Editor

I have received two review reports from the referees and am pleased to tell that the referees are generally satisfied with your responses to the referee's earlier concerns. However, both referees suggest that the manuscript can be much more improved, which I fully agree with.

Anonymous Referee #1 suggests that a paragraph (L. 125 ~ 136), where your subsurface models are introduced, is a bit difficult to follow. The referee raises some important points that should be clarified in your revised manuscript. So, please consider the comments carefully, and revise the manuscript to improve readability.

Anonymous Referee #2 points out that "The high runoff rates for the downscaling of EC-EARTHv3 in Antarctica" suggests there is a (not minor) compensating error in simulating AIS SMB with your model chain. Can you justify that this point does not affect the scientific arguments of this paper?

Please attend to these important issues carefully and revise the paper accordingly. In addition, both referees have provided some useful comments and suggestions to improve the quality/readability of this paper. Please also consider them.

Reply: We agree that the paragraph on lines 125-136 is difficult to follow. We have added text to make it clearer. Also, we have added text to the paragraph dealing with the very high runoff values for the EC-Earth3 downscaling. The scientific argument of the paper is that the change in temperature for the end-of-century high emissions scenario is higher in the EC-Earth3 downscaling compared with the EC-Earth2 downscaling for both Greenland and Antarctica. This difference in temperature change leads to a negative value in the δΔ(SMB) (rightmost column in Table 2). The positive temperature bias for Antarctica in EC-Earth3 is indeed giving very high runoff rates and precipitation amounts but, as seen in Table 2, is not affecting the sign of the δΔ(SMB) value. We have added this information to the discussion section. The other reviewer comments have also been addressed.

Anonymous Referee #1

Overall, the manuscript is much improved over the first and second submissions. The vast majority of reviewer questions/comments have been adequately addressed and the manuscript is now much more thorough and stronger. The authors make it clear why they use only the EC-Earth models from the vast GCM options in CMIP5 and 6. They provide more justification, including an interest in how a cold bias in the CMIP5 version, which was resolved in the CMIP6 version, has an impact on the SMB. Further, they provide more information about why the timings are different between Greenland and Antarctica. They also provide justification for the spin up times, and attempt to clarify the subsurface offline model (although I am still a little confused by this paragraph). Whilst I had no problem with the choice of RCM used, the additional information included to satisfy the other review is a welcome addition to the manuscript too. The authors also provide more regional specifications and have updated their citations based on the time between initial submission and now. I would like to thank the authors for their hard work in each rendition of the manuscript, I hope they also see that it has improved the manuscript and strengthened their work.

I have only very minor suggestions (technical mostly) now and would therefore be happy to recommend it for publication. I address the small issues below:

Minor:
Line 125-136: I am still confused by the subsurface model paragraph. Whilst you attempt to justify why you use it for some of the runs but not others, I am still not sure where the experiment differs and why. I think it may be due to the words 'model output' being used a few times, but I am not sure which model this refers to: HIRHAM, EC-Earth or the Subsurface model. In the previous version, it seemed like you used the subsurface offline model only for Greenland, but now it reads like both locations use it. Is this correct? I think with a re-write, it should likely be solved, so I recommend technical corrections.

Reply: Yes, in the first version we only used the offline subsurface model on the Greenland runs, but then we added a subsurface model to the Antarctic runs in the second version. The main difference in the current version is that an offline spin-up for the built-in HIRHAM5 subsurface us applied for the Greenland runs before the 20 year HIRHAM5 runs are performed; while this is not done for the Antarctic runs since this spin-up routine is not available for the Antarctic domain. The offline stand-alone subsurface model, which is run subsequently using the HIRHAM5 output, includes however a spin-up procedure and is performed on both domains. We have added information to the paragraph.

Technical:
Ln 88: change 'in estimating' to 'when estimating'

Reply: Done

Line 125: Move this first sentence to line 120 (approx.) as I was confused why the dates varied by 1 year in section 2 (line 115-121) until I read this line.

Reply: Done

Ln 197: AIS hasn't been defined before- I would not use an additional abbreviation in this sentence when you already have so many. Similarly, ERA-I was before called ERA-Interim (Ln 190), but from now on you use ERA-I. Make a decision on which to use.

Reply: We have changed to ERA-Interim and replaced AIS with Antarctic Ice Sheet in two places.

Ln 275: perhaps write out the dates here, as I wasn't sure which reference period you relate to, especially when they vary by location.

Reply: We have added the reference periods for the GCM driven runs and the periods used for the ERA-Interim driven runs.

