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Climate of the Past Discussions

Interactive comment on "Modelling snow accumulation on Greenland in Eemian, glacial inception and modern climates in a GCM" *by* H. J. Punge et al.

Anonymous Referee #1

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Review Comments on: Modelling snow accumulation on Greenland in Eemian, glacial inception and modern climates in a GCM, H.J. Punge, H. Gallee, M. Kageyama, G Krinner (cpd-8-1523-2012)

Summary: This paper is a description of the impact of implementing a more realistic snow model on Greenland in the IPSL coupled climate model. The climatic and surface mass balance (SMB) effects of the change are described and evaluated, mainly in the context of a modern/preindustrial climate simulation, but also under two sets of paleoclimate boundary conditions representing the last interglacial and the last glacial inception. The development of GCMs in this direction (usually, as here, with a view to

improving atmosphere-icesheet coupling) is a timely subject as a number of modelling groups are engaged in similar work, and I can see the detail included in this paper being useful to others. Although it is a fine model description paper, the scientific conclusions drawn about the climate of the past are rather limited

Presentation: The paper is very well written, detailed but still clear and comprehensible. The only exception to this lies in the multi-panel figures, which I found often too small to draw information from easily.

Bigger Comments: To me, this paper feels like an interim result, documenting an important stage on the way to the final product of a climate model with a physically appropriate coupling to an icesheet model. So, on the one hand, as a part-time model developer engaged in related work, I found the paper both interesting and useful. On the other hand, as a part-time climate scientist, this halfway effect made it feel a little frustrating at times. There's actually relatively little about the 126kyr and 115kyr experiments, and the fact that the underlying Greenland icesheet topography is fixed at its modern configuration for both paleo experiments means that the (few) conclusions drawn about snow accumulation at these times are necessarily idealised and along the lines of statements about model sensitivity rather than reality. That's not to say that it's not worth publishing as it stands, but I did wonder whether Geoscientific Model Development might be a more natural home for this than Climate of the Past.

A good case is made in section 3 for the improvement of surface climate in the new model, broken down into the effect of the new snow and the effect of changing the vertical structure of the model, although it might be noted that the old model still just about falls within the error bars of the obs curves in as many panels of figures 1 and A1. I was rather less convinced that the authors had really demonstrated that the SMB numbers had been improved by the new snow though - looking at table 2, at least, the improvement in agreement with the regional models for precipitation seems to be attributable to the change in vertical levels in the model, and although integrated runoff was too low with the old snow it's now rather too high, resulting in a total SMB for

the new snow models that's in worse agreement with the regional models than it was before. Given the importance of refreezing of melt within the snowpack, I thought it would be worth a note on the degree to which this is/isn't happening within the snow model.

The resolution of the model is, as the authors note, probably the main issue here, and there's a related issue that I think could be usefully noted and discussed. A big problem in applying SMB numbers from an atmosphere model to an icesheet is the fine grid resolution required to capture the margin of the icesheet where a lot of this excess melting (from both snowpack SMB and PDD calculations) is occurring. Assuming that actually running your atmosphere at such a resolution is usually prohibitively expense for a GCM, some downscaling/interpolation of the atmosphere model SMB is usually done before actually trying to drive the icesheet model with it. The SMB numbers reported in this paper are thus probably not what would actually be used to force an icesheet model. It might be useful to see how different the SMB numbers are if calculated at a resolution appropriate to the icesheet, rather than the atmosphere if possible, or at least to note how the physically derived SMB from the new snow model will be transferred to a higher resolution icesheet model. Whatever the many flaws of PDD methods, as amply noted by the authors, the resultant SMB calculations are practically simple to transfer to a higher resolution grid and adjust (in an equally flawed manner!) to the icesheet topography, and I would like to know what is planned for the IPSL modelling system.

Smaller comments:

What is the computational cost of the new snow model compared to the old - would it be used purely on Greenland in the final model, or more generally? If higher atmospheric resolution is planned to produce SMB more appropriate for using with the icesheet at the end of the day, how expensive will that be?

Given that the figures do have a lot of panels, I'm not sure it's really worth including the

runs forced with some interannual variability as well as the climatologically forced runs, seeing as there is very little difference in most cases.

Your conclusions about Eemian SMB (pg 1541) sensitivity and improvement seem to be based on a comparison with just one other model study? As such I think the uncertainty of the final statement at least ("results [...] present an improvement") could be highlighted.

I think it's worth noting the assumption of linearity implicit in breaking down your results into those caused by the change in vertical structure and those caused by the snow model as you do (pg 1536, figure 4)

Could you comment more (physically) on why the change in atmospheric levels is required for the new snow scheme to remain stable? And, for completeness, how does LMDZ4_v3 differ from _v2?

pg1524, line 15: "dimishes largely" isn't great English pg1536, line 22: "mean annual warming [...] in winter (etc)." sentence structure is confusing. pg1541, line 8: does "estimated" SMB in this paragraph mean the PDD-calculated version? It could be more explicit.

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