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

Anonymous Referee #2

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SUMMARY:

This manuscript describes the 'DeepMIP' (PMIP) protocol for palaeoclimate simulations of the latest Palaeocene and Eocene.

DeepMIP is a valuable addition to the world of MIPs, as eloquently and succinctly summarised by the authors: 'models of past high-CO2 [> 800 ppmv] periods have never been evaluated in a consistent framework'. The manuscript is clearly written, flows well and has a logical structure. The protocol itself has no doubt taken a lot of in depth discussion to finalise, and comes across as having been thoroughly designed. However, there are a few boundary conditions (solar constant and CH4) that need updating. In some places, some expansion of the text is required to clearly explain what may already be apparent to experts immersed in the science, but would be helpful information for

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the less well-versed. These mainly relate to summarising existing literature and would not be fundamental changes to the manuscript structure or protocol details. In addition to the model products, the new [syntheses of] geological records will be an important result.

In summary, this is a very well written manuscript that is enjoyable to read and presents a robust and much needed protocol for simulating the latest Palaeocene-Eocene climate. With minor changes, I believe it is well suited for publication in GMD, and I look forward to the MIP results.

General and specific comments follow.

GENERAL COMMENTS:

1. There needs to be better consistency between the way the core simulations are referred to: a. Whether there are 3 or 4 (I understand that there are 3 palaeo simulations and 1 preindustrial simulation and that these are the core, but this is not clear enough in the manuscript when interchanging between describing 3 and 4 core simulations): b. How the palaeoclimate simulations are named as both 'pre-PETM', 'PETM' and 'EECO' versus 'two early Eocene, and one latest Paleocene' etc.; better to pick one convention and stick to it throughout. I think the pre-PETM, PETM and EECO nomenclature is clearer. E.g. page 4, line 2-3 (?); page 9 line 12, page 11 line 8, and others. c. Use the term 'core' instead of alternatives. e.g.: Page 4, line 2(?): change 'four main simulations' to 'four core simulations'. Or, use 'main' instead of 'core' throughout. Page 11, line 11: 'core' instead of 'standard'. Better to check throughout.

2. 'palaeo' and 'paleo' are interchanged throughout. Better to choose one convention and stick to it, since GMD is an EGU journal, I recommend 'palaeo'. Please correct throughout.

3. In sections 4.2.3 and 4.2.5, the choice to use a higher solar constant (1365 W m-2) than what is suggested for the latest Palaeocene-Eocene (1359 W m-2; Gough,

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1981; see manuscript) is justified by stating that it will in part counteract using lower atmospheric CH4 than probably existed (and vice versa). I struggle to accept this justification. Using the updated CMIP6 preindustrial solar constant (see point 32) would provide a much smaller difference between the latest Palaeocene-Eocene and present day solar constants (+2 W m-2). Besides this, without a quantified effect of each (solar constant versus CH4), this speculation seems to be very vague, and the effects are likely to be non-linear, surely. Since these are relatively straight forward boundary conditions to implement in the model (compared to palaeogeography, for example), why not use a more suitable solar constant (presumably 1359 W m-2) and a representative CH4 – few of the boundary conditions are certain, but if we know CH4 was elevated then surely it should be in the model set-up. Otherwise what can be achieved by the model-data comparison? This also effects section 4.3.5. It is a valuable sensitivity study, but with regard to my comment on this above, this section might need rethinking/phrasing (e.g. the sensitivity study to use the preindustrial value of 1361 W m-2, or others if the literature presents alternatives to 1359 W m-2/indicates the uncertainty on this).

SPECIFIC COMMENTS: (suggested inserted text in italics)

4. Page 2, line 5: 'Together with the CMIP6 preindustrial simulation, these form the first' (or other such indication that the preindustrial simulation is part of the core experiment; see comment 1)

5. Page 2, line 7: 'core palaeoclimate simulations, one core preindustrial simulation and a set of'

6. Page 2, line 17-18: 'It also aims to assess their relevance for our understanding of future climate change.' This would be a valuable addition, but I don't think it's really followed up later. I suggest adding a brief section to the article explicitly dealing with this.

7. Page 2, line 19: I checked in CMIP and PMIP and I don't think this will be part

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of CMIP, so maybe make this a little clearer here; from this line I was left with the impression that DMIP will be in CMIP6.

8. Page 2, line 22 and throughout: proxy for what? Suggest 'climate proxy'. This should be checked throughout and always amended so that it is clear what the 'proxy' is a proxy for.

9. In general there is a misuse of 'which', when used for restrictive clauses it should be 'that', though maybe this is different in American English: a. Page 2, line 25 b. Page 2, line 26 c. Page 3, line 13 d. Page 5, line 3 e. Page 9, line 1(?) f. Page 9, line 22 g. Page 10, line 19 h. Page 11, line 28

10. Page 2, line 26: 'of particular relevance' for what?

11. Page 3, line 2: suggest summarising the intriguing model-data mismatches and inconsistencies between 'proxies'.

12. Page 3, line 3-4: insert commas after 'Gasson et al. (2014)', 'Lunt et al. (2013)' and 'Carmichael et al. (2016)'. Change comma to semi-colon after 'inception' and 'Eocene simulations'.

13. Page 3, line 8: suggest rephrasing 'proxy-proxy differences' (see comment 8. 'data' used previously, or could be more specific: 'differences between geological data').

14. Page 3, line 9-10: suggest reordering the time periods so that they are chronological (and again below in lines 19-21).

15. Page 3, lines 19-21: as well as reordering (comment 14), suggest adding a brief description of these time periods to make it clear what they are and why they were specifically chosen (e.g. a brief description under each numbered list element); otherwise that information is lacking. In particular, this information should explicitly (but not exclusively) tie-back to (i), (ii) and (iii) from lines 11-14; perhaps at least one sentence on each.

