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Discussions

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Interactive comment on "Greenland Ice Sheet sensitivity and sea level contribution in the mid-Pliocene warm period – Pliocene Ice Sheet Model Intercomparison Project PLISMIP" *by* S. J. Koenig et al.

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General comments

This paper presents an assessment of uncertainties on the reconstructions of Greenland Ice Sheet during the Pliocene, firstly linked with the choice of the ice sheet model (inter-model comparison) and secondly linked with the ice sheet boundary condition in the climate model and in the ice sheet model. They show that the biggest source of uncertainty is not linked to which ice sheet model is chosen or its initial configuration,

but to the ice sheet boundary condition in the climate model.

This result is important, especially for ice sheet modellers. I would expect this result, and actually have similar results using IPSL-CM5A + GRISLI (Contoux et al., submitted). In addition, several authors already demonstrated the multistability of the Greenland ice sheet (e.g. Crowley and Baum, 1995; Solgaard and Langen, 2012). I think the discussion could emphasize a bit more on that point, giving us clues to understand why this strong dependency exists, and in particular if it makes sense or if it's an artefact of ice sheet models. Moreover by analyzing the multi model outputs, the authors give more constraints on the most probable locations of the Greenland ice sheet during the late Pliocene, saying that they must be localized over the nucleation centers of the East and South mountains. This result has important implication for PlioMIP phase 2. The paper is well written and concise. The figures are informative and of good quality. The results are an important step forward for the community. Thus I recommend that this paper be published with minor corrections listed below.

Minor points

Title. I think the title is not informative ("sensitivity" to what?), one alternative could be: Ice sheet model and boundary condition dependency of simulated Greenland Ice Sheet for the mid-Pliocene (still long, but more informative). But maybe you absolutely want to have PLISMIP in the title. . .

Introduction. Page 2824, line 19. Reference to Dowsett et al. 2012 is not relevant here.

Page 2825, line 16. Add "a" and "b" to the references de Vernal and Mudie 1989 (if you keep them).

Page 2826, line 2-3. I agree with Anders Carlson, there is not so much evidence, especially terrestrial, allowing us to assess the presence/absence, extent and variability of Greenland Ice Sheet during that period. However, there is a strong glacial episode during MIS M2 over the Northern Hemisphere (see De Schepper et al., 2014, Earth

Science Reviews for a review of marine and terrestrial evidence). There is also a recent study which suggests ice free Central Greenland before 2.7 Ma (Bierman et al., 2014, Science Reports).

2.1.1 Forcing. Page 2827, line 19. Reference to Haywood et al., 2011 b is irrelevant here. I also don't understand the reference to Box, 2004, line 19 and also page 2828, line 4. (and which is in fact Box, Bromwich and Bai, and does not use HadAM3 nor Pliocene conditions...?)

Page 2828, line 6. Please precise what vegetation you prescribe on the deglaciated parts of Greenland in your Had_plio.nogris GCM run.

Page 2828, line 10 "that provided by Hill (2009)" precise that it is the PRISM3 GrIS.

Page 2828, line 1-11. Please also refer to the corresponding simulation names (Plio_prism, Plio_prism.icefree and Plio_nogris.icefree)

3.1 Ice sheet model forcing. In this paragraph, please refer to Fig 1a,b,c,d,e,f,g and h when you describe the climatologies.

Page 2830, line 1. Replace Had_nogris by Had_plio.nogris to be coherent with figures and tables.

3.2 Modern Control Greenland Ice Sheet. Page 2830, line 17. Results of NCEP2_ctrl are not in Table 2. Why not?

Page 2830, line 20. These numbers are different than the ones in table 2, so I guess you are here talking about the NCEP2_ctrl simulation. Please clarify this passage.

3.3.2 Inter-model and inter-scenario analysis.

Page 2833, line 2. "the areal extent is largely governed by how much melting is simulated". In general, that is only partially true when one starts ice free, because in this case one also has to grow the ice sheet. However in your simulations accumulation does not seem to be a limiting factor because you manage to grow big ice sheets

in Plio_prism.icefree. Thus, I think you should say a small word about accumulation before stating that ablation is the main driver.

Page 2833, lines 10 to 28. Maybe a little summary sentence at the end of this paragraph is needed. Something like "The combination of these confidence tests shows that the presence of ice on Northwestern Greenland is very unlikely, whereas the presence of ice on the East mountains is extremely likely." However, I am wondering how to interpret figure 6a over Central Greenland, since the high confidence is due to all models simulating ice presence in Plio_prism and Plio_prism.icefree simulations, + all models simulating ice absence in Plio_nogris.icefree . . .

3.3.3 Relative sea level contributions. Considering the shortness of this paragraph, and the absence of constraints that we can give on sea level contribution from Greenland, I think it is not very relevant to put it in the title.

Page 2834, line 9. Remove "and".

Page 2834, lines 10-11. Are you sure it is not the other way around? The volume of Plio_prism is superior to the volume of Plio_prism.icefree (by the way, replace Plio_prism.nogris by Plio_prism.icefree)

Page 2834, line 15. "differing GCM forcings". This is vague and could be related to Aisling Dolan's paper. Please precise "ice sheet boundary condition in the GCM".

4. Discussion. Could be useful to show the PRISM3 ice sheet and the ice free topography you used in HadAM3, since the ice sheet boundary condition in the GCM seems to be crucial.

Page 2835, line 5. Replace Plio_prism.nogris by Plio_prism.icefree

Page 2835, lines 10-12: "proxy records of terrestrial and oceanic origin reconstruct a Pliocene Greenland similar to a projected future Greenland". Considering the huge uncertainties on both Pliocene and future Greenland ice sheets, I would remove this sentence (or rephrase).

Page 2835, line 15. And ice free Central Greenland, see Bierman et al. 2014, Science reports.

Page 2835, line 27. "a change in the climate forcing" once again I would be more precise and say "a change in the ice sheet boundary condition in the GCM"

Page 2836, line 1: "less . . . dependent results" Less than what? Precise or rephrase.

Page 2836, line 4: "GCM boundary conditions", you just changed one conditions, the "ice sheet GCM boundary condition"

5. Conclusions

Page 2836, line 26: same the –> the same

Page 2836, line 25. "we find that less ice sheet model dependent results require..." This sentence is obscure to me. Do you mean "Since we have shown that ice sheet model dependency is low, forcings from different GCMs using the same boundary conditions (Haywood et al. 2013[more relevant than citing 2010 and 2011b since you talk about the PlioMIP results]) is now required to further constrain uncertainties in simulating..."

References

Box 2004 is in fact Box et al. Correct if you keep this reference.

Dolan et al 2014 actually has a lot more authors than that (including myself), and the title has changed. Please update with Aisling Dolan for the last version.

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