Climate
of the Past
Discussions

Interactive comment on "Using results from the PlioMIP ensemble to investigate the Greenland Ice Sheet during the warm Pliocene" *by* A. M. Dolan et al.

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My co-authors and I wish to thank the reviewer for their careful review of the paper. We have addressed their comments as detailed below.

Reviewer 2 (Anonymous)

General comments

The manuscript of Dolan et al. investigates the sensitivity of the Greenland Ice Sheet (GrIS) to atmospheric forcing fields during the warm Pliocene. The document is nicely written and presents some really interesting analysis. This paper is a certainly a valu-

able contribution, and in particular it represents a needed step towards the next phase of PlioMIP. However, the manuscript could be improved in some places. The ISM description is generally too weak. I can understand that the ISM physical description is not necessarily needed for this paper, but I would have appreciated more description of the SMB computation. In particular, the chosen SMB model is very simple and a justification for this choice is needed. For example, some possible improvements of the original PDD scheme are not even considered nor listed, such as melt factors depending on temperature (Tarasov and Peltier, 2002) or water retention (Janssens and Huybrechts, 2000). Also, from the text, I assume you used mean annual and July temperature in order to evaluate the PDD, via a sinus function. This seems again a strong simplification and, therefore, a justification for not using directly the monthly fields from the climate models would be appreciated. Also, there is no information about an eventual partitioning between snow and rain from the total precipitation. In addition, the authors discard the precipitation correction for elevation changes. I acknowledge the fact that a simple parametrisation is far from obvious, as precipitation is a complex process that cannot be represented by a function of altitude only. However, neglecting this effect strikes me as a strong assumption. This could be justify for small changes in the ice sheet topography (such as for the initial downscaling for example).

However, for large changes happening during the Pliocene (from present day ice sheet to almost ice free), this assumption may be inappropriate. Considering their initial SMB (Fig. 8), I believe that COSMOS, MIROC or MRI (AGCM) would have presented much reduced GrIS with a precipitation correction factor, as we cannot really expect that with a 3km gain on the west flank on the ice sheet (and thus a cooling of âĹij18âŮęC) the precipitation would stay the same. Neglecting the precipitation correction would probably tend to exacerbate model differences and it does not seem justified. At least a discussion would be greatly appreciated.

> We thank the reviewer for their general comments and are happy to provide more detail and discussion as suggested. We have added a section further describing the

conversion of temperatures to the PDD scheme and detailing why July temperatures are used rather than all the monthly temperatures. We have also added a section describing the non-linear nature of precipitation and how this impacts the use of parameterizations on Greenland. Finally we have added the suggested references for improved PDD parameterizations, along with some justification for not using them.

Specific comments

3483 Title Maybe switch from Pliocene to mid-Pliocene warm period?

> Done

3485-3488 Introduction It would be great to have a little bit more of a discussion about the data here. Some references you cited later (e.g. Bierman et al. (2014) about summit being ice free or de Vernal suggesting a forested South Greenland) do not appear in this section. Also, how well the models capture the Arctic warming as reconstructed from proxy?

> Added suggested references and also some giving general picture of high-latitude warming in data and model of the Pliocene.

3488 It would have made more sense to me to see the inter-model differences (currently in 3.1.) in here, instead of in the results section.

> Moved paragraph describing PlioMIP Greenland climatologies

3490 l. 18-19 Again, it seems that you don't use the monthly fields from the climate models. What about the seasonality of climate fields in the PlioMIP ensemble? Could this seasonality have an impact on the computed PDD? Is July temperature meant to represent mean summer temperature?

> As stated above, we have now given more information regarding the computation of PDDs in BASISM.

3490 l.26 is this lapse rate used to correct the temperature as the elevation change

during the simulation?

> Added clarification of lapse rate used "both in the initial conditions and as the ice sheet surface evolves during the simulation".

3491 l.26-3492 l.10 Following my main comment, Charbit et al. (2013) suggest that PDD scheme flavours strongly impact the model results for glacial inception, not only the ablation parameter values. Also, you may want to add a bit of discussion regarding the results of Rogozhina and Rau (2014) on the importance of the temperature standard deviation?

> Our model uses an empirically based relationship between temperature and PDDs, in order to minimise uncertainties due to parameterisations tuned to modern day climatologies, so most of the discussion in these papers is not applicable. We have included more discussion of the melt scheme used, see above.

3492 l.4 I think you meant "2008a".

> Changed

3492 l.21-22 And for the Pliocene run?

> Added a sentence making clear that "These parameter sets were than used with each of the climate forcings from the PlioMIP ensemble."

3494 l.3-14 I might be wrong but I think the low sensitivity of the pre-industrial ice sheet to ablation rates comes from the fact that you have very little ablation over the GrIS under pre-industrial climate. Especially if as you have a bias towards a higher ice sheet, the lapse rate would tend to limit further the melt. A time series of melt for the pre-industrial simulation might help you to diagnose this? Again, maybe part of this low sensitivity is related to the fact that you discard the precipitation correction?

> Added some further explanatory text to the discussion of pre-industrial ice sheet simulations.

3494 l.25-28 True, and the horizontal model resolution is also crucial.

>Added note about resolution

3495 l.3-6 If you start your simulation with a present-day geometry, you will eventually end up with an inner sea. You need to describe your initial ice configuration (bedrock, ice thickness, ice temperature) for the Pliocene experiments.

> Added a couple of sentences describing the isostatic rebound model used in section 2.2.

3498 l.9 Annual / summer mean?

> Added "annual mean"

3498 l.10 "A strong warming" compared to what? When?

> Rephrased to make this sentence clearer

3498 l.24-25 I suggest you get rid of "amin" notation.

> Removed notation

3500 I think it could be useful to have a summarizing table with some averaged numbers for each ensemble member (GrIS volume difference during the mPWP, temperature, precipitation, SST, ice fraction).

> We already have two tables which we believe summarises this information. Table 3 gives the precipitation and temperature values (for the Pliocene and pre-industrial) and Table 4 shows the GrIS volume and area for each ensemble member.

3504 l.13-18 The findings of Bierman et al. (2014) are that soils have been subaerially exposed for more than 1 million years. Is it not jumping onto conclusion to claim that it was ice free during the warm Pliocene?

> We agree, but the paper suggested that this could be the case. We have rephrased it to be clear that the implications are from the source.

3518 Table 1 What is preferred or alternate LSM?

> Added reference and more information on the land-sea mask configuration

3519 Table 2 I suggest you add in a separate table, the values corresponding to the red-blue-yellow filled dot?

> Table has been added to the supplementary information for the paper

3520 Table 3 What is the "Greenland region"? Formatting: COSMOS-AOGCM row.

> Calculations for climate fields over Greenland have been changed – see response to Reviewer 1 regarding Table 3

3523 Figure 1 Is there any isostatic model embedded in BASISM? Also, where the bedrock data comes from, surely there is some kind of isostatic adjustment in Figure 1. Stone et al. (2010) suggested that the bedrock was a major source of model sensitivity and you may want to comment a little bit about that? Again, you should specify somewhere the initial ice configuration for the Pliocene simulations.

> Section has been added to ISM description based on previous comments

3524 Figure 2 The differences are on the same height level? If this is surface level, I don't understand why we cannot see the impact of the topography difference on some of the models.

> The differences shown are from the original model simulations and have not been corrected to one height. As we have used the field surface air temperature, we have added "surface air" to figure caption to make this clearer.

3526 Figure 4 Same as before.

>Added "surface air" to figure caption

3532-3 Figure 10-11 Annual mean?

> Added "annual mean" to figure caption