A review of « Investigating the multi-millennial evolution and stability of the Greenland ice sheet using remapped surface mass balance forcing », Rahlves et al., 2025.

Rahlves and co-authors present a new method to account for the melt–elevation feedback without requiring full coupling between atmospheric and ice sheet models over Greenland. This alternative to computationally expensive coupling directly modifies the SMB forcing fields within CISM to adapt them to year-by-year changes in surface elevation. This method, referred to as SMB remapping, is evaluated against other approaches commonly used in the literature over both short (centennial) and long (multi-millennial) time-scales. After comparing its performance with existing methods, the authors include the representation of glacial isostatic adjustment in simulations using the approach they consider most robust for capturing melt–elevation feedback. They also compare projections driven by SMB fields derived from various emission scenarios across different ESMs. In conclusion, SMB remapping proves to be a valuable approach for accounting for melt–elevation feedback, as it reduces biases and uncertainties associated with conventional parameterizations and better represents the structure of the ablation zone in projections.

This method is original and appears promising. It will likely be employed in future studies. The manuscript is well written and well structured. I recommend accepting the paper with only minor revisions, as outlined in the comments below.

Main comments

- From a general perspective, I recommend providing more detail in the Experimental setup section. Although the authors reference other papers for different part of the method, the originality of this study relies on the methodology itself, so it is essential to describe it as clearly as possible. See the minor comments, but feel free to go beyond them to improve clarity. For instance, I also suggest including a figure to illustrate the 4 methods used for considering the feedback. This section could also be made more consistent in the description of the different experiments, for example, by standardizing the variable names in the equations (see minor comment).
- The discussion is already well developed, but I recommend addressing these few following points:
    - Discuss the influence of the differences in initialed topography for CISM and MAR topography (on which the SMB is computed).
    - NorESM and other ESMs used do not account for evolving ice sheet topography. This could be a source of uncertainty as changes in topography of the ice sheet may influence large-scale climate circulation. What would be the potential influence on your results?

- On shorter time-scales, depending on the ocean conditions considered here (see minor comment), are there any uncertainties to mention? As the atmosphere warms and changes, ocean conditions also evolve. This may affect the mass loss of the ice sheet, and I guess this could add some uncertainties to the results obtained here, as far as ice sheet is not completely retreated inland.

Minor comments

L40: "Simplified physics" for atmosphere ocean and land/polar surface processes?

L120: How CISM considers icebergs and their contribution to the total mass balance?

L120: Could you precise what CISM is considering for ocean conditions?

L142: MAR v3.12 (Fettweis et al., 2017) → more recent reference actually using MARv3.12: Lambin et al. (2023)

L142: As I guess MAR didn't run on CISM 4km grid, did you receive the SMB and ST products from MAR already interpolated on the CISM 4km grid? If not, could you precise how did you interpolated it on the 4km grid? And I guess that this interpolation is the first step before using it to calculate your SMB anomalies and remapped SMB? Precise if necessary.

L145-146: "Outlet-glacier retreat is prescribed via retreat masks up to 2100, after which the mask is held fixed." Does it mean that the ice sheet is retreating with a constant rate after 2100? Please clarify here.

L141-147: When saying that the mean value is repeated, I guess you're talking about the SMB values used as forcing for the ice sheet model. Please clarify.

L160: Could you also specify to what you refer with SMB_ref_ERA5 ? I guess it's the annual mean SMB for the reference period (1960-1989) from MAR-downscaled ERA5 SMB.

L163: An extra figure illustrating all your 4 methods could be interesting to well understand how these 4 methods are working, and what's common or different between them.

L168: If I understand well, SMB(h_fixed) = SMB_ESM(t) from equation (2). If these 2 variables are referring to the same thing, could you rename with the same name? This way, it could be easier to compare methods.

L176: I would add "total" or "full-SMB" (+ and anomalies remapping) in this title to be clearer and not be confused with the title of point 2.3.4. Or call it remapping method.

L222: As you used the mean SMB 2180-2100 to extend your simulations, I guess you also used a same lookup table from 2100 to the end of your simulations? If yes, could you

precise it in the text as well as if it's a "mean lookup table" of 2180-2100, or the one in 2100,...? Otherwise, could you detail what's used after 2100?

L229-231: As I'm not sure to well understand how exactly you interpolate the SMB values from the lookup table with the new elevation of the model (and the basin classification), could you be a bit more specific for the points 2 and 3?

Figure 4: It could be useful to display the SMB differences here instead of in the Appendix. Differences are more visible. You could perhaps merge both Figure 4 and A1 into one and refer to this one in your Appendix. Because you're describing these differences in an entire paragraph (L268-274).

L278: I guess you didn't remove any drift of your model of these results. But, if you have quantified it, could you mention it and compare it to the differences you obtained here (3.4Gt) when explaining that this value is smaller than the uncertainty of your model, or detail this uncertainty?

L375-376: "The runs suggest that any eventual ice sheet stabilization is highly sensitive to both the emissions pathway and the choice of ESM." I suggest also to add, here, or in another paragraph talking about the RCM, that it's also dependent of the RCM used to downscale ESM's climate and "translate" it into SMB.

Typo

L54: "extending to the year 2300" → 2200.

L67: "of of the ice sheet" → of the ice sheet

L129: (Broeke et al., 2009) → (Van den Broeke et al., 2009), same in the reference list.

L138: (see Fig. 6 in Rahlves et al. (2025)) → (see Fig. 6 in Rahlves et al., 2025).

L411 : «adaptability of of » → adaptability of

References

Lambin, C., Fettweis, X., Kittel, C., Fonder, M., & Ernst, D. (2023). Assessment of future wind speed and wind power changes over South Greenland using the Modèle Atmosphérique Régional regional climate model. International Journal of Climatology, 43(1), 558–574. https://doi.org/10.1002/joc.7795