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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

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First, we would like to express our thanks to the reviewer for the constructive and helpful comments. Below, we give response to the general comments and the changes we will apply to the manuscript to improve the paper.

General response

General question is about model-dependence of our key results. While any modeling result to some extent is model-dependent, in our case there are two non-trivial aspects of such model-dependency. Firstly, as we show in Ganopolski et al. (2010) (hereafter G10), simulated glacial cycles are very sensitive to the choice of model parameters which is line with results of previous studies.. As it is described in G10, we carefully

selected values for the most important model parameters based on a large ensemble of model simulations. Secondly, our model has a number of important advances compared to other climate-cryosphere models used before for similar studies. In particular, we employ physically–based approach for modeling surface mass balance instead of commonly used semi-empirical schemes. Another advantage of our approach is explicit treatment of the ice sheet-dust feedbacks, which play an important role in our simulations. Therefore, we would not expect that the models which are not properly tuned or which are based on much more simplistic approaches or which do not account for the most important processes will produce equally good agreement with empirical data. However,the good agreement of the Baseline Experiment with paleodata is not the main message of our paper – this is just a test for the model ability to simulate realistic response to prescribed climatic forcings, a test which we believe, our model successfully passed. The main result of our paper is that 100 kyr cyclicity represents direct, strongly nonlinear response of the climate-cryosphere system to the orbital forcing (under sufficiently low CO2 and reduced regolith area) and that these cycles are phase locked to the 100 kyr eccentricity cycles. And as far as this result is concerned, we strongly believe that it is correct and, therefore, model-independent.

Specific comments

1. The meaning of "agrees well" is, of course, subjective and we will make a more thorough discussion in the revised manuscript. As it is seen in Fig. 1, the agreement is better for the younger cycles than for the oldest, which is not surprising since the model was tuned for the last glacial cycle and the older cycles (prior to MIS 11) differ from the younger in some respects. Certainly, we do not believe that a single model run can challenge well-established empirical data; however, Termination 6 is indeed somewhat problematic, because, according to the EDC3 time scale, CO2 starts to grow when the summer insolation starts to fall. As a result, the model fails to terminate the glacial cycle in accordance with LR05 (around 550 ka) and has to "wait" for the next insolation rise. As far as the contribution of the Southern Hemisphere is concerned, the 10%

assumption, of course, is rather crude but we do not expect that it is relevant for the discrepancies between model and data.

2. The model used here (as well as the modeling setup) is precisely the same as in G10. Therefore, the reviewer is absolutely right (we will make it explicit in the manuscript) that the model was tuned for the last cycle and than used without any changes for the eight cycles. We will also recapitulate in the revised paper the main conclusion of G10 that simulated results are sensitive to the parameters choice.

3. The model simulates significant changes in the ocean circulation during glacial cycle, as it was discussed in G10. They are responsible for millennial scale variations. Changes in atmospheric circulations are relatively subtle as one would expect on the very coarse resolution of CLIMBER-2. Moreover, the model does not include stationary orographic waves. We found no indications that changes in oceanic or atmospheric dynamics are of primary importance for the simulated 100 kyr cycle and therefore decided not to discuss them in order to concentrate on the main aspects of the paper.

4. Obviously, a low computational cost of CLIMBER-2 is the main reason for using the model for simulation of glacial cycles. Still, simulation of eight glacial cycles requires about two weeks on a single processor of a IBM IDataPlex Cluster (IPLEX). However, thanks to the availability of a large number of processors on the IPLEX, we were able perform a large ensemble of simulations simultaneously. In G10 we demonstrated that the computational cost can be reduced significantly by using an acceleration procedure (which is important for expensive GCMs) but here we did not use the acceleration technique to be fully consistent with the Baseline Experiment described in G10.

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