Author Response to Reviewer #1

Disentangling the drivers of future Antarctic ice loss with a historically-calibrated ice-sheet model

Violaine Coulon, Ann Kristin Klose, Christoph Kittel, Tamsin Edwards, Fiona Turner, Ricarda Winkelmann, and Frank Pattyn
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Reviewer Comment, Author Response, '*changed manuscript text*'

This paper presents a suite of new ice sheet simulations for Antarctica, that explore a range of critical parameters where substantial uncertainty exists. By using an observationally-constrained starting point and a rigorous statistical framework for assessing ensemble members, the authors are able to disentangle the dominant drivers of ice sheet evolution both through time (out to year 3000), and across different sectors of the continent. Their results are consistent with previous findings, in terms of contributions to sea level, but the paper makes a significant advance through its rigorous and multi-parameter approach. The figures are extremely good - both informative and clear - and the text is very well written.

Overall I could find nothing of much substance to comment on. There is a typo ('adressing') at line 114, but this is I think the only one I found. At line 424 I thought maybe the Robel and Banwell paper could be mentioned - in terms of how meltwater ponds might localise. At line 481 I thought maybe a comment about model resolution could be made, and followed up in more detail in the model description Appendix. I for one am not going to argue that a model resolution of 16 km is insufficient for this kind of study - I think it is entirely pragmatic for an ensemble approach like this - but I know that there are others in the community who might like to see more justification for a 'low res' simulation, or at least some evidence that the GL tracks reliably.

But these are minor points. Overall I found this a fascinating and enjoyable paper to read, and it will almost certainly be of great value for future assessments of SLR.

Dear Nick Golledge,

Thank you very much for the positive feedback and for your constructive comments on how to further improve our manuscript. We plan to address your comments as follows:

- We corrected the typo at line 114, thank you for identifying it.
- We included Robel and Banwell (2019) as a reference in the discussion section. We have specified that the influence of cascades of interacting melt pond hydrofracture events, which has been shown by Robel and Banwell (2019) to limit the speed of ice-shelf collapse through hydrofracture processes, has been ignored here. Therefore, our projections may overestimate the risk of surface melt-induced destabilisation.
- With respect to the model resolution, we included the following statement in the discussion (line 481):

  '*As high spatial resolution remains a limiting factor for studying ice-sheet behaviour in an uncertainty quantification framework as presented here, we adopted a 16km* *spatial resolution to allow for ensembles on multi-centennial timescales along with thorough parameter exploration. This relatively coarse resolution is used in combination with a flux condition allowing to account for grounding-line migration (as discussed in Appendix A). However, while our grounding-line migration may work effectively with coarser resolutions, it is important to note that smaller bedrock irregularities and pinning points (Morlighem et al., 2020) may well be overseen with this approach.'*

In addition, building upon your suggestion, we have introduced the following discussion regarding our use of a flux condition to account for grounding-line migration in Appendix A (line 538). The discussion is accompanied by a new figure (S12 in the supplementary material, shown below), which presents the results of the MISMIP+ Ice 1 experiments (Cornford et al., 2020) with Kori-ULB at different spatial resolutions (1, 2, and 4-km) with and without (at 2 and 4-km resolutions) the flux condition to determine grounding-line migrations.

'Similarly, we find that applying a heuristic rule or parameterisation for the flux across the grounding line (Pattyn et al., 2017) passes the test of being able to maintain a steady state with the grounding line located on a retrograde slope due to buttressing (MISMIP+; Cornford et al., 2020, see Figure S12). In addition, it produces responses to the loss of the buttressing within the range of other ice-sheet models (using different ice-flow approximations), even at coarser resolutions (Figure S12; see discussion in Pollard and DeConto, 2020). Furthermore, multi-model ensemble estimates of future ice sheet response within ISMIP6 (Seroussi et al., 2020; Sun et al., 2020) clearly demonstrate that the overall behaviour of Kori-ULB (previously f.ETISh) is in line with results from the high-resolution models that participated in the ensemble.'

We hope that these will constitute sufficient evidence that the grounding line tracks reliably and is within the range of other models using different ice-flow approximations.

