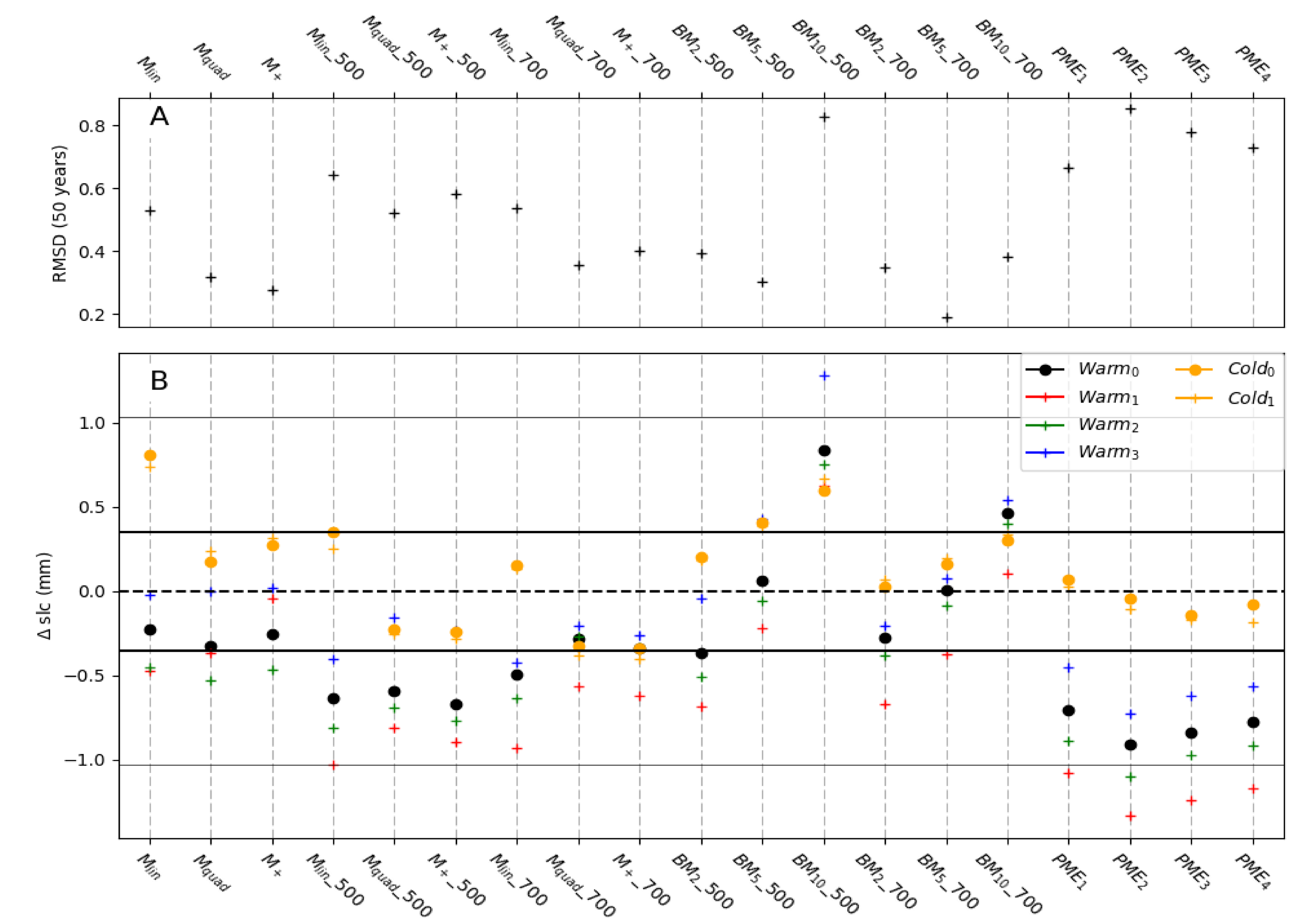


Results: melting over 100 years



Melt rates parameterized in colours, computed by the coupled model in gray (4 members). The 2 thick lines represent under-overestimation of 50 % by the parameterized melt rates

Results : sea level contribution (SLC) after 50 years



Performance of parameterizations compared to coupled simulations. (A) RMSD of SLC with respect to the coupled results average (4 members). (B) Difference between parameterizations and coupled melt rates.

Conclusions

- This study evaluates the performance of sub-shelf melting parameterizations compared to coupled
- The ocean model uncertainties are accounted for through 4 ocean configurations
- Among the simple params, the **M₊ give the best predictions** of coupled results for all scenarios
- The Mlin shouldn't be used any more
- The **Mquad is also good** but slightly underestimates SLC for Warm_i scenarios
- Hypothesising an horizontal circulation (To, So taken at varying depths) in the simple params gives better results in general
- All the 2D plume model emulator implementations underestimate the SLC
- The **box model** gives the best results when used with **5 boxes**.

References

[1] Beckmann and Goose, 2002, OM
[2] Pollard and De Conto, 2012, GMD
[2] De Conto and Pollard, 2016, N
[3] Lazeroms et al., 2018, TC
[4] Reese et al., 2018, TC
[5] Hellmer et al., 2012, N
[6] Dutrieux et al., 2014, S
[7] Spence et al., 2014, GRL
[8] Asay-davis et al., 2016, GMD

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