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Climate of the Past Discussions

Interactive comment on "Evolution of the large-scale atmospheric circulation in response to changing ice sheets over the last glacial cycle" *by* M. Löfverström et al.

Anonymous Referee #1

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This paper presents modelling results to examine how the paleo ice sheets at different key periods of the last glacial cycle (MIS5b, MIS4 and LGM) may have impacted the the atmospheric circulation through both thermal and topographic forcings, and how the perturbations induced by ice sheets may have influenced the evolution of ice sheets themselves. The simulations are performed using the atmospheric CAM3 model and the ice-sheet reconstructions by Kleman et al (2013) used as boundary conditions. The results presented in this manuscript suggest that the large-scale atmospheric winter circulation rather resemble that of the interglacial period during MIS 5B and MIS 4 with a southwest-northeast tilt of the North Atlantic jet stream. This is attributed to the weak interaction between the mean flow and the ice sheets. At the opposite, at

the LGM, a zonalisation of the jet is observed in response to the large North American ice sheet. A second interesting results concerns the presence of warm temperatures anomalies over Alaska and Siberia due to a strong anticyclonic circulation resulting from the ice sheet topographic forcing that prevents perennial snow cover from occurring in these areas The paper offers an interesting contribution to the understanding of the links between ice sheets and past atmospheric circulation during the last glacial cycle. It is clearly organized and very well-written. Therefore, the paper deserves being published in Climate of the Past provided that a few minor revisions, suggested below, are addressed.

Specific comments:

Page 1384 (Introduction): The authors explain that the atmospheric circulation during the long build-up phase of the Northern hemisphere ice sheets has received little attention. Although they are right, they should mention a recent study by Beghin et al. (2014) in Climate of the Past that investigated the relationships between atmospheric circulation and development of ice sheets throughout the last glacial cycle.

Zonalisation of the jet at the LGM: The authors should more thoroughly discuss the extent to which the zonalisation of the jet at the LGM is model-dependent. To my knowledge, most of the models included in the PMI3 database do not produce this zonalisation, except the GISS model (in which the ice-sheet boundary condition are given by the ICE-5G reconstruction; see also Ullman et al., 2014, Climate of the Past).

Page 1390 and table 3: Could the authors give explanations of the reason why the equator-to-pole gradient is slighltly smaller at LGM than at MIS4?

Page 1391:

Would it be possible to better assess the relationship between the location of sea-ice margin and and wind direction? A possible way would be to perform atmospheric simulations forced by different reconstructions of sea-ice cover.

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Lines 1-2 : The authors refer to a “pattern familiar from present-day observations”. Could the authors add an additional figure showing both model results for the present-day period as well as the present-day observations for eddy heights?

Line 8: I am not really sure to understand this sentence? What is also “imparted by the Atlantic storm track”? Is it the southwest-northeast tilt? If so, could the authors explain why?

Page 1392: Lines 5-6: I am not really convinced that changes in precipitation from MIS4 to LGM are larger than the changes from MIS5b to MIS4. Unless a proper justification is provided, this sentence appears as an overstatement and should be removed.

Page 1394: “The anticyclone over North America is therefore split up into one part forced thermally, and one part induced mechanically by the ice sheet topography at higher latitudes”. It took me a little time to understand from which feature in figure 5 this statement was derived. Therefore, I think that this figure should be commented and explained in more details to be understandable by a larger audience not fully familiar with atmospheric dynamics.

For a better understanding of the relative effects of mechanical and thermal forcings, it would be useful to show the evolution of the 300 hPa eddy geopotential corresponding to the sensitivity experiments of the “no-ice sheet cases” (described page 1395).

Could the authors better justify the last sentence “Due to the relatively weak mean flow. . . . . diabatic cooling over the ice sheet”. Which is the feature in figure 6 that allows to derive such a conclusion?

Page 1396 Line 24 : In which figure are the westerly winds displayed ?

Overall, I think that some features do not appear clearly in the figures, such as the contours of the continents in figures 2 to 6 or the contours of the ice sheets in figures 4 and 6. My suggestion is to change the thickness and/or the colour of the lines, increase the width of the figures and indicate both latitudes and longitudes. Also, arrows indicating

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the advection of warm/cold/dry air should be added in figures 3 and 5.

Typo:

Page 1391, line 26: south Iberia (instead of south to Iberia).

Page 1399, line 2: add “from” between “result” and “the choice”.

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