

## Review Hager et al. 2023

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### **General comment:**

In this paper, Hager et al. address a topic which is extremely relevant for the future sea-level contribution of the Greenland ice sheet (and as such, well within the scope of this journal): evaluating the ability of ISMIP6 ocean thermal forcing parameterizations to predict thermal forcing at tidewater glacier termini. This is accomplished through experiments with the MITgcm, using a set of idealized Greenland fjords and ocean boundary conditions, and parametrised subglacial discharge, glacier submaring melting (IcePlume package) and icebergs (IceBerg package). Sensitivity tests are designed by varying tidal amplitudes, subglacial discharge, iceberg coverage, and bathymetry. Incorporating and assessing the impact of iceberg melting in fjord simulations represents an important innovation, and the approach and methodology used by the authors is sound, although I think some additional clarifications and reorganization are needed in the Methodology section (see minor specific comments below). The authors indicate that the bathymetric control on the intrusion of Atlantic water into the fjords is the primary control on near-glacier thermal forcing, followed by iceberg submarine melting. It is found that grounding line thermal forcing varied by 2.9 °C across all simulations and is heavily dependent on the depth of bathymetric sills in relation to the Polar-Atlantic Water thermocline. The authors highlight that using a simple adjustment for fjord bathymetry, the ISMIP6 submarine melt implementation is able to predict grounding line thermal forcing within 0.2 °C. Finally, Hager et al. introduce new parameterizations accounting for iceberg-driven cooling, which accurately predicted interior fjord thermal forcing profiles in both iceberg-laden simulations and observations from Ilulissat Icefjord. The results are presented in a very clear and structured way, and fully support the authors' conclusions, which are extremely relevant for the ice-sheet modelling community.

In view of this, I recommend this work for publication, and I only have some minor comments which are listed below.

### **Specific comments:**

- 1) It would be good to have some additional text (either in the main text or in the supplementary) explaining the choice on the simulation length and output averaging choice (L96-99). From what I read in the text, I am left with two main questions: (1) why water properties stop evolving after different amount of time in different simulations (2) as simulations are meant to represent a seasonal evolution, it is somehow strange to see they are extended up to 2.5 years. I don't expect this to be a major issue, but it would be nice to see an explanation.

- 2) It is a bit confusing to find the new parametrizations in Table 1 well before they are defined in the text. One simple solution could be to refer to the section where they are introduced in Table 1 (for instance: New Parametrizations (see section xxx));
- 3) I think table C1 should belong to the main text, as it is extremely informative and widely referenced to. Moreover, in Subsection '2.1 Model setup', I found it not immediately easy to have a broad overview of the differences in each simulation. Including Table C1 in the main text would likely be enough, but also some simple text reorganization could be useful (for instance: the total number of simulations is provided only at the end in L134-135);

### **Technical comments/suggestions:**

L29: it could be good to specify/expand to what extent these processes are small scale (spatial and temporal) compared to those in global climate models (and ice-sheet models).

L30: Suggest splitting sentences, e.g., "To date, sea level projections have instead ...".

L31: Maybe 'simplified'?

L32: Suggest 'that are large sources of uncertainty'. Also, 'future mean sea levels'.

L87 and elsewhere throughout the text: Suggest either adding South/North/West/East arrays in Fig. 1, or use different naming (e.g., along fjord, across fjord?) as it is not immediately clear where S/N/W/E are.

L105: Maybe explain why significant tidal mixing was expecting, or add a citation?

L243-245: missing reference to Fig./table? Don't know where percentages come from

L280 and formula 12: not sure if this explanation should be moved to the methods section, similarly as subsections 2.3, 2.4, 2.5.

L319: perhaps something like 'its contribution to the variability of near-glacier...'?

L372: Maybe better use 'Such an approach'? Same for later occurrences.

L462: 'ISMIP6 parametrizations'.

Figure 2: I am confused by the presence of Qberg and Hberg shadings: what are they (Hberg is introduced only later in Fig. 4.), and are they cited in the text? It is ok to keep them, but at least an explanation in the legend is needed. Also, there is a typo in the inbox legend, purple line should read ISMIP6melt & AMmelt.