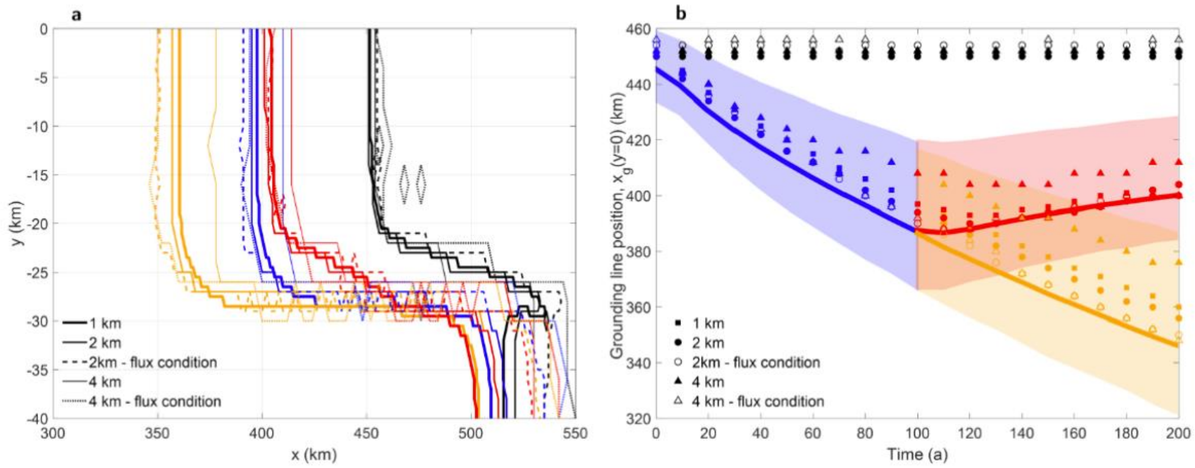
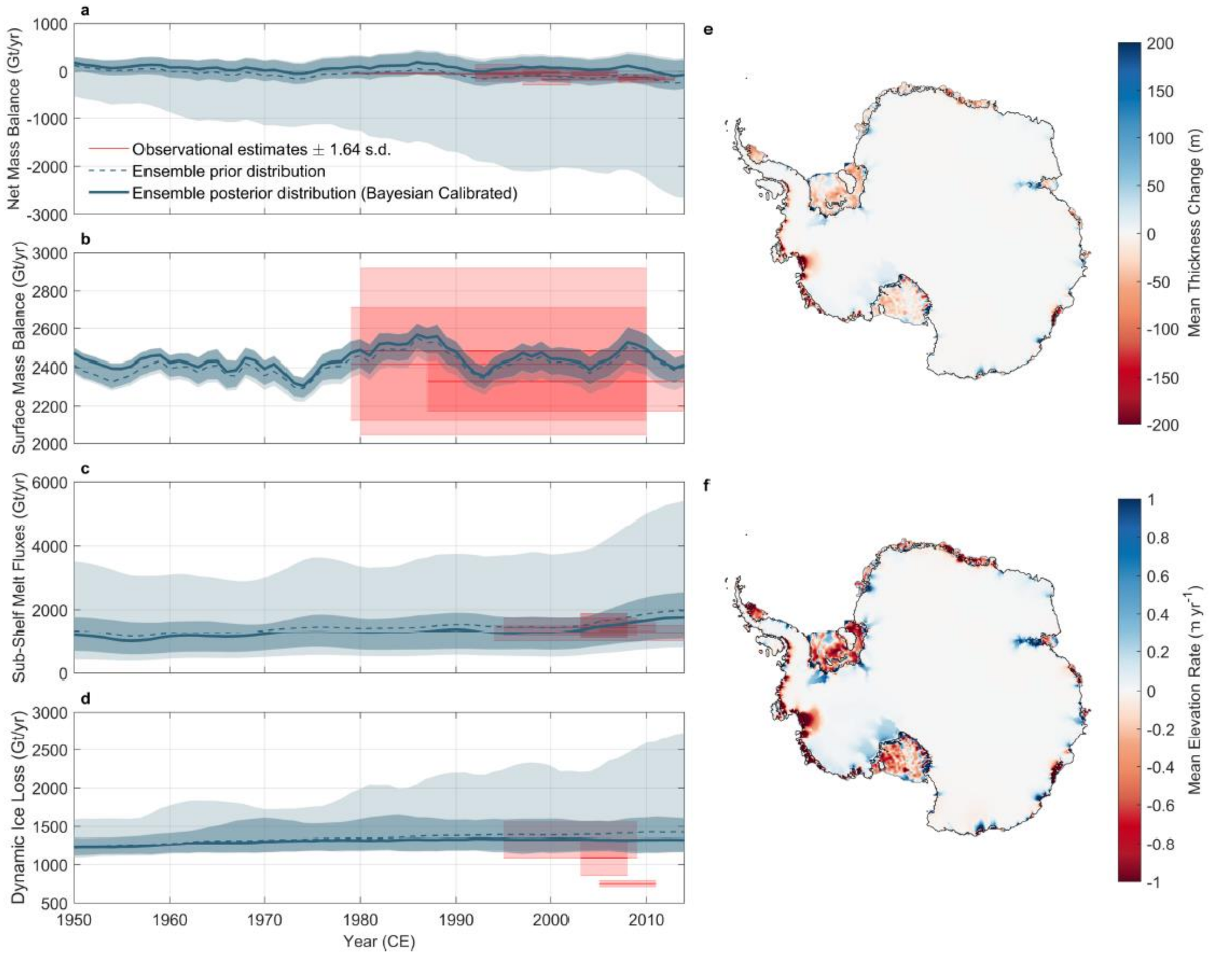


