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Geoscientific Model Development Discussions

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.

Anonymous Referee #1

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This study by Varma et al. is a valuable effort to investigate the impact of using orbital acceleration techniques to perform lengthy, multi-millenial, transient climate simulations with a GCM, simulations that would otherwise not be feasible with a model of this resolution and complexity. In most previous model intercomparisons, it has been assumed that applying orbital acceleration does not significantly influence the results, however, as Varma et al. indicate, this has thus far only been tested with models of intermediate complexity. The simulations and results presented by Varma et al. are well designed and allow one to address this issue. However, I do have one main concern that I would like to see addressed. Furthermore there are a number of minor and technical comments that in my view would improve the manuscript.

Main comment:

My main concern is that the approach is rather descriptive and lacks a more quantitative approach to assess if the orbital acceleration technique impacts the simulated climate evolution. A more quantitative method or matrix should be designed to clearly indicate which regions and variables (and therewith processes) can and cannot be investigated based on simulations applying orbital acceleration techniques. An example could be a test if the simulated values are significantly different from each other taking into account natural variability in the system, however other and perhaps better methods can be designed.

Minor comments:

Page 5620, lines 10-17: It is mentioned that the impact of applying acceleration techniques is mainly limited to the high latitudes, a point that is supported by figure 3 for surface temperatures. However, figure 2 shows large differences in the behaviour of global mean temperatures at larger depths. Are those differences also confined to the high latitudes or do they perhaps finger print the main pathways of deep ocean circulation and thus a very different spatial extend compared to the surface temperatures?

Page 5620 lines 10-17: A point related to the above, is that it is not fully clear to me why deep ocean temperatures are presented. To investigate if future model studies that apply orbital acceleration should or should not investigate deep ocean temperature changes? Or are they only presented to make the point that high latitude surface differences are related to deep ocean temperature biases? Does the study solely focus on surface variables? Please clarify in the text.

Page 5621, lines 9-10: Is that the only, or main reason to use GCMs?

Page 5623 line 3: Consider including a scentense explaining the changes in annual mean insolation.

Page 5623 lines 10-12: For the PIG an ensemble mean is presented. Please clarify

why this is done, why only for a single period and how this might potentially impact the result. Specifically I'm thinking of the amount of internal (decadel to centennial) climate variability that is present in the single runs while it is averaged out in the ensemble mean.

Page 5623, lines 17-22: Fixed GHG values are used. Would your results differ if also GHG changes would be imposed with an acceleration factor of 10? In other words, do the results only apply to accelerating the orbital forcing or is it likely that the same is true for accelerating GHG changes?

Page 5623 line 27: What about the initialization of the accelerated PIG simulation? Is the same procedure applied? If not, does that perhaps partly explain the differences in the temperature evolution at larger depths?

Page 5624 line 9: It would help the reader if a short discription is given of the kind of analyses that will be presented and how that allows one to investigation the impact of using orbital acceleration techniques.

Page 5625 line 4: In figure 2 it is apparent that the temperture evolutions at 1884m depth between the PIG and the LIG differ strongly while at other depth levels they are much more consistent and in line with the similarities in the orbital forcing. Please shortly discuss what could explain these differences.

Page 5626 line 2: Please indicate how these results (850hPa zonal wind changes) help in identifying the impact of orbital acceleration. It appears a little arbitrary which variables and levels have been investigated and which have not. Please clarify.

Page 5627 line 3: In line with the point above, please shortly mention why EOFs are investigated, how do they help to investigate the research question of this manuscript?

Page 5628 lines 1-11: The conclusion that regions that are in direct contact with the deep ocean are more likely to be biased by the applied acceleration technique sounds reasonable. However, the data and analysis to support this finding is rather limited and

appears only losely based on the geographical extend of the regions where differences are found. Following my main comment, a more quantitative approach could lead to a more clear pattern showing the deep oceans and high latitudes as regions in which the impact of orbital accaleration is greatest. This would also allow one to pinpoint more specific regions in which the acceleration technique impacts the results and if they are or are not directly driven by the connection (e.g. the North Atlantic, the Southern Ocean, North Pacific?, Arctic?)

Page 5628 lines 1-11: How did the authors come to the conclusion that sea-ice plays an important role in expaining their finding? Please provide a more thorough description.

Page 5628 lines 1-11: Are there perhaps still other processes that could explain the described differences between the accelerated and non-accelerated simulations?

Page 5629 lines 3-8: It would be very usefull if the description of the regions that should not be targeted when applying orbital acceleration is more specific than only mentioning the high latitudes. Only the regions of deep convection? Only ocean regions? What kind of processes should not be targeted in investigations applying orbital acceleration? Such a more detailed listing would provide a usefull reference for future paleoclimate modeling studies.

Page 5629 lines 21-23: How is the importance of initialization of the transient simulations in certain regions established?

Figure 1: consider depicting insolation changes since the provide a much more direct picture to the reader as to the evolution of the main climate forcings applied in the simulations.

Figure 2: Why is an additional running average applied to the non-accelerated values? And if this is done in all figures, perhaps the description of the applied averaging in the main text should be adjusted.

Figure 3: How are the two fields substracted in the right-hand-side panel since the

accelerated runs consist of ten times less data points. Please clarify.

Figure 4: The zonal winds appear affected for most of the globe and not limited to the high latitudes. Furthermore, in the LIG simulations the impact on the NH westerlies appears of similar size as the impact on the SH westerlies. Please explain why only the differences in the SH are described in the main text.

Figures 5-7: Please clarify why in this part of the analysis no running mean is applied to the non-accelerated model output. Is the EOF analysis impacted by the fact the there are ten times less datapoints in the accelerated simulations? Consider calculating a difference plot for the EOFs (if meaningfull).

Technical comments:

Page 5624 line 16: “as we go further deep”. Please reformulate.

Page 5629 line 13: Comparison with what? Please rephrase.

Figure 3: Consider putting the latitude on the vertical axis.

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