

REVIEW#2

This is the author's reply to RC2. We kept the general comments from the referee in original and added answers for each aspect directly below in blue.

The detailed comments will be addressed when preparing the revised manuscript.

In this paper, the authors analyze the first NorESM simulation including an interactive Greenland ice sheet model. The authors indicate a minor impact of interactive model on the global climate dynamics simulation. They do find differences in Arctic climate by 2100 and a large impact of the elevation-melt feedback on the overall ice sheet mass loss

Thank you for this summary and detailed feedback! We see the manuscript improving by including and addressing your comments.

General comments

The results are very interesting since there are very few examples of this type of coupled ice sheet-climate simulations. However, the analysis of results is difficult to follow as there are too many loose numbers in the text – these could be presented in tables instead – and with inconsistent metrics – sometimes ranges or extremes are presented, sometimes mean values with standard deviations -. The paper would benefit of some assessment of statistical significance of the differences between simulations (e.g, Figure 2), as well of (attempt of) explanations of these differences.

Thank you for this comment. We will go through the text and make the numbers more coherent. We only have three simulations and mainly compare time periods of 20yr means. We will try to include significance where it is possible and meaningful.

In the conclusions, the authors highlight how their results differ as those from previous work from EMICs. It would be interesting that the authors provide more detail on that.

EMICs differ from GCM in resolution and in complexity of parameterized processes. It is outside the scope of this study to analyze and discuss why the results are different. We can add information about the general differences in model complexities in the text.

The design of the simulations needs some more clarity, taking some parts of the model description (submitted) here where they are relevant to explain the results. For instance, Figure 2 does not provide information about initial NorESM2-NorESM2fixed (temperature, surface elevation) differences (for a pre-industrial or 1850 climate). Also, the treatment of meltwater fluxes in the “fixed” simulation is not clear; perhaps these fluxes could be compared in the manuscript.

We will consider adding information from the model description where it improves clarity. However, we would like to minimize repetition if possible (these variables are discussed in Goelzer et al., (Disc.))

Title and main conclusion

The title can be misleading, as it refers to “Limited global effect of climate-Greenland ice sheet coupling (...)”. The conclusions rather refer to the limited effects of Greenland ice sheet change on the global climate. In the title the word climate is first, and the coupling could be uni-directional (“one-way”). Therefore, the title can read as if climate change does not affect Greenland or global sea levels when both climate and ice sheet are modelled together within NorESM ... In general, I would highlight more the added value of the coupling

in title and conclusions, e.g., along the lines of mapping climate and (land, sea) ice change with a single model that permits to establish direct connections within the Earth System. This is an interesting point. We are considering changing the title to avoid misleading information. At the same time it is important to not generalize our findings and state that there is never an effect of the added Greenland ice sheet component to the climate. It might just be NorESM or this particular setup.

Figures

Please add statistical significance. I suggest increasing the size, e.g., until at least page width. For Figure 2, it would be interesting to zoom in on the Greenland area/high latitude differences, and to relate with elevation differences.

We can unfortunately not increase the figure size due to the journal's style guidelines.

Figure 7 tries to show the elevation and resulting SMB changes. We don't see the value of adding a zoom in SAT figure to the manuscript.

Results

Please introduce the structure of this long section. Also, consider adding numbered subsections. The differences in Arctic climate in the *fixed versus coupled simulations are a very interesting result, it would be great if the authors could go into more depth there.

This is a very good suggestion. We will structure this section better with more clear headers and will add a few more sentences to explain this.

Table 1 – please add standard deviations. Can you indicate which of the coupled versus fixed differences are statistically significant?

We will try an analysis of the table and see if there is significance, to put the numbers in bold and if there isn't any, to add a statement about this in the caption.

Line 146 Figure 1d seems to show a trend for the pre-industrial simulation? Can you quantify this and comment on it?

The trend is a desired effect of the initialisation: to reproduce an observed mass loss over the historical period. This is described in some detail in Goelzer et al., (Disc.). We will add a short description to clarify that.

Line 148 I don't see a graph or table in support of the global SST analysis

Lines 200-212: precipitation, is there a figure/table in support of "staying the same"? Also, numbers in the text can be replaced by a table.

This is similar what reviewer#1 added: we are considering adding a figure for precipitation. Figure 4 is already showing spatial comparisons of SST.

Greenland ice sheet changes:

There is not much analysis of surface mass balance or energy components here, is there any reason not to do this?

Thank you for this comment. There is already an evaluation of the SMB in the companion paper Goelzer et al., (Disc.) and we did not see an additional value to the story of our manuscript by including a detailed analysis of SMB and energy here. Further, this would only pertain to the coupled experiment and not to the comparison of NorESM and NorESMfixed, which is your focus in this paper.

Please increase size and add elevation contour lines to Figure 7, to illustrate changes in equilibrium line altitude. Perhaps interesting to add a figure/table with evolution of the mean equilibrium line altitude? (can be calculated from the ablation area % and the function of cumulative area below a certain elevation, or “hypsometric curve”)

Given the fixed figure sizes in Earth System Dynamics, the only way to increase the size of individual panels is by changing their order. We prefer not to do that because the current setup follows a certain logic that we believe is important to keep.

The subplots show mainly SMB anomalies. Adding the ELA would likely add to confusion, because the ELA would be based on the absolute SMB, not the SMB differences shown in the Figure 7. Further, a detailed discussion of the SMB is not the scope of this manuscript: to compare differences between coupled and uncoupled experiments. However, a detailed SMB discussion that you would like to see can only be done for the coupled simulation. A more detailed analysis is done in Goelzer et al., (Disc). We can add a comment referring to that paper for the interested reader.

Figure 7h: there seems to be a strange “corner” along the equilibrium line altitude, do you know what causes this?

We cannot identify exactly which strange corner you refer to. In general, there are a few visible artefacts in some of the figures that are due to the downscaling and possibly the anomaly calculations.

We did not reply to minor comments here but will include and address them in the revised manuscript.

References:

Goelzer, H., Langebroek, P. M., Born, A., Hofer, S., Haubner, K., Petrini, M., Leguy, G., Lipscomb, W. H., and Thayer-Calder, K.: Interactive coupling of a Greenland ice sheet model in NorESM2, EGUsphere [preprint], <https://doi.org/10.5194/egusphere-2024-3045>, 2025.