Figure S12: **Grounding-line positions for the MISMIP+ Ice 1 experiments with Kori-ULB**. (a) Final grounding-line positions at the end of each step of the Ice 1 experiments within the MISMIP+ ice stream domain, which is a rectangular domain spanning 640 km in the x direction and 80 km in the y direction. Ice flows in a direction roughly parallel to the x axis (with a mirror symmetry in the lateral center of the ice stream – midchannel position is at $y = 0$). (b) Midchannel grounding line positions plotted against time for the Ice 1 experiments. A retrograde bed slope is observed between $x = 400$ and $x = 500$ km. All experiments are run at different spatial resolutions (1, 2 and 4 km), and with (at 2 and 4-km resolution only) and without using a flux-condition to determine grounding-line migrations. Black curves and symbols correspond to the Ice 0 (control) experiment. Blue curves and symbols correspond to the Ice1r experiment (melt-induced retreat). Red curves and symbols correspond to the Ice1ra experiment (no melting readvance). Finally, yellow curves and symbols correspond to the Ice1rr experiment (further melt-induced retreat). More information on the experiments setup and the domain are provided in Cornford et al. (2020). Lines and shaded regions in (b) show the envelopes for the 'main subset' of MISMIP+ models, copied from Cornford et al. (2020, their Fig. 7a).

In addition to the above, we would like to draw your attention to a correction made to Figure 1. We initially displayed the ensemble mean and standard deviation while our intention was to present the median and 5-95% probability interval. The revised version of the manuscript includes the corrected figure (shown below).



Finally, we would like to inform you that the data acknowledgement section has been updated as follows to provide a Zenodo link (10.5281/zenodo.8398772) that grants access to the simulations outputs and associated scripts:

'*The code and reference manual of Kori-ULB ice-sheet model are publicly available on GitHub via https://github.com/FrankPat/Kori-dev. The specific Kori-ULB model version used in this study, the simulations outputs and the scripts needed to produce the figures and tables, and the scripts are hosted on Zenodo (https://doi.org/10.5281/zenodo.8398772). All datasets used in this study are freely accessible through their original references. The CMIP6 forcing data used in this study are accessible through the CMIP6 search interface (https://esgf-node.llnl.gov/search/cmip6/). The MAR outputs used in this study are available on Zenodo (https://doi.org/10.5281/zenodo.4459259; Kittel et al., 2021)*'

Best regards,

Violaine Coulon, on behalf of all co-authors.

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