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Interactive Comment

Interactive comment on "The impact of the North American ice sheet on the evolution of the Eurasian ice sheet during the last glacial cycle" *by* J. Liakka et al.

J. Liakka et al.

johan.liakka@senckenberg.de

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Referee comment 1

Specific comments

– The main results in the paper are based on simulations using the preindustrial modeled ocean heat transport. The authors also show that the main result of the paper, namely that the Eurasian ice sheet is shifted westward by the changes in atmospheric circulation induced by the Laurentide ice sheet, strongly depend on the ocean heat transport used. The westward shift is actually much less pronounced if the modeled

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Interactive Discussion
Discussion Paper

LGM ocean heat transport is used. The authors should make this clear in the abstract and the conclusions.

Reply from the authors

Thanks for the tip. We will add some sentences about this issue in the abstract and conclusions.

Referee comment 2

– The authors should discuss the assumption that climate and ice sheets are at equilibrium during the simulated time slices in some more detail. What is the possible role of the ice sheet history for the actual ice sheet state at the simulated stages?

Reply from the authors

We have already devoted some parts of Section 4.3 (about the of ice growth at MIS5b) to this issue, but we agree that we can elaborate more on this, especially in the context of the MIS4 and LGM ice sheets. In Section 4.3, we explicitly discussed the effect of the ice-sheet history on the ice-sheet extent at MIS5b by simply starting the simulation from a different initial condition (the geologically constrained outline of the MIS5b ice sheet in Eurasia). This experiment shows that the ice-sheet history does not appear to have a significant impact on the existence of the MIS5b ice sheet as almost the entire initial ice sheet melts away due to warm conditions (see Fig. 9a,b in the manuscript).

We have carried out equivalent simulations for the MIS4 and LGM ice sheet, but we did not include those results in the manuscript. However, the results from those experiments are attached in this document (Fig. 1). This figure is equivalent to Fig. 5 except that we use the geologically constrained outlines as initial condition instead of an ice free state. Note that the outlines of the simulated ice sheets in Fig. 1 here are very similar to the ones in Fig. 5. The only exception is the MIS4 EAonly simulation, which is larger when using a pre-existing ice sheet as initial condition. This suggests that the ice-sheet extent is not that sensitive to the ice-sheet history at those timeslices. More

CPD
11, C2997–C3002, 2016

importantly, the main conclusion here – that the North American ice sheet induces a westward migration of the Eurasian ice sheet –appears not to be influenced by the history of the Eurasian ice sheet. In other words, as the North American ice sheet expands, the induced westward migration of the Eurasian ice sheet is not particularly sensitive to details associated with its current spatial distribution.

We will add Fig. 1 in this response to the Supplementary and discuss it along with the ice-sheet history/MIS5b discussion in Section 4.3.

Referee comment 3

– The separation of precipitation into rainfall and snowfall based on temperature between -10C and +7C seems somehow arbitrary to me. Are the model results sensitive to this particular choice?

Reply from the authors

See also our reply to Referee 1. Those specific numbers in the snowfall-rainfall-ratio parameterization are default in the model and based on Marsiat (1994). The model results are not particularly sensitive to this parameter choice. Figure 2 in the attachment to this response letter shows the simulated ice thickness at LGM (EAonly in panel a and fullGlacial in b) using, respectively, -3°C and +3°C as temperature limits for snow and rain as opposed to -10°C and 7°C in Fig. 5. The resulting ice extents in Fig. 2 in the attachment are very similar to those in Fig. 5e,f, implying that our results are not that sensitive to the exact values of the temperature limits. As long as the average between the snowfall and rainfall temperature limit is close to 0°C (which obviously makes sense) changing the temperature limits has only a small the ice sheet evolution. More specifically, changes in the precipitation/snowfall partitioning could speed up or slow down the growth of the ice sheet by modulating the accumulation. But it would not have any significant impact of the extent of the ice sheet, which is primarily determined by the location of the 0°C isotherm of the summer temperature.

We will add the Marsiat reference to ice-sheet model section.