Anonymous Referee #2

I'm really glad to read that the authors have addressed most of the reviewers' comments and I would like thank the authors for their efforts. There is still an important, major discussion lacking though on the downscaled SMB components for HIRHAM5 runs over Antarctica (see below), after which the paper would be ready for publication in my opinion. Although the SMB results are indeed in the range of other current estimates, this is not the case for individual SMB components, which suggests that good results are obtained for the wrong reasons. The high runoff rates for the downscaling of EC-EARTHv3 in Antarctica are of particular concern, and may have for instance strong consequences for risk assessment of ice shelves vulnerability. Please expand more on these values. More minor comments are reported below.

L62-64: Please expand briefly in the text on the information brought by these evaluations about the performance of EC-EARTHv2&3 relative to others CMIP models.

Reply: We have added text on the CMIP5 evaluation.

L70-72: This is incorrect. Mass is lost by the ice sheet when the ice flows through the grounding line and becomes afloat. Since ice shelves are already floating terminations of glaciers, occurrence of melting below the ice shelves and/or thinning of ice shelves has an indirect consequence on mass loss through ice sheet dynamics (by triggering the retreat, acceleration and drawdown of marine-terminating glacier) but do not contribute directly to the mass balance in the way suggested here. Please rephrase.

Reply: We have changed the text and added a few sentences here.

L93: I know what you mean here, but strictly speaking this is another shortcut that could be avoided, as melt is not part of the SMB. If all melt refreezes, like in Antarctica, there is no direct link between surface ablation and melt. I suggest to replace with something like "leading to large meltwater runoff amounts" or equivalent.

Reply: We have changed the sentence.

L199-200: This is correct for the SMB, but as a result of a very different balance between its components.

Reply: We have changed the sentence to make this clear.

L283-288: This is where I suggest that your results are in significant disagreement with the literature and here I would call for a more complete comparison with other state-of-the-art estimates of individual SMB components (see Lenaerts et al., 2016; van Wessem et al., 2018; Kittel et al., 2021). The average (1971-2000) ice-sheet integrated runoff values of the EC-EARTv3 downscaling of 854 Gt yr-1 with 593 yr-1 for the ice shelves (Table 2 in the revised manuscript) deserve particular attention. These numbers given for the present climate state are even higher than the average values projected for the end of the century under ssp585 for the warmest ESM in Kittel et al. (2021). More than 3000 Gt yr-1 of projected RU for the AIS by the end of the century is also very high. Moreover, I'm not sure it relates exclusively to a positive temperature bias in EC-EARTH since HIRHAM5 driven by ERA-I already yields high runoff rates (172 Gt yr-1 over the present period, which would correspond to the meltwater fluxes in other RCM estimates, i.e., implying that the whole melt amount runs off entirely). In this reference run, high runoff rates are partly compensated by high snowfall rates in the uppermost range of the whole RCM ensemble (Mottram et al., 2021). Please comment on all of this.

Reply: We have added text to this paragraph highlighting the issues with very high runoff numbers using HIRHAM5 and also downscaling EC-Earth3.

L364-366: The absence of uncertainties associated with your average values complicates a bit the comparison, but as far as I can read in Kittel et al. (2021) (their Table 1), the highest of the 4 future runoff anomalies amounts to 260 Gt yr-1 for the grounded ice, which differ by much more than 150 Gt yr-1 from the HIRHAM5_EC-EARTH3 future anomaly of 1094-261 = 833 Gt yr-1 reported here. Could you give more details on your calculation?

Reply: We believe there is a misunderstanding here. We are saying that the model mean grounded ice runoff anomaly in the Kittel study is about 150 Gt yr-1 (we simply took the mean of the 4 values) and that this mean anomaly is far less than the runoff from our Ec-Earth3 downscaling. We have changed the sentence to make this clearer. We have also updated our reference of the Kittel study.

Kittel, C., Amory, C., Agosta, C., Jourdain, N. C., Hofer, S., Delhasse, A., Doutreloup, S., Huot, P.-V., Lang, C., Fichefet, T., and Fettweis, X.: Diverging future surface mass balance between the Antarctic ice shelves and grounded ice sheet, The Cryosphere, 15, 1215–1236, https://doi.org/10.5194/tc-15-1215-2021, 2021.

Mottram, R., Hansen, N., Kittel, C., van Wessem, J. M., Agosta, C., Amory, C., Boberg, F., van de Berg, W. J., Fettweis, X., Gossart, A., van Lipzig, N. P. M., van Meijgaard, E., Orr, A., Phillips, T., Webster, S., Simonsen, S. B., and Souverijns, N.: What is the surface mass balance of Antarctica? An intercomparison of regional climate model estimates, The Cryosphere, 15, 3751–3784, https://doi.org/10.5194/tc-15-3751-2021, 2021.

Lenaerts, J.T.M., Vizcaino, M., Fyke, J. et al. Present-day and future Antarctic ice sheet climate and surface mass balance in the Community Earth System Model. Clim Dyn 47, 1367–1381 (2016). https://doi.org/10.1007/s00382-015-2907-4

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