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The Cryosphere Discussions

Interactive comment on "Remapping of Greenland ice sheet surface mass balance anomalies for large ensemble sea-level change projections" *by* Heiko Goelzer et al.

Anonymous Referee #3

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As part of ice sheet model intercomparison efforts, participating modeling groups utilize forcing fields such as anomalies of the surface mass balance (aSMB). These anomaly fields are constructed under the assumption that the ice sheet geometries (extent and surface height distribution) between the model and the reference are identical. If the geometries differ substantially, some remapping of the forcing fields is necessary to minimize unrealistic forcing. The authors present a compact and new procedure to remap atmospheric forcing fields, and they apply it to the Greenlandic ice sheet exemplarily.

The ice sheet is divided into sectors, which resemble here drainage basins of the ice

sheet. For each sector, they construct a lookup table of the actual aSMB and the (ice) surface elevation for defined elevation intervals from bottom to the top. The final lookup table contains the elevation-aSMB relationship for each basin. During the remapping, the applied relationships of the actual and neighboring basins are weighted according to their distance to the point of interest. The actual ice sheet elevation defines for each grid point the remapped forcing field. If this remapping is performed for all time steps, also transient aSMB fields could be remapped.

The authors show that the procedure works reasonably well for the trivial case, where the forcing field is remapped to the original reference topography. They also derive the influence of a temporarily evolving ice sheet elevation on the applied aSMB. Ultimately, they apply the procedure to model results of the initMIP exercise (Goelzer et al., 2018), where they analyze the formerly strongly diverging sea-level contributions of different models. These sea levels come closer together because the influence of the partly substantial different horizontal extent of the simulated ice sheets is corrected.

The manuscript is well-structured and written. I consider the reporting of scientific/technical procedures as important because they will help us to enhance the reproducibility of results and allows us to compare and understand diverging results. I recommend accepting this manuscript after minor revision.

1 General comments

The manuscript is well written and leaves only room for very few suggestions. The main assumption is the already mentioned strong dependence of the surface mass balance (SMB) with elevation. For the ablation part of the SMB, this is clear considering the strong relation between elevation and the near-surface air-temperature, where the latter could be understood as a proxy for melt potential. However, the same does not necessarily apply for the accumulation as part of the SMB. Could this difference disturb

your procedure? If yes, under which circumstances does it occur?

In some basins, you detect a substantial spread in the constructed primary lookup table (mid-east, south, north-west). Does a larger spread indicate that a further division of this section should be performed? Can you provide a criterion, that helps to weight the benefits of smaller basins and potentially smaller spread versus larger basins and larger spread?

You checked the sensitivity of ds_{norm} for values between 50 km and 125 km and haven't found a strong dependence. What happens if ds_{norm} reaches the grid resolution of the ice sheet model (dxi_{sm}): $ds_{norm} \longrightarrow dx_{ism}$? Do you detect beside discontinuities at the boundaries of the basins any other problem? What happens when the generally coarse grid of a driving global atmosphere model (resolution: dx_{atm}) is used, where we easily reach: $ds_{norm} \longrightarrow dx_{ism}$? This analysis may help to explain what happens if we drive the ice sheet directly with the output of global atmosphere models.

In the derivation of the SMB-height feedback, I have found the part (page 14) between lines 19 and 22 (incl.) confusing. May you move it into the supplement and refer to it for the interested reader, while the following "alternative" method becomes the main method.

The results of section 4.3 (“Application to a large ice sheet model ensemble”) suggest that the correction (Figure 12c) is larger for models with a bigger initial sea-level contribution and ice-sheet extent. Have you tried to analyze the relation between $\frac{A-A_{ref}}{A_{ref}}$ and Δz_{sl}, where A_{ref} and A are the reference and actual ice-covered area in each model, respectively, and Δz_{sl} is the sea-level difference (Figure 12c)? Please, at least add this figure to the supplements?

2 Specific comments

2.1 Text

Page 3, Line 10 What does "similar" actually mean? Please, clarify.

Page 4, Line 13 What happens if you use the mean instead of the median?

Page 4, Line 23 You may want to be more generic by replacing the "climate model's surface elevation" with the "reference field's elevation"?

Page 6, Line 1 I guess I understand you, but the sentence is not entirely clear. Please rephrase.

Page 8, Line 8-9 Here you state that the basins 7–9 have the largest mismatch. What is the reason behind?

Page 9, Line 15 Do you mean "where the modeled ice sheet is smaller (e.g. Basin 16, Figure 7d)"?

Page 16, Line 1 Please provide a citation for ocean area of $3.618 \cdot^{14}$ m^2?

Page 17, Line 12 The relationship is nearly uniform in each sector's center. You may clarify this if you think it's necessary.

2.2 Figure

The figures show in general the main features. However, some lines are hard to recognize, because they are too thin. Please check the figures.

Figures 5, 7, 10, and 11: In some of these figures, small deviations are hard to notice because the color around small deviations is white or gently yellow or light-blue. Would it be possible to use a color-bar, where either the deviation around zero is not white or, alternatively, mark the ocean with a light-gray color, for instance? If the ocean would be gray, you do not need to add a contour line to represent to coast.

Figures 5 and 7: The red contour lines are barely seen. Please thick the lines and mention its purpose in the related figure captions.

Figure 3: Please mention the meaning of the lower-right labels (basin number as defined in figure 2) in the figure caption.

Figure 8, Subplot b: It's hard to see if "extended-original" is as large as "remapped-extended?" Please replace "remapped-extended" with "extended-remapped."

Figure 9: Mention that each subfigure's title indicates the basins as defined in figure 2. The lower right subfigure is smaller due to the color-bar. Could you improve it? For example, by moving the color-bar to the right or below the group of subfigures.

Figure 10, Subfigure a) and b): Since the interior of Greenland shows only pale colors, you may add the zero contour line to guide the reader. If so, please mention the zero-contour line in the figure caption.

Figure 11: Since the interior of Greenland shows only pale colors, you may just add the zero contour line to guide the reader.

/sectionBibliography Goelzer, H., Nowicki, S., Edwards, T., Beckley, M., Abe-Ouchi, A., Aschwanden, A., Calov, R., Gagliardini, O., Gillet-Chaulet, F., Golledge, N. R., Gregory, J., Greve, R., Humbert, A., Huybrechts, P., Kennedy, J. H., Larour, E., Lipscomb, W.

H., Le clec'h, S., Lee, V., Morlighem, M., Pattyn, F., Payne, A. J., Rodehacke, C., Rückamp, M., Saito, F., Schlegel, N., Seroussi, H., Shepherd, A., Sun, S., van de Wal, R. and Ziemen, F. A.: Design and results of the ice sheet model initialisation initMIP-Greenland: an ISMIP6 intercomparison, Cryosph., 12(4), 1433–1460, doi:10.5194/tc-12-1433-2018, 2018.

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