Referee technical comments

Technical comments

Page 5212, line 19: ERA-Intirim -> Era Interim

Page 5215, line 10: "high latitude height anomalies". Please specify that it is geopotential height.

Page 5219, line 7: "a monotonically decreasing" should be "monotonically decreasing"

Page 5223, line 17: "yields a cooler summer" should be "yields cooler summer"

Page 5223, line 21: "a equivalent" -> "an equivalent"

Page 5223, line 21: here and elsewhere in the paper please specify that you are referring to cyclonic and anticyclonic ANOMALIES and not absolute values.

Page 5224, line 13: "our results is" -> "our results are"

Reply from the authors

Thanks for all the technical comments. We will modify the manuscript accordingly.

References

Marsiat, I.: Simulation of the Northern Hemisphere continental ice sheets over the last glacial-interglacial cycle: experiments with a latitude-longitude vertically integrated ice sheet model coupled to a zonally averaged climate model, Paleoclimates, 1, 59–98, 1994.

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CPD

11, C2997–C3002, 2016

Interactive Comment

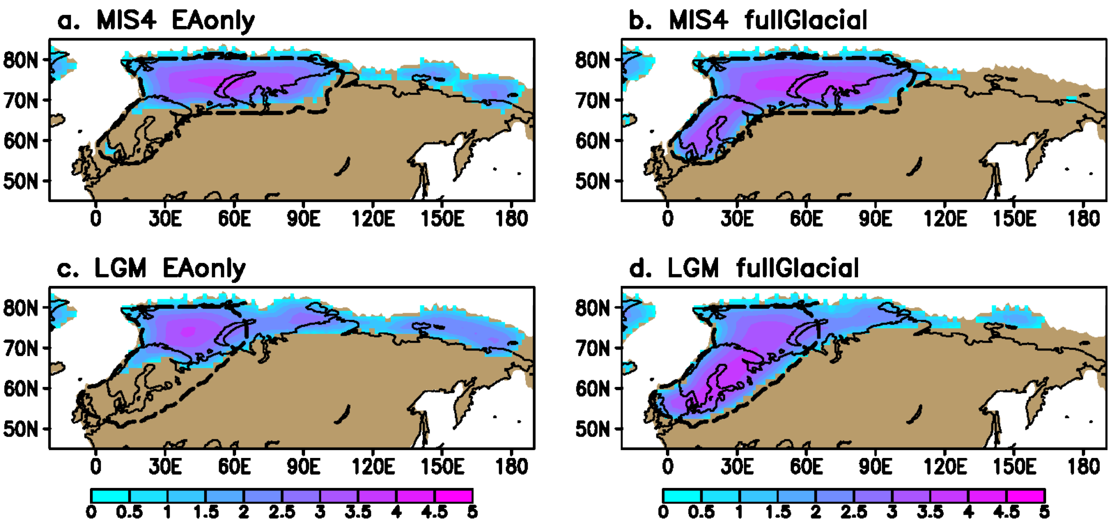

Fig. 1.

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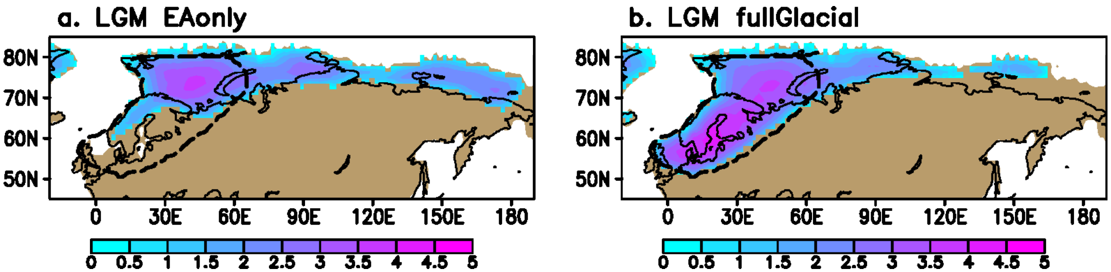

Fig. 2.

CPD
11, C2997–C3002, 2016

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