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Interactive Comment

Interactive comment on "A technique for generating consistent ice sheet initial conditions for coupled ice-sheet/climate models" *by* J. G. Fyke et al.

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Reply to reviewer 2 comments:

General comments and responses:

We thank the reviewer for their comments. We agree with the reviewer's comment that there is no fundamental improvement in this paper compared to previous studies, in terms of integrating past history into the preindustrial climate state. The improvement lies in the ability to do this within a framework that allows the preindustrial ice sheet state to be consistent with the preindustrial climate state so that future coupled experiments start from a system-wide consistent state.

Specific comments and responses:

REVIEWER: Justify 30-year equilibrium climatology

We have updated this sentence to better highlight why we chose to use 30-year climatologies.

Full 30-year climatologies of SMB and surface temperature were used to ensure that both the mean climatology and any non-zero impacts on ice sheet evolution due to interannual SMB variability about the mean (Pritchard et al, 2008) were properly captured.

REVIEWER: Perhaps a sketch of different models with inputs/outputs, to help readers not familiar with Community suite of models

We have now included such a sketch (new Figure 1)

REVIEWER: "...for a 122kyr standalone 5 km..."

This statement has been removed, and the methods description re-organized in line with the reviewer's suggestions.

REVIEWER: One motivation for generating SMB lapse rates is that climatology is affected by topography, especially elevation. So that SMB/T values that do not depend on ice sheet elevation could be a limitation of the technique? Comment.

We are not completely clear on which technique the reviewer is referring to (ours, or Helsen's). But this may be a moot point, since both methods DO generate SMB/T fields that depend on evolving ice sheet elevation. Ours capture elevation effects on SMB/T because these fields are calculated at all potential levels in a particular X/Y location at each time. So the ice sheet surface simply interpolates the nearest SMB/T values vertically to obtain the elevation-consistent SMB/T. In contrast, Helsen et al. require a complex (though useful) procedure to regenerate SMB 'lapse rates' for each X/Y location. The reviewer can find more details of the procedure used in this manuscript, in Lipscomb et al. (2013).

REVIEWER: why 600 years of constant climate slices?

The use of 600-year constant-climate periods was motivated primarily by technical constraints of running a very long simulation within the CESM system, which is for deep-seated software issues not a trivial procedure. We mention this now, in the text. A more elegant approach, which Fyke has used previously in a different model, is to do the interpolation 'in-line' in the executable as the simulation proceeds. However, this would have required much alteration of basic CESM code, and so it was decided for this initial experiment to do the interpolation externally to the model executable. We now note in the manuscript this reason, and also suggest that a future improvement (for example, prior to public release of the code responsible for this work) would be to place the interpolation in-line. However, we also note that the more elegant in-line approach would almost certainly give very similar final preindustrial results, especially given the (relatively) slow nature of glacial-interglacial climate change. In summary, we are not particularly worried that the 600 year approach is seriously impacting our conclusions.

"Use of 600-year constant-climate climatologies, instead of continuously-interpolated SMB and temperature fields, was driven primarily by technical challenges encountered in running (for the first time) a 122-kyr simulation within the CESM framework. Improvement of the procedure described here will include migration to a more continuous, in-line approach. However, we not concerned that the initial method used here would differ appreciably from any smoother interpolation approach, given the relatively slow millennial-scale rates of change of climate during the last glacial cycle. "

REVIEWER: How were the thresholds chosen'?

The threshold values were set to the average NGRIP values at the absolute years that were used for the CO2 and orbital forcing for the CCSM paleoclimate simulations. This was done because, for example, the CCSM LGM simulation represented a time slice

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that was NOT the minimum in the NGRIP oxygen isotope time series. Thus in order to avoid 'extrapolation' of colder-than-simulated-LGM climate states, the thresholding was introduced. The realistic assumption here is that the LGM and MHO climates as simulated by CCSM represented the true end-member states, and that, for example, the minimum in d180 during the glacial period was not actually the coldest period, but simply rather the period with the greatest accumulation of ice on land. Our other option was to time-shift the end-member climatologies to the minima/maxima in the d18O record. However, this would then become inconsistent with the CO2/orbital forcings used to generate the climate simulations, and so we chose thresholding as the 'lesser of two evils'. In either case, we are quite confident final result (of thresholding, or time-shifting) on the preindustrial GIS state is likely quite small.

REVIEWER: The notation of equations 1-3 are impossible to understand

We have cleaned up the symbology in these equations significantly, and removed overbar and underbar arrows.

REVIEWER: not clear if surface temperature is also interpolated

Yes surface temperature is dealt with in a way identical to SMB. We neglected to include surface temperature in the methodology description, and now it is added where necessary.

REVIEWER: show location of summit and western ablation area, in one of the Greenland maps

These locations are now indicated on the end-member SMB/temperature maps (see next comment).

REVIEWER: show SMB maps for three end-members

We have now produced these end-member SMB maps, and also end-member maps of surface temperature.

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REVIEWER: move methodology explanation to section 2.2

Done, see above.

REVIEWER: show absolute map of basal temperature at 1850

We have removed the plot of basal temperature difference, and replaced it with two absolute plots of basal temperatures (for the equilibrium and transient simulations). It is clear by eye the difference between the two. We have included in the text an analysis of the extent of the bed existing at the pressure-dependent melting point (which is a prerequisite for basal sliding). We find a notable decrease in bed at the pressure-dependent melting point, suggesting less sliding at preindustrial for the transient spin-up case, and thus less dependence on sliding parameterizations, and parameters.

REVIEWER: show volume evolution

We have now included a time series of volume evolution in the manuscript.

REVIEWER: change "is" to "in large part"

Done.

REVIEWER: acknowledge that main aim of inverse methods is to do short term forecasts, which ideally require very close-to-obs initial conditions, which this method does not solve

We have now noted that inverse methods are aimed primarily at short-term forecasts, in the manuscript. For the reviewer's information, we included this discussion, as it has been proposed that inversely-generated ice sheet conditions be used as the initial ice sheet condition in fully coupled ice-sheet/climate model simulations. Here, we wished to highlight the potential difficulties with the inverse approach in a coupled model setting, not necessarily denigrate the powerful inverse method itself.

REVIEWER: Price: model initialized w.r.t balance velocities, not observed velocities

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This has been corrected in the manuscript.

Interactive comment on Geosci. Model Dev. Discuss., 6, 2491, 2013.