16. Page 3, line 23-24: ‘The pre-PETM. . .and the EECO’. I’m sure this is true, but it’s not very clear how or why this is true. Addressing comment 15 would probably solve this.

17. Page 3, line 29-30: after ‘recent interest in. . .relevance to future warming’ add some example references.

18. Page 4, line 8-9: so would this then constitute 5 core simulations for those groups?

19. Page 4, line 10: add simulation names in header ‘(pre-PETM, PETM, EECO)’

20. Page 4, line 11: clarify that ‘three core palaeoclimate simulations’; there are four (or five – comment 18) core simulations.

21. Section 4.2: It’s a little unclear as to what boundary conditions relate to which of the three core palaeoclimate simulations. It would be helpful if this could be clarified through the text in this section.

22. Section 4.2.1: So, are all groups expected to adjust their model’s bathymetry in line with the boundary conditions? Can/will all groups do this? If not, maybe add a few lines on this so it’s clear.

23. Page 4, line 14: remove back-to-back parentheses, adjust to ‘Herold et al. (2014; henceforth H14)’

24. Section 4.2.2 (iv) river runoff: do some models compute this from their orography and land-sea mask?

25. Section 4.2.3: it would be helpful to add a figure compiling and summarising the greenhouse gas concentrations (at least for CO2) over this period from the geological data, including uncertainty. I understand the time axis would probably need to expand over a substantially wider period that these simulations cover, but then the periods represented by the three palaeoclimate simulations could be highlighted (e.g. vertical shaded bars if time is on x-axis). It would give helpful context as well as summarise

the uncertainty. The 1x, 3x, 6x and 12x CO2 values (plus 2x and 4x?) could also be indicated (e.g. dashed horizontal lines).

26. Section 4.2.3: This is entitled 'Greenhouse gas concentrations', but really only addresses CO2. I suggest at least adding a discussion and presentation of CH4 boundary conditions (see comment 3), but otherwise rename this section appropriately.

27. Page 6: line 7-8: add refs for the records showing this (CO2 and extant temperature records). Possibly also clarify what 'extant temperature records' means in this context; is it the temperature proxy archive that survives or the temperature reconstruction?

28. Page 7: some extra commas are needed: Line 5 after '(see Section 4.2.5)' Line 6 after 'In effect'

29. Page 7, line 6: 'at the CMIP6 preindustrial concentrations'?

30. Page 7, line 8: 'terms of global surface temperature'? This is unclear so needs clarifying.

31. Page 7, line 10-11; can this also be justified scientifically? What are the implications/added value of the results of these 2x and 4x CO2 simulations?

32. Page 7, line 27: the solar constant is out of date. The CMIP6 preindustrial value will be 1361.0 W m−2 (Matthes et al., 2016). Also affects page 10, line 23.

33. Page 8, line 6: replace 'SSTs' with 'Sea Surface Temperatures (SSTs)'

34. Page 8, line 24: Do you mean 'hydrological' instead of 'geological'? Otherwise I'm not sure what is meant by 'geological cycling'.

35. Page 9, line 7: what is the address/location/reference for the PMIP database?

36. Page 9, line 7: replace 'in the Appendix' with 'in Appendix 1, including Tables 1-3'.

37. Page 9, line 9: 'Appendix 1, Tables 1-3'.

38. Page 9: some extra commas are needed: line 26: after 'Ideally' line 30: after

'studies'

39. Page 10, lines 4-6: why carry out sensitivity studies of 'widening/constricting and shallowing/deepening key ocean gateways, raising/lowering mountain ranges, and changing the bathymetry of ocean shelves'? Please summarise (from the literature) the kind of changes or uncertainties in these boundary conditions that are thought to have taken place during this period, and what effect they may/may not have had?

40. Page 10, line 27: what should be there instead of 'Section ??'; is it 'Section 4.2.6' or 'Section 4.2.7'? Where is this discussed? I think the discussion needs adding to one of these sections (4.2.6 or 4.2.7 or both).

41. Page 10, line 28: 'will be a function of'.

42. Page 11, line 17: 'will be to develop new ways'.

43. Page 11, line 22: remove parentheses from within parentheses: 'see Dowsett et al., 2012)'.

44. Page 11, line 29: add comma: 'In this respect, we are'

45. Page 11, line 29: reference the PlioMIP special issue properly, because I assume that is why the URL is given (i.e. in addition to the Haywood et al. ref).

46. Page 12, line 8: Change 'Appendix A' to 'Appendix 1' (or vice versa earlier).

47. Page 12, line 9: 'variables below (Tables 1-3) should be submitted'

48. Table 2: replace 'SST' with 'Sea surface temperature', replace 'T' with 'potential temperature' (I assume it is potential temperature?), replace 'S' with 'salinity'.

Reference cited in review: Matthes, K., Funke, B., Anderson, M. E., Barnard, L., Beer, J., Charbonneau, P., Clilverd, M. A., Dudok de Wit, T., Haberreiter, M., Hendry, A., Jackman, C. H., Kretschmar, M., Kruschke, T., Kunze, M., Langematz, U., Marsh, D. R., Maycock, A., Misios, S., Rodger, C. J., Scaife, A. A., Seppälä, A., Shangguan,

M., Sinnhuber, M., Tourpali, K., Usoskin, I., van de Kamp, M., Verronen, P. T. and Versick, S.: Solar Forcing for CMIP6 (v3.1), Geosci. Model Dev. Discuss., 1–82, doi:10.5194/gmd-2016-91, 2016.

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