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The Cryosphere Discussions

Interactive comment on "Exploring the impact of atmospheric forcing and basal boundary conditions on the simulation of the Antarctic ice sheet at the Last Glacial Maximum" *by* Javier Blasco et al.

Anonymous Referee #3

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Blasco et al. investigated the effects of glacial atmospheric boundary conditions and basal drag on the equilibrium state of the LGM Antarctic ice sheet (AIS). For this purpose, they performed sensitivity experiments with an ice sheet model by modifying glacial atmospheric forcing obtained from PMIP3 LGM simulations as well as parameters in the basal drag. They showed that the differences in the glacial atmospheric forcing among PMIP3 model caused discrepancies in the simulated LGM AIS by an amount of 6m SLE, which is similar to that obtained from sensitivity experiments with different basal drag. I think the content of this study matches the interest of the reader

of The Cryosphere. Furthermore, as a climate modeler, I find this result quite interesting, and think it offers valuable information to both ice sheet and climate communities. Below, I address several concerns mostly focusing on the discussion of the results.

General comments

1. I think the authors should discuss the uncertainty in the glacial atmospheric forcing arising from the ice sheet configuration used in PMIP3 LGM simulation. In the PMIP3 LGM simulations, the climate models are forced with PMIP3 LGM AIS, which has a volume of 22.3 meter SLE compared with PI (Abe-Ouchi et al. 2015). This value largely overestimates the reconstructed value of the LGM AIS (Less than + 15 m SLE), and causes an inconsistency between the LGM AIS used for climate model simulations and the simulated LGM AIS with the ice sheet model. Therefore, the author should address this problem, and suggest the climate modeling community to perform LGM simulations with a more realistic AIS, which matches the reconstruction. In addition, I have a comment on a sentence starting from P12L5 " A way to potentially test the plausibility of the employed climatic fields is to compare with ice proxies." I agree to this sentence, but again, the inconsistency in the LGM AIS used in climate models and the reconstructed LGM AIS bothers me. For example, even if some PMIP3 glacial atmospheric forcing show consistent results with available ice core data, and regarded as reasonable glacial atmospheric forcing, I don't think it is physically correct. Please add a discussion on this point in section 4.3.

2. The basal melting of the ice shelf is fixed to zero in the simulations. I think this is a reasonable simplification to focus on the main topic of this study, however you should at least discuss the potential effect of the simplification you made. For example, while Obase et al. (2017, JCLIM) show that the basal melting at the LGM largely reduced compared with PI in their simulations with regional ocean model, the basal melt of LGM was still more than 50% of the PI experiment. Based on their estimates, the simulated area and volume in your experiment can be considered as the maximum estimate, and that the uncertainties in the ice shelf basal melting can have an impact on the LGM

AIS. Please add a discussion on this topic.

3. It is interesting to see that the differences in glacial atmospheric forcing caused large discrepancies in the simulated LGM AIS, especially for that of CNRM5. While it is not the main topic of this study to understand the cause of the difference in atmospheric forcing, I think it is valuable to discuss some possible reasons. For example, the result of CNRM5 reminds me of a study by Marzocchi and Jansen (2017, GRL) who compared the sea ice among PMIP3 LGM simulation. In their Fig. 3, you can find that CNRM5 simulates the smallest austral summer sea ice extent in LGM among PMIP3 models. This will cause warmer summer temperature over the marginal region of AIS and contribute to the negative mass balance. Perhaps, you may add one or two sentences on this point.

Specific comments

P2L30-31: This sentence describes several processes, which affect the estimate of the volume of LGM AIS. However it is unclear how the modifications affect the estimate. Please add some explanations on this point. You may focus on one or two processes, which are relevant to this study.

P3L3: I mostly agree with this sentence, but is it really true that the basal meting is negligible during LGM? For example, Obase et al. (2017, JCLIM) showed with regional ocean model that there is still some basal melting occurring at LGM. Please modify this sentence in a more modest way.

P4L10: This sentence is difficult to read. Do you mean that in some models, the simulated results largely differ from ice core reconstructions? Please modify this sentence.

P6L15-20: I had difficulty understanding this sentence, since I'm not familiar with an ice sheet model. Please describe this sentence in more detail. Why do you use PD temperature field at sea level rather than surface? How does RACMO calculate the sea level temperature field? Do they assume a constant lapse rate in converting the

temperature? If so, is the value of the lapse rate identical to what you chose in your ice sheet model?

P6L19: How did you decide this value of the lapse rate? Do you have any reference for this?

P8L14: Are these results consistent with previous studies?

P9L6: How did you define ground line temperature? Does the location of grounding line depend on simulations?

P11L20-25: Please add a discussion on the role of basal melting in this sub-section.

P12L1-2: I like this finding.

P12L4-5: I don't think it's that simple. On one hand, the very thick and extensive PMIP3 LGM ice sheet can induce a drastic expansion of LGM AIS due to the large decrease in surface air temperature. However, on the other hand, the thick ice sheet will reduce the amount of precipitation, which will cause a thinning of LGM AIS, opposite to PMIP3 LGM ice sheet.

P12L8: You may cite a recent article by Kageyama et al. (2020, Climate Past Discussion), which discusses preliminary results of PMIP4 LGM experiments.

Fig. 5: It's hard to see the contour of the surface topography. Please modify this figure.

FIg.S1: I think this figure contains some important information on the reproducibly of modern Antarctic ice sheet. Please move it to the main manuscript.

References

Kageyama, M. et al.: The PMIP4-CMIP6 Last Glacial Maximum experiments: preliminary results and comparison with the PMIP3-CMIP5 simulations, Climate of the Past Discussion, https://www.clim-past-discuss.net/cp-2019-169, 2020.

Marzocchi, A., and Jansen, M. F.: Connecting Antarctic sea ice to deep-ocean circu-

lation in modern and glacial climate simulations, Geophysical Research Letters, 44, 6286-6295, 10.1002/2017gl073936, 2017.

Obase, T., Abe-Ouchi, A., Kusahara, K., Hasumi, H., and Ohgaito, R.: Responses of Basal Melting of Antarctic Ice Shelves to the Climatic Forcing of the Last Glacial Maximum and CO2 Doubling, Journal of Climate, 30, 3473-3497, 10.1175/jcli-d-15-0908.1, 2017.

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