

Interactive comment on “DeepMIP: experimental design for model simulations of the EECO, PETM, and pre-PETM” by Daniel J. Lunt et al.

Anonymous Referee #1

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General comments

This manuscript describes the DeepMIP protocol for common climate simulations for periods older than the Pliocene. These periods, the Early Eocene Climate Optimum (EECO), the Paleocene-Eocene Thermal Maximum (PETM) and the period immediately prior to the PETM, are among the warmest period known in the Earth climate history. This makes them interesting to model in the context of better understanding processes at work in warm climates, such as the future one could be, and of testing the models' ability to represent these warm climates.

The paper is generally clearly written and the justification and experimental design of the experiments are quite convincing as far as these past climates and comparison to

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available data is concerned. It is proposed to run sensitivity experiments to account for different sets of boundary conditions, and experiments with different CO₂ levels to account for the uncertainties in the CO₂ reconstructions, which is interesting to test climate sensitivity to CO₂ under these conditions. With this perspective, the experimental design could be improved to better liaise with the CMIP6 exercise. In particular, the CMIP6 DECK includes a preindustrial and an abrupt4xCO₂ experiment, in which the CO₂ level is quadrupled from the pre-industrial level. The DeepMIP protocol recommends to run the pre-industrial as in CMIP6 but it would be very interesting for the groups to also run the CMIP6 DECK abrupt4xCO₂ simulation. If the DeepMIP protocol also included a similar 4xCO₂ experiment with the deep-time continents and ocean, then it would be easy to examine whether the deep time continents and oceans have an impact on the Earth's sensitivity to greenhouse gases increase, and how much can be inferred on climate sensitivity from these climates. I would therefore argue for changing the priorities in the experimental design (cf page 7, lines 9-11) and to test 2x and 4xCO₂ (and higher) first, rather than 3x and 6xCO₂. The pre-industrial control and the abrupt4xCO₂ experiments have also been proposed to be mandatory for modelling groups wishing to take part in the PMIP4 exercise, to better liaise with CMIP6, so the above recommendation would also warrant a better relation to PMIP4 activities.

Apart from the more specific comments below, what is missing from the manuscript at this stage is a table summarizing the experiments and boundary conditions, and the names given to the experiments so that all groups use these names. Additional figures could also be inserted to better illustrate the scope of the project and the different options in boundary conditions, as explained in the comments below.

Otherwise, the paper is clear and well written and can be published after these corrections are made.

Specific comments

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pages 2-3, section 2: this section on previous work could be illustrated by a figure showing what can be improved from this previous work.

page 3, section 3: for outsiders, it would be good to have a figure locating the three periods in a broader chronology of the Earth climate evolution.

page 4, section 4.2, lines 11-12: "There are three standard simulations" seem to contrast with the sentence at the top of the page: "The DeepMIP experimental protocol consists of four main simulations". It would be good to clarify this: three periods, but four simulations.

page 4, section 4.2.1: it would be good to stress at this point that the same paleogeography is used for all three periods. Also, the main cautionary points in the implementation of the paleogeography, such as straits and shallow basins, should be highlighted, in relation with the sensitivity experiments proposed in section 4.3.2.

page 5, lines 7ff, about the soils: I am not very familiar with this issue, but I would expect spatial heterogeneities in soil properties, so how can these be prescribed "homogeneously"?

page 7, value of the solar constant: it has been revised to 1361 W/m² (Matthes et al, <http://www.geosci-model-dev-discuss.net/gmd-2016-91/>). Since this paper is still in discussion, it will be worth referring to its final value when it is out. However, this has an impact on the discussion about early Eocene values in section 4.2.5 and on the sensitivity experiments proposed in section 4.3.5. Is the value found by Gough (1981) actually tied to a present value of 1365 W/m²?

page 7, justification of not changing the solar constant in the DeepMIP experiment, to counteract the absence of elevated CH₄ in the design. This should be better justified. Both forcings are not equivalent and it is rather easy to change the CH₄ values in the models. At least the radiative forcing from the CH₄ high values should be evaluated

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and compared to the non-changes in the solar constant.

page 9: sensitivity to paleogeography: maps of differences could be shown to convince modelling groups that it is worth investing the time to perform these sensitivity experiments. A practical question is about where to actually find this other paleogeography.

page 12: the PMIP data base should be used ! this is the only way cross-period analyses can be performed and other groups can be involved, bringing additional diagnostics and analyses. So the list in Table 1 should be expressed in terms of PMIP/CMIP6 variables. In particular, the acronyms "FLNS", "FLNT" etc should be explained.

Typos/rephrasing

page 2, line 7. Replace "paleo simulations" by "paleoclimate simulations" (we hope that the simulations are new, and not "paleo")

page 2, line 15: "deep-time model intercomparison project". should this be "deep-time climates"? The project does not aim at comparing deep times, but rather their climates, doesn't it?

pages 4 and 5: references should be added for the CESM and CLM models.

page 7, line 25: the Louvain-la-Neuve group has recommended to use the term "astronomical parameters" rather than "orbital parameters" since obliquity is not an element describing the orbit of the Earth.

page 9, line 9: reference to Appendix 1 should be changed to Appendix A.

page 10, line 27: the link to the section is missing

page 11, last line: parentheses are missing around the web site reference.

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