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Interactive comment on "Application of an ice sheet model to evaluate PMIP3 LGM climatologies over the North American ice sheets" *by* Jay R. Alder and Steve W. Hostetler

Anonymous Referee #1

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Introduction:

The authors present an attempt to evaluate climate model results for the last glacial maximum (LGM) produced as part of the Paleoclimate Modelling Intercomparison Project 3 (PMIP3) using an ice sheet system model (ISM). The evaluation is largely based on results from the surface mass balance model of the ISM, which employs a positive-degree-day (PDD) melt model.

Main comments:

The biggest problem with the present manuscript and my reason to advice rejection is the ice dynamical aspect of the modelling. As the authors write themselves P10,6, the

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relaxation time of 5000 years is not enough for the model to reach steady state. The chosen period is clearly too short for the ice flow to sufficiently respond to the imposed SMB forcing. This means that the ice sheet is in an arbitrary state after 5000 years as it relaxes from the assumed initial reconstructed geometry to balance with the imposed forcing. This is a fundamental flaw in the experimental setup.

Although the ice sheet model is described as thermodynamic, I see no evidence that the ice temperature is evolved or even initialised. This would have to be clarified. However, it is important to realise the main difference between the options discussed to arrive at an initial state (btw. I don't understand the second option for initialisation at P4,1 without a reference). While the result of the first approach is a fully self-consistent (thermo-)dynamic ice sheet model state, this is not the case for the given choice of imposing a reconstructed geometry.

Furthermore, differences in the SMB forcing between climate models imply that each GCM generates its individual response time scale dependent e.g. on the spatial SMB gradients. It is possible that the North American ice sheets were never really in balance with the climate during the LGM (something to discuss), but assuming an arbitrary period to evolve from an arbitrary initial state is certainly not an acceptable solution to this problem.

Another problem with the present setup (that would at least need to be acknowledged) is that the "coupling" between climate and ice sheet model is reduced to the lapse rate effect on temperature. The further away the ice sheet geometry evolves from the ice sheet that was prescribed for the GCM, the less reliable are the climatic fields entering the calculations. This is in particular a problem where the land type changes e.g. from ice sheet to land cover, or vice versa.

I believe a study relying entirely on the SMB component of the ISM would arrive nearly at the same conclusions as the present manuscript. The statements P4,16 are clearly ignoring any flow of the ice, which indicates that the dynamic aspect of the ice sheet

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model is not really considered in the discussion anyway. Further support for that approach could be drawn from the July panels of Figure 2, which give a good impression where a feasible ice sheet can exist. In that case, however, the SMB model (here PDD) would have to be treated with much more detail and a clearer correspondence with the underlying GCM results would be in place. An interesting additional check would be what climates the GCMs produce as present-day conditions (positive SMB for Greenland, ...) to distinguish models that are generally warm biased from models that are warm biased only at the LGM but OK for the present and the same for cold biases for the two periods.

I am afraid this is unfortunate timing, but some, if not much of this work will likely be superseded by the CP discussion paper by Niu et al. https://doi.org/10.5194/cp-2017-105.

Minor comments:

Abstract: The long form of PMIP3 should be "Paleoclimate Modelling Intercomparison Project", not "Palaeoclimate Modelling Intercomparison"

P13,13 something wrong with this sentence

Discussion and reference to Ziemen et al. in the introductions seems appropriate. doi:10.5194/cp-10-1817-2014

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