The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
https://doi.org/10.5194/tc-2021-140-RC2, 2021

Comment on tc-2021-140

Anonymous Referee #2

Referee comment on "Uncertainties in projected surface mass balance over the polar ice sheets from dynamically downscaled EC-Earth models" by Fredrik Boberg et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-140-RC2, 2021

General comments

This paper presents projections of the surface mass balance (SMB) of the Greenland and Antarctic ice sheets produced with HIRHAM5 driven by two versions of EC-Earth that took part of the CMIP5 and CMIP6 exercises. Diversifying projections of ice sheet SMB is crucial for a better assessment of the uncertainties related to different members, emission scenarios, or global and regional model biases. While the paper fits well within this scope, in too many places the methodology and analysis still look insufficiently documented to consider publication without major revisions. Considerable improvements compared to the previous version of the manuscript have to be acknowledged for some parts of the paper. However, important comments have also not been taken into account and serious issues persist. Particularly, of major concern are the absence of justification of the chosen GCM and reference periods (in line with RC1), and the incomplete evaluation of the downscaled climate and SMB using HIRHAM5, all already noticed in previous reviewers' reports. Diversity in models is always beneficial, providing that the models perform adequately and are appropriately evaluated. In that sense I encourage the use of regional models other than the widely employed RACMO2 and MAR models, but efforts are still needed in this paper to reach a sufficient level of evaluation for HIRHAM5 products. Although the regional model results over Greenland for the reference present period seems more reasonable (which is a prerequisite before analyzing projections), those for Antarctica are in significant disagreement with the literature and results for both ice sheets need to be more properly discussed. Antarctic ice shelves, over which runoff for the reference present period was exaggerated by several orders of magnitude compared to the existing literature in a previous version of the manuscript, have simply disappeared from the revised version, which is not a satisfying way to deal with this issue. SMB changes in these areas do not contribute directly to SLR but local changes can affect the ice sheet dynamics, especially if these runs are used to drive an ice sheet model. Other minor, though important comments are provided below. I encourage the authors to go through previous reviewers' reports and identify the remaining comments to be considered (they are all meant to help you improving the paper) and adapt the manuscript accordingly or provide a justification otherwise.

Specific comments

Section 2: I get that you used EC-Earth because the CMIP runs have been performed at the DMI which is also the affiliation of most of the authors. But this is not enough to justify a choice for a model, and we would want to know more about EC-Earth performance over your regions of interest at least at the RCM boundaries. In the present version we only have a picture of how EC-Earth compares to other CMIP models in terms of relative change in precipitation as a function of change in temperature (which shows that EC-Earth is actually in the upper half of the model ensemble). Here temperature and humidity from the forcing fields are indirectly evaluated through the comparison of average, spatially integrated temperature and precipitation dynamically downscaled by HIRHAM5 against a reference run of HIRHAM5 driven by ERA-I and already evaluated in a previous publication, but what about regional differences ? what about other climatological variables (sea surface conditions, circulation in the forcing itself)?

It is not clear how these reference periods have been chosen neither why they differ between Greenland and Antarctica (20 vs 30 years).

Minor comments

P3L63: Instead of distinguishing between evaporation and sublimation, the paper would more gain in exhaustivity in distinguishing between surface sublimation and drifting snow processes, especially for Antarctica as the latters are currently considered to currently drive ablation at the surface of the ice sheet.

P4L122: Why is the subsurface model only applied to Antarctica? Please justify. Is it an offline method, i.e., Do the changes in surface properties feed back on the atmosphere ?

P4L122-123: I don't really understand the meaning of this sentence as it seems obvious to me that you will use your model results to comment on the SMB change. Do you mean SMB is a diagnostic variable (sum of SMB components vs prognostic = dz/dt * rho) of the model ? Is it computed offline?

P4L123: "better than" what? Please clarify/justify.

P5L143: Why this period and not the historical period?

P5L151-152: What are these results telling us regarding the main objective of this paper? what are their implications?

P5L155, "over the ice sheets": Do you mean each model on their own ice sheet mask ? which region did you use specifically?

P5L156: You could comment on the expected consequences for the downscaling.

P6L164-165: This does not justify why did you choose this specific model though. Note that HIRHAM5 downscalings are on the upper part (or half) for both model ensembles and for both ice sheets.

P6L181: This is confusing since the SMB of Antarctica is not negative. Please rephrase.

P6, Section 3: I would advise being more explicit at the beginning of this section about the approach adopted to evaluate HIRHAM5 runs (HIRHAM5 driven by ERA-I taken as a reference instead of observations etc, performance of HIRHAM5 driven by ERA-I can be found in …). Add and discuss regional differences, instead of only comparing spatially and temporally average values of temperature and SMB components in Table. Compare with other RCMs, discuss the balance between individual components when needed (especially for HIRHAM5 driven by EC-Earth3 in Antarctica: 261 Gt of runoff over the grounded part of the ice sheet vs 3137 Gt of precipitation….)

P7L198-200: So, does the period over which you compare the temperature between the GCM and the RCM driven by ERA-I differ?

P7L219: Specify that this stands for precipitation on grounded ice only.

P8L223-224: Elaborate on the consequences for ice sheet SMB (integrated and regional). What about other surface (ablation) processes relative to the reference run?

P8L232: Why is the approach more realistic in a former study? Why it has not been conserved in the present work?

P8L238, "420 Gt/yr": Specify that this stands for grounded ice only.

P8L242-249: Please discuss the related implications for the present period as well as for projections, show regional differences and add ice shelves to the analysis. Are these differences significative? How do they compare, for instance, to natural variability?

P9L256-258: How do these numbers compare to previously published projections of GrIS SMB?

P9L260-265: Same than previous comment.

P10L299-300: see also Kittel et al. (2021) for Antarctica and Fettweis et al. (2013), Hofer et al. (2020) and Noël al. (2021) for Greenland.

P10L311-313: What about absolute values of the anomalies ? Are they also comparable?

P11L323-325: You give here an argument that undermine your own methodology since you have not discussed the representation of surface oceanic properties in both versions of EC-Earth for the reference period.

P22, Figure 4: Report explanations of letters and colors directly on the plots instead of grouping everything in the caption to improve the readability of the figure.

Fettweis, X., Franco, B., Tedesco, M., van Angelen, J. H., Lenaerts, J. T. M., van den Broeke, M. R., and Gallée, H.: Estimating the Greenland ice sheet surface mass balance contribution to future sea level rise using the regional atmospheric climate model MAR, The Cryosphere, 7, 469–489, https://doi.org/10.5194/tc-7-469-2013, 2013.

Hofer, S., Lang, C., Amory, C., Kittel, C., Delhasse, A., Tedstone, A., and Fettweis, X.: Greater Greenland Ice Sheet contribution to globalsea level rise in CMIP6, Nat. Com., 9, 523–528, 2020, https://www.nature.com/articles/s41467-020-20011-8

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.

Noël, B., van Kampenhout, L., Lenaerts, J. T. M., van de Berg, W. J., & van den Broeke, M. R. (2021). A 21st century warming threshold for sustained Greenland ice sheet mass loss. *Geophysical Research Letters*, 48, e2020GL090471. https://doi.org/10.1029/2020GL090471