In this paper, the authors use an ice sheet model coupled to a Gravitation, Rotation, and Deformation (GRD) model to investigate the impact of modeling choices on the retreat of the Thwaites glaciers under warming scenarios. They conclude that resolving the grounding line of the ice sheet model has the strongest impact on sea level change estimation compared to the GRD model and the coupling interval. However, they highlight the importance of including a viscoelastic response of a GRD model with a coupling interval of at least 10 years is needed to prevent an overestimation of Thwaites contribution to sea level change.

I would like to thank the authors for the particular care they took in submitting a manuscript that is well written with a sound layout and methodology, and very nice figures. I would encourage its publication after minor revisions.

I will begin with general comments followed by specific ones.

We thank the reviewer for his positive remarks about our manuscript, its findings and its figures. In the sections below we address each of the reviewer's comment and detail the way in which the manuscript has been modified to incorporate the reviewer's feedback. We sincerely thank the reviewer for his comments, both general and specific, which have noticeably improved the quality of the manuscript.

General comments

I think section 2.1 or the description of the ice sheet models could use additional information.

From what I could read, you do not mention the basal sliding law you are using, nor do you mention whether you are using a grounding line parameterization to diagnose the grounding line. You mention a floatation threshold which is vague. In addition, please add how you are applying ocean melt at the grounding line.

Thank you for this comment, section 2.1 has been modified accordingly, and an Appendix 2 has also been added to provide further details.

I also think that it would be useful to say a few words on how you are performing your model initialization and the dataset you are using for this (e.g., geothermal heat flux, bed topography, …) and at the very least add a figure on the ice sheet initial state (error w.r.t velocities since this is the metric you are choosing) and the drift of your initial state prior to applying the SSP5-8.5 scenario forcing.

Thanks for this suggestion, we have added this information and these figures to the manuscript and Appendix 2.

While the differences in SLIM and PLUS are described, in section 2.1, their differences are fundamental in the rest of the study. For this reason, I would find it useful to have a table in that section summarizing the differences between both allowing the reader not to have to find the detail in the text.

Thanks for this suggestion, we have added this table (table 1) to the manuscript.

In section 2.2, please add a figure of the GRD initial state and the bed uplift drift from the GRD model prior to adjusting the ice sheet model.

Initially, as no ice variation is fed into the GRD model, there is no bed uplift drift of the GRD model. The initial state of the solid Earth is simply the initial bed topography which can be visualized in Fig 1.

I am not sure there is a need for section 2.3. Lines 94-97 belong to section 2.1 and the resolution of the GRD model would fit in section 2.2. In addition, please add whether the ISSM grid is evolving over time or remains fixed throughout the experiment.

We have incorporated section 2.3 into sections 2.1 and 2.2. The ISSM grid does not evolve over time and remains fixed throughout the experiment. We have added this information in Appendix 1 where we felt it was most appropriate.

Line by line comments

Line 9: replace “difference” by increase or decrease.

The abstract has been modified accordingly.

Line 48: does this mean that the ISSM and GRD models have grid nodes in common? If not, please add how you perform the regridding from one model to the other.

Thanks for this comment. This does indeed mean that the ice sheet and GRD models share the same grid nodes. We’ve updated the manuscript to include this information.

Line 50: what do you mean by “SMB parameterization”? In the text you clearly state you are using a climatology form RACMO and forcings from CESM2. These are not parameterization but rather forcing choices.

Manuscript modified accordingly.

Line 65: “2 weeks to capture …” is it really to capture the rapid changes or is it also necessary to avoid a CFL violation? Maybe both?

Thank you for the comment. The 2-week time step was chosen both to capture rapid changes and to satisfy the CFL condition. This is a conservative choice to ensure that time stepping does not interfere with our analysis of other model parameters, such as spatial resolution. Indeed, preliminary tests at project inception showed that longer time steps (1–2 months) had little to no impact on early simulations. We have updated the manuscript to reflect this information.

Line 68: Please explain this sentence further. What do you mean by icecaps outside of the ASE, do you mean around the world or just in Antarctica? (The previous sentence mentions that your grid covers the entire globe.) Also, if your goal is to focus on the ASE, what is the added value of using GRACE’s trends for SMB outside of the ASE as opposed to keeping the SMB to the value used at initialization?

Thanks for this comment. This sentence refers to icecaps around the world (including but not limited to Patagonia, Greenland, High Mountain Asia etc.) The added value of using Grace data is to account for ocean loading due to far-field ice mass change (Gomez 2020), notably in the first few decades of the simulation. The idea was to include any possible effects of present-day rising sea level on WAIS initial stability. In the long-term, contributions from other glaciers are dwarfed by that of WAIS of course. We've modified the manuscript to include this information

Line 89: replace "(Ivins et al. 2020 …)" by "Ivins et al. (2020, 2023) and Lau and Faul (2019)".

Manuscript modified accordingly.

Line 99: what do you mean by "major coupled model components"?

Manuscript modified accordingly to avoid confusion. The major coupled model components referred to those listed in the following paragraph: "GRD effects, mesh structure, basal melt parametrization and SMB forcings."

Line 104: same comment as in line 50.

Manuscript modified accordingly.

Line 194: If by "kilometer scale" you mean ~1km, please rephrase as Leguy et al. (2021) showed that the needed resolution to capture grounding line behavior is model dependent.

The manuscript has been modified accordingly.

Line 200: please replace "twice" by another comparative word (maybe "more"). Until prove such a number, you cannot really claim it.

Manuscript modified accordingly.

Line 237-238: Berdahl et al. (2023) showed that variation in basal sliding laws influences the rate of retreat of the grounding line and, in the presence of GIA, the collapse of Thwaites could be reversed.

Thanks for pointing this paper out, the manuscript has been modified accordingly.

Figures

Fig. 1: the color scale makes it difficult to distinguish whether the bed is below sea level or slightly positive. I would suggest adjusting the scale so that there is a clear transition between positive and negative base elevation. If the colorbar is modified in this figure, it should be modified in Figures A2-A4.

Thank you for the comment. We have adjusted the colorbar so that the transition between red and blue hues now aligns with the transition between bedrock above and below sea level.

References

Berdahl, M., Leguy, G., Lipscomb, W. H., Urban, N. M., & Hoffman, M. J. (2023). Exploring ice sheet model sensitivity to ocean thermal forcing and basal sliding using the Community Ice Sheet Model (CISM). The Cryosphere, 17(4), 1513-1543

Leguy, G. R., Lipscomb, W. H., and Asay-Davis, X. S.: Marine ice sheet experiments with the Community Ice Sheet Model, The Cryosphere, 15, 3229–3253, https://doi.org/10.5194/tc-15-3229-2021, 2021.

Gomez, N., Weber, M.E., Clark, P.U. *et al.* Antarctic ice dynamics amplified by Northern Hemisphere sea-level forcing. *Nature* **587**, 600–604 (2020). https://doi.org/10.1038/s41586-020-2916-2