Clim. Past Discuss.,
https://doi.org/10.5194/cp-2018-26-AC1, 2018

Climate of the Past Discussions

Interactive comment on "Arctic warming induced by the Laurentide ice sheet topography" *by* Johan Liakka and Marcus Lofverstrom

Johan Liakka and Marcus Lofverstrom

johan.liakka@gmail.com

Received and published: 1 June 2018

We thank D. Ullman for reviewing the manuscript and providing helpful comments that have improved the manuscript. Please see below for the responses to the specific comments.

Reviewer comment 1

Line 11 (in abstract): "These results suggest a positive feedback between continental-scale ice sheets and the Arctic temperatures that may help constrain LIS elevation..." Why is this a "positive" feedback? I tend to consider positive feedbacks to be amplifying feedbacks. But the mass-balance feedback described in this paper counteracts (or "constrains") the initial change. LIS grows –> warmer Arctic temps –> reduced LIS sur-

Printer-friendly version

Discussion paper

face mass balance –> LIS shrinks. Isn't this a NEGATIVE feedback? Please consider changing throughout.

Reply from authors Yes, we agree it is a bit confusing. We were thinking of this as a positive feedback in terms of temperature (higher LIS -> more heat transport -> less albedo, more water vapor -> higher temperature -> less albedo, more water vapor ...). You are right that in terms of mass balance it should be a negative feedback. To avoid all confusion, we have removed the word "positive" from the abstract.

Reviewer comment 2

Line 30 -> model simulations are 60 years in length; 35y for spinup, 25y for analysis. Is this enough? For the spin-up, can the authors demonstrate with some key atmospheric variables that the simulation is no longer demonstrating drift? Similarly, does 25 years provide enough time to appropriately assess a climatology?

Reply from authors Model simulation lengths of 60 years is common when using a slab (mixed-layer) ocean model (the same was used in e.g. Bitz et al. 2012; Löfverström et al. 2014). Because there no deep ocean representation in the model, the ocean spin-up is completely determined by the equilibration time-scales of mixed-layer, which is typically 20 years. The relatively short spin-up in our simulations is illustrated in Fig. 1 (enclosed in this document; see below), which shows the time evolution of the (annual) global-mean and Arctic (average north of 70N) surface temperature from the LIStopo0 and LIStopo1.25 simulations. The spin-up phase (as used in the manuscript) is highlighted with dashed lines and the climatological averaging period with solid lines. In Fig. 1, it is evident that steady state is reached after approximately 25 model years.

The reason why we chose to compute the climatology over 25 years instead of say 30 or 35 years is that we noticed that some of the simulations required a few additional years to reach equilibrium. Hence, to be on the "safe side", we decided to compute the climatology over the last 25 years instead of the last 30 or 35 years. However, as is seen in Fig. 1b, the Arctic temperature is not very sensitive to this choice. The

main result of our study, i.e. the LIS-induced Arctic warming (difference between the LIStopo1.25 and LIStopo0 in Fig. 1b), would not change much if the averaging period was 5-10 years longer or shorter than the present choice.

Reviewer comment 3

Line 12-17 -> The surface mass balance model used in this study is a simple PDD approach. A PDD factor based on observations from modern Greenland might not be completely relevant for the LIS (see Pollard et al., 2000, Global and Planetary Change). It may be worth noting this limitation: that a fully-resolved energy balance model would provide a more complete assessment of surface mass balance. However, Pollard et al. (2000) showed that for paleo applications, conclusions of a PDD approach are generally consistent with an energy balance model. This is to say that I think the general trend of surface mass balance change due to LIS elevation (Fig. 4) is likely robust. However, the observation of positive surface mass balance over Siberia, except in the LIStopo1.25 simulation, might be sensitive to the selection of the PDD factor in the surface mass balance model. Further sensitivity analysis of the PDD factor used in these simulations may be necessary.

Reply from authors Good idea. We have added a comment about the uncertainty of PDD models in the discussion section.

References

Bitz, C. M., Shell, K., Gent, P., Bailey, D., Danabasoglu, G., Armour, K., Holland, M., and Kiehl, J.: Climate sensitivity of the community climate system model, version 4, J. Climate, 25, 3053–3070, 2012.

Löfverström, M., Caballero, R., Nilsson, J., and Kleman, J.: Evolution of the large-scale atmospheric circulation in response to changing ice sheets over the last glacial cycle, Climate of the Past, 10, 1453–1471, https://doi.org/10.5194/cp-10-1453-2014, 2014.

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2018-26, 2018.

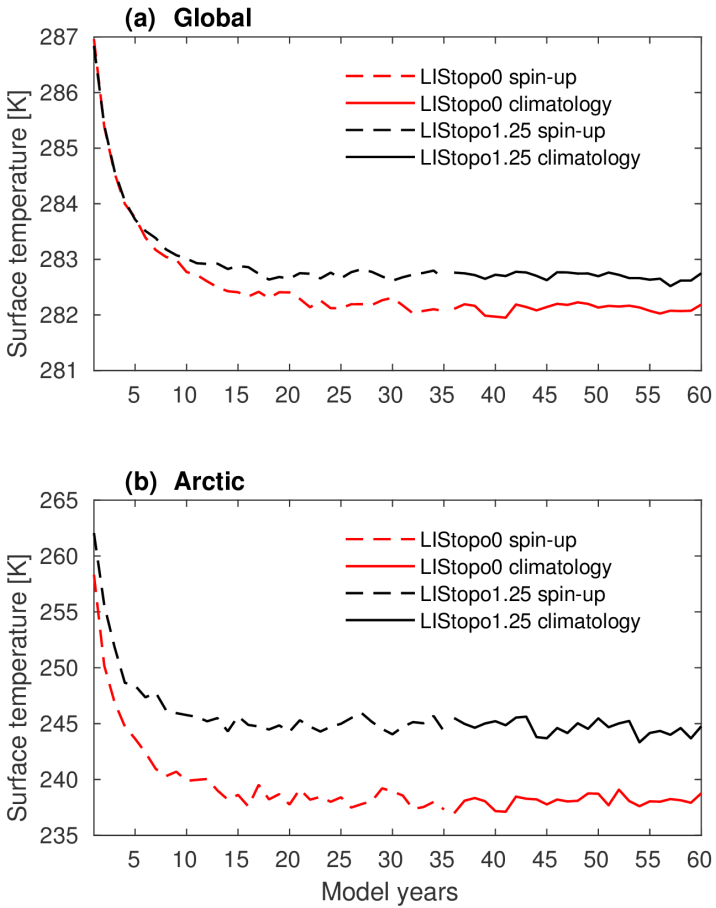

Fig. 1. Temporal evolution of the global-mean (a) and Arctic (b) annual-mean surface temperature in the LIStopo0 (red lines) and LIStopo1.25 (black lines) simulations.