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Climate of the Past Discussions

Interactive comment on "Two modes of glacial climate during the late stage 5 identified in Greenland ice core records" *by* M.-L. Siggaard-Andersen et al.

Anonymous Referee #1

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This paper provides an interesting new analysis of the relationship between different tracers – Ca and Na, in particular – in the NGRIP ice core and argues for that two different modes of circulation variability are captured by differences in their relationship. This idea is not new, in that differences between continental tracers such as Ca and "marine" tracers such as Na has been suggested before. However, I am aware of no previous study that quantifies the relationship particularly well. This study is an improvement in this respect, and that is a positive aspect of the paper. It is convincing that there are very different relationships during Stage 5 and during the subsequent glacial period, and I agree with the authors that this must reflect rather different atmospheric circulation regimes. This is an important finding, because it directly addresses a very

important question: whether or not there are major changes in atmospheric circulation associated with the changing height of the Laurentide ice sheet. The relationship between atmospheric circulation and ice sheet size has recently been suggested as part of the explanation for the occurrence of Dansgaard-Oeschger events during glacials, but not during interglacials.

I have four concerns with the paper. First, while I agree that the changes in Na and Ca very likely reflect changes in atmospheric circulation, the specific changes inferred are not very convincing. The authors illustrate a conceptual picture of their "Mode 1" by showing the 500 hPa geopotenial heights for a particular month (December 1978), and their "Mode 2" by another month (January, 1974). There is very little discussion of the characteristics of these different circulation regimes, the reasons given for choosing winter only examples, nor any evidence that these particular circulation regimes should indeed change the Ca and Na relationships as suggested. Indeed, the transport lines drawn on the Figure 4 plots seem to be entirely qualitative. This would be more convincing if a statistical treatment of calculated back-trajectories were done. The relationship could then be examined between these back trajectories and the observed changes in Na and Ca in the upper portion(s) of the GRIP, NGRIP and GISP2 cores. Some work along these lines has indeed been done in an earlier paper by H. Fischer and others, and there may in fact already be a convincing relationship shown that agrees with that inferred by Siggaard-Andersen et al. However, these is not discussed in any detail.

Second, the possible relationship between the height/size of the ice sheet and the atmospheric flow is speculative, but quantitative analyses of these relationships do exist, and should be more thoroughly examined and cited. In particular, see Roe, G.H., and R.S. Lindzen, 2001: The mutual interaction between continental-scale ice sheets and atmospheric stationary waves. J. Climate, 14, 1450-1465; Roe, G.H., and R.S. Lindzen, 2001: A one-dimensional model for the interaction between ice sheets and atmospheric stationary waves. Climate Dynamics, 17, 479-487. There also may be more recent work on this subject.

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Third, one might expect a similar relationship to be found in the Holocene as in Stage 5, yet no Holocene data are shown. This is perhaps because the relevant data are not available for NGRIP, but such data could be taken from the GRIP and GISP2 cores.

Fourth, I do not find the discussion of deuterium excess convincing. How does this support the interpretation of Ca and Na? This needs a much fuller discussion or should be removed from the paper.

In summary, I find this an interesting paper, appropriate for Climate of the Past. To be publishable, however, substantial revision will be necessary to address the concerns expressed above.

Interactive comment on Clim. Past Discuss., 3, 285, 2007.