The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-140

Anonymous Referee #1

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-RC1, 2021

General comments:

The authors use HIRHAM5 regional climate model to downscale two EC-Earth models (one for CMIP5 and one for CMIP6), in order to assess projected surface mass balance from Greenland and Antarctica in the future. Whilst this is an important area of research given the uncertainty in future SMB estimates, especially with the difference in CMIP5 and CMIP6 climate sensitivity, there are still very big assumptions being made, and little justification for their research design. After reviewing their previous submission and the changes between versions, there still remains large questions in my mind in terms of the robustness of the results given that only 1 model from each CMIP is used to draw conclusions on the future of Greenland and Antarctic SMB. I am pleased to see the evaluation of HIRHAM5 is now included, and have no issue in the choice of RCM (as the authors note, most similar studies use MAR/RACMO, but there is no need for them to be used exclusively). However, I still see no justification for the choice of GCM. There are also a number of other questions remaining on their method design choices and how this influences the results. Therefore, I can't recommend the manuscript for publication in its current state and recommend major revisions.

Specific major comments:

Methods: Overall, the manuscript would benefit from justification of certain choices you have made in your methods and model setup. I list a number of questions below, which need some justification and also discussion on how your choices may influence your results.

- Model selection: Why EC-Earth, and why the specific realisations that you chose? Whilst I appreciate the high time- and computing power-consumption of downscaling

GCM/ESMs with RCMs, there still needs to be some justification of your selections. Efforts are being made to ensure that the 'best' GCM/ESM realisation are chosen for specific regions using selection criteria (see Pickler and Mölg 2021 and earlier references within). Even referencing earlier literature which highlights the success of EC-Earth compared to other models against observations could be cited. What if EC-Earth performs relatively poorly (compared to reanalysis and observation data) compared with other models? Or what if these specific realisation members (r3i1p1 and r5i1p1f1) are not reflections of the average ensemble for EC-Earth? In the discussion you mention the Southern Annual Mode, but there is no discussion of whether EC-Earth is able to represent the SAM characteristics. In your discussion, you mention the Bracegirdle study which found a large spread in conditions between CMIP5 models (line 315), which further suggests that you need to justify why you have chosen only 1 model. Whilst you do compare EC-Earth to ERA-I for the ice sheets, you don't then compare any other GCMs to ensure that EC-Earth is an appropriate tool. Figure 4 is a step in the right direction, but again doesn't provide any information on whether these two models are the best suggestions of historical/future climate for the ice sheets. Which models are included in Figure 4? Line 154 is quite broad- there are over 600 realisations for CMIP6 models in total, which ones are you using in Figure 4?

- Selected time periods: Why are you using different time periods (and different durations) for Greenland and Antarctica? What is the justification for looking at 20 vs 30 years, and why have different time periods in both historical and future runs? If you are trying to compare the SMB and discuss the uncertainties between CMIP5 and CMIP6, why add to the complexity by choosing different time periods? With ERA-I only available from 1979, and therefore this simulation is 8 years shorter than the Antarctica GCM runs (Line 199), why still chose the 1971-2000 period? There is then some discrepancy throughout the manuscript. For instance, Figure 3 shows 2081-2100 but Antarctica uses the period 2070-2100 in other results. Why are there different spin up times for historical and scenario forcings for Antarctica?
- Why downscale to such high resolutions when you spend very little time discussing the regional differences? It would be nice to include more about the regional differences between the CMIP runs, as well as just presenting the continent-averaged values.
- Discussion Ln 310: this paragraph should be more descriptive. To what extent do your results agree with RACMO2 and other models? They all agree with an increase for CMIP6, but are the magnitudes of increase similar in your results to the others? Similarly, in line 298 onwards, you mention the opposite results of other studies, but also do not go into detail about why they disagree. This needs to be discussed more so that the reader can interpret why your results differ or agree.

Other specific comments:

Throughout: Why v2 and v3? I would recommend abbreviating the model runs to something more intuitive considering CMIP5 and CMIP6 GCMs are used. Perhaps v5/v6 or EC-Earth5 EC-Earth6, so that it is instantly understandable for the reader. It only becomes clear in the third paragraph of the methods that EC-Earth2 and EC-Earth3 are the actual names of the model.

Ln 93: regional climate models is used rather than an abbreviation here. As there are many abbreviations throughout, perhaps you could avoid using the abbreviation in line 75.

References:

Pickler and Mölg (2021) General circulation model selection technique for downscaling: exemplary application to East Africa. JGR Atmosphere, https://doi.org/10.1029/2020JD033033