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Climate of the Past Discussions

Interactive comment on "The role of orbital forcing, carbon dioxide and regolith in 100 kyr glacial cycles" *by* A. Ganopolski and R. Calov

Anonymous Referee #2

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This manuscript presents very impressive results from a coupled climate-cryosphere model with simulations extending over the last eight glacial cycles. The manuscript is well written, the scientific content is of high quality and therefore the paper certainly deserves publication. Still, I am far from convinced by the authors results. As also mentionned in the other reviewer's comments, my questions are mainly on the baseline experiment. Of course, the sensitivity experiments and the authors conclusions depend very strongly on the robustness and the physics behind this baseline experiment. It is not clear to me whether the very good agreement with data comes from good physics or good parameter tuning. I would feel more comfortable if the authors were clearly explaining what the "critical assumptions" and "critical parameters" are for obtaining this baseline simulation. More generally, I would like to have a bit more information on this experiment.

1 - From reading their previous papers, my guesses are that the key critical ingredients in the baseline run are dusts, basal sliding and energy balance over the ice sheet. All these processes are parameterized in some fashion and the results are likely to depend a lot on these parameters. The manuscript would be more valuable if the reader could get some insight on this critical problem. Just getting the "right result" is a bit frustating, and the reader would like to know a bit more how it works...

2 - A related problem is the geographic distribution of ice. For instance, there are strong indications that the Saalian glaciation was very different, with a much larger Fennoscandian ice sheet compared to the last glacial maximum (and consequently a smaller Laurentide). Since most of the model building and tuning has been done over the last cycle (eg. Ganopolski et al. 2010), it would be interested to know how different the model results are between different glacial cycles. This would be an easy and useful addition to the manuscript (for instance a plot of the Fennoscandian volume vs. time).

3 - Another critical question is the precise timing of deglaciations. My understanding of the manuscript is that the main forcing involved here is the precessional one (modulated by eccentricity). There is a large number of papers (data and modeling) dealing with the question of the precise relationship between terminations and forcing. It would also be a very interesting addition to have the lead-lags between terminations (defined by for instance maximum change, or some given mid-level threshold) and the forcing, here insolation maxima.

4 - As stated by the authors in the introduction, in most previous works with simplified models (Pollard, Berger,...), the 100 kyr CO2 variation was a necessary input in order to obtain a realistic ice volume history. This is not the case in the present study. It is not obvious what physical processes are leading to this result. In Pollard (1983) this was linked to bedrock depression, but also (mostly) to accelerated flow in the presence of ice-calving. Again, my feeling is that basal sliding (and possibly dusts?) are the key non-linear mechanisms in the authors' results, but this is not stated in the

manuscript. Furthermore, this contradicts the regolith discussion at the end, with more basal sediments (more sliding) leading to the disappearance of the 100 kyr cyclicity. I would really like to better understand the physics behind these results, but unfortunately some important pieces of information are missing here...

5 - in the introduction: "... None of these hypotheses explains the robust phase relationship between glacial cycles and 100-kyr eccentricity cycles". This is wrong. With the exception of Huybers and Wunsch (2005), most previous models are strongly linked (just like this one) to the precessional component of the insolation forcing. Through amplitude modulation of the forcing, all of them are more or less phase-locked to eccentricity, just like in this manuscript.

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