Geosci. Model Dev. Discuss., 8, C1697–C1702, 2015
www.geosci-model-dev-discuss.net/8/C1697/2015/

Geoscientific Model Development Discussions
Open Access

Interactive comment on "Transient simulations of the present and the last interglacial climate using a coupled general circulation model: effects of orbital acceleration" *by* V. Varma et al.

O. Elison Timm (Referee)

oelisontimm@albany.edu

Received and published: 12 August 2015

General comments

The authors investigate how the accelerated orbital forcing affects the simulated climate evolution with a state-of-the-art coupled ocean-atmosphere general circulation model (AOGCM). The technique of accelerating the time-dependent external forcing (or if you will, time-dependent boundary conditions) has been used in earth system models of intermediate complexity, and comparisons between accelerated and un-accelerated forcing simulations have been made. This study builds on these earlier experiments and asks the questions, is the acceleration technique appropriate for transient (pale-

oclimate) simulations with AOGCMs, and what type of distortions and biases can the acceleration technique imply for the modelled climate response.

The overall structure of the manuscript is very well done. The method section describes the important aspects of the model, the initialization of the simulations and the forcing. With the exception of a description how the orbital forcing is actually accelerated in the model. For experts, it may be much too obvious, but for the sake of clarity it should be explained more clearly.

The results that were chosen here as examples to compare the differences between accelerated and un-accelerated runs are all key variables that characterize the transient climate response. However, the motivation why they have been chosen should stressed. In the discussion -albeit being a GMD and not a CP journal contribution - there could and should be some more attention to the physical processes, in general. In particular, in the discussion of the processes that lead to the differences in the simulations. Not only between accelerated (A) and un-accelerated simulations (UA), but also between the different outcomes of the comparisons for the two different time periods.

The latter I believe makes the study very interesting, because it has some surprising outcomes to discuss: Obviously the forcing is similar but has subtle [compared with other pairs of time intervals] differences between the two time periods (PIG, LIG). It appears that the larger discrepancy between A and UA simulations are identified in the PIG, in which the orbital changes are a smaller in the precession component.What components of the orbital forcing or what feedbacks could explain the different outcomes? One candidate could be feedback from changes in sea-ice. Therefore, I would encourage the authors to add to the existing paper a few more results and a deeper discussion of their results.

Minor Comments:

(page and line indicated as pxxlxx)

The method section says that the results shown for the simulation PIG accelerated is the three-member ensemble average. It should be noted that this affects the signal-to-noise ratio (externally forced response to internal variability). As a result I would expect in the time series shown in Fig.2 - Fig. 4 that the results based on LIG accelerated 3-member ensemble average appear smoother compared with PIG results. That seems to be the case, but in the precipitation case of the EOFs (Fig. 7 and Fig. 8) it is surprising that the second mode carries an orbital response in LIG, but not in PIG. So, given that it should be 'easier' to detect an orbitally forced signal in the second EOF in PIG accelerated (compared LIG accelerated) it suggests that the larger forcing during LIG caused a different hydrological response pattern. That needs to be discussed, what could cause the hydrological response to spread over two EOF modes in LIG. But please make sure that EOF modes 2, 3 (4) are not close in their eigenvalues (explained variances) and the orbital mode does not show up in mode 3 (or 4).

p4l25 -p5l2 Description of the orbital forcing PIG vs LIG: Please describe the obliquity changes with more attention to the details. Over the time of the PIG and LIG the changes are different in magnitude but they show a similar change in the beginning. This is important for the discussion of the different early PIG and LIG responses, in my opinion (e.g. Figure 2, why is LIG ocean temperature changing so different in the early parts of the simulations?). Furthermore, the conclusion comments on the importance of the initial state, too.

p5l22-p6l2: Please make a statement if 400 years were sufficient to bring the deep ocean close to the steady-state. In other words can you assert that the first few 100 model years in the accelerated forcing are free of initial-state adjustments? And second, the orbital precession between 9ka and 130ka is about 0.02 units off in the beginning. Could this affect the first few hundred model years in LIG accelerated simulation, and thus the interpretation of forced response in the initial warming seen in the deep ocean?

Results:

The description of the results is well written. However, somewhere in the text (Section Discussion) one could explain the physical response of the system that causes the reported changes in the climate variables. In particular, the role of sea-ice for the ocean surface and deep ocean temperature response is important. A figure with sea ice area time series would be a good addition to the figures 1-4 before looking at EOFs.

p8l2

Consider a short paragraph on describing wind changes in subtropical regions/ tropics. What happens to trade winds, for example? Or refer to papers, if this had been discussed elsewhere in more detail already. p8l13-p8l15 The EOF analysis should be motivated (e.g. "A frequently applied technique in analysing climate modeling is the Empirical Orthogonal Function (EOF) analysis" [ref to be added, e.g. books by Wilks, Statistical Methods in the Atmospheric Sciences, Academic Press) , von Storch and Zwiers, Statistical Analysis in Climate Research, Cambridge Univ. Press].

p9l3-p9l9

For the discussion, I find the differences in the spatial structure in the North Atlantic between LIG and PIG results interesting. Could it be an indicator for the different sea-ice albedo feedbacks?

p9l24-p927

The AMOC changes could be described in connection with the ocean temperature response already. In fact, it would be worth mentioning that overall the AMOC is strong and shows relative small changes. Therefore, shifts in rainfall in tropical/monsoonal regions are (to first order) free from internal AMOC-related changes.

p10 Discussion:

This section should be expanded:

(1) Discussion of causes for the difference in the polar regions and deep ocean.

(2) Discussion of different orbital responses between PIG and LIG (e.g. two EOF modes representing orbital response in LIG vs one during PIG (provided that the EOF results support my point, see comment above).

(3) It would be also insightful if the authors could discuss the role of obliquity and precession in connection with sea ice changes (Timmermann et al., 2014).

p.11 Conclusion:

p11l22-p11l23: The initialization problem has not been discussed explicitly and it deserves clarification. If it is a main conclusion, results and discussion must address the problem.

Technical comments

p6l27: Write "Not only is this trend variability missing in the accelerated run, also the general [...]."

p7l12: write "[...] simulation lags (and underestimates) the cooling of the non-accelerated run."

p7l29: Rewrite the sentence part "Similarly, for the LIG as well a poleward shift [...]". Unclear grammar/meaning

p8l15: Start a new paragraph with "Even though the general pattern [...]"

p11l2: Govin et al. 2014: Reference missing?

Suggestion:

It would be very insightful to have a figure similar to the plots in Fig.2 but for top of atmosphere shortwave radiation times (1 - planetary albedo) (calculated with monthly mean data). This would show where the energetic changes take place and how large they are.

References:

Timmermann, A., T. Friedrich, O. Elison Timm, M. O. Chikamoto, A. Abe-Ouchi, and A. Ganopolski (2014), Modeling Obliquity and CO2 Effects on Southern Hemisphere Climate during the Past 408 ka, J. Clim., 27(5), 1863–1875, doi:10.1175/JCLI-D-13-00311.1.

Interactive comment on Geosci. Model Dev. Discuss., 8, 5619, 2015.