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Climate of the Past Discussions

Interactive comment on "PlioMIP2 simulations using the MIROC4m climate model" *by* Wing-Le Chan and Ayako Abe-Ouchi

Anonymous Referee #1

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I enjoyed reading the manuscript "PlioMIP2 simulations using the MIROC4m climate model". It is well-written. The figures are well-made. The results and analysis are clear and logical. I am in support of publishing this study. Here are a few thoughts that the authors might consider:

1. I am afraid, the conclusion (also in the abstract) that CO2 below 400 ppm provides a better simulation, could be better supported. This conclusion is derived from comparing the global mean SST difference between simulated SST and PRISM3 SSTs, and "Since the global difference is determined more by the low latitudes, Eoi350 gives the best global fit (a difference of 0.14°C)" (citing the original text). However, it is worth noting that 1) tropical SST estimates have uncertainties (Tierney et al., 2019, GRL) and 2) Eoi400 does provide better match with mid- and high latitudes' SSTs. The proxy

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data-model comparison can benefit from Student-t test by considering the proxy data uncertainty and spatial spread as well as the model data spatial spread.

2. Further, PlioMIP2 is designed to focus on KM5C in order to avoid ambiguities of model-proxy data comparison introduced by orbital cycles (Haywood et al., 2016). As part of this effort, datasets from PRISM4 (cited in the manuscript) and PlioVAR (McClymont et al., 2020) are developed. PRISM3 dataset included more tropical sites than PRISM4 or PlioVAR. One might wonder that if the same analysis discussed in section 4.8 were done with PRISM4 or PlioVAR dataset, the conclusion might be different.

3. Section 4.1: the description of simulated surface air temperature has mentioned a few times that the CO2 induced warming is homogenous (uniform). However, by examining Fig. 3 and 4, it looks that there is a clear polar amplification signal with increasing CO2. It shows up in Fig. 3a and when comparing Fig. 4 Eoi experiments with different CO2.

Other comments: 1. line 9: please spell out PMIP.

2. Line 23: PlioMIP2 is designed to simulated KM5C, this sentence hints that the current simulation is not using realistic orbit, which is not the case.

3. Line 18, please also reference more recent publications, here are a few examples: For pollen:

Panitz, S., Salzmann, U., Risebrobakken, B., De Schepper, S. and Pound, M.J., 2015. Climate variability and long-term expansion of peat lands in Arctic Norway during the late Pliocene (ODP Site 642, Norwegian Sea). Climate of the Past, 11, pp.5755-5798. For Fossil floras: Fletcher, T., Feng, R., Telka, A.M., Matthews Jr, J.V. and Ballantyne, A., 2017. Floral dissimilarity and the influence of climate in the Pliocene High Arctic: Biotic and abiotic influences on five sites on the Canadian Arctic Archipelago. Frontiers in Ecology and Evolution, 5, p.19.

4. Line 65 – 68: Here is another important reference for CO2 using boron isotope:

Martínez-Botí, M.A., Foster, G.L., Chalk, T.B., Rohling, E.J., Sexton, P.F., Lunt, D.J., Pancost, R.D., Badger, M.P.S. and Schmidt, D.N., 2015. Plio-Pleistocene climate sensitivity evaluated using high-resolution CO 2 records. Nature,

5. Line 85 – 86, I don't understand this. Is the flux change still happening between atmosphere and ocean?

6. Line 90, what is the sigma level referred to? P/Ps?

7. Line 93 – 95, What is the cloud scheme? Is there microphysics? Does the model simulate indirect effects of aerosols? or the direct effect? or none?

8. Line 98, "Water and heat exchange between the land surface and atmosphere, and runoff flux to a river routing model are represented." What does "represented" mean? Is there a multi-layer radiation scheme or simple scaling?

9. Line 104, does the sigma level here mean potential density level? Please specify.

10. Line 111, what about the radiation scheme for sea ice? Is it simple scaling with fixed end members of albedo? or more sophisticated radiation scheme?

11. Line 136, why did the doubling CO2 experiment use 571 ppm instead of 570 (285x2)?

12. Line 46 – 47, Please specify that paleogeography is also changed according to the PlioMIP2 protocol.

13 line 160, This whole sentence is very confusing. I don't think it is needed. Please remove.

14 Line 194 – 195, I don't understand what do you mean by "bias"?

15 Line 254 – 262, it would be help to use present-day known deep water formation sites (such as GIN sea, Lab sea) as the geographic reference to construct this section (e.g. deep water formation weakens in the GIN sea, but strengthens in Lab sea).

16 Line 286, the authors might consider including another recent simulation in this list: Feng, R., Bette L, O.B., Brady, E.C. and Rosenbloom, N.A., 2020. Increasing Earth System Sensitivity in mid-Pliocene simulations from CCSM4 to CESM2. https:/doi.org/10.1002/essoar.10501546.1

17 Line 304 to 305: It might worth noting that this is different from the recent PlioMIP2 runs with CCSM4/CESM1 and 2 (the study listed in the above) (heat transport are reduced in both hemispheres).

18 Line 350 – 351, "It is worth noting that not only does Eoi280 give the best fit at low latitudes, but bucks the trend at the northern high latitudes where the discrepancy is smaller than that for Eoi350." I don't understand this sentence.

19 Line 390-391, "with modelled climate, ice sheets and vegetation exhibiting strong regional variations associated with orbital parameters, whether as time-dependent forcing in transient simulations (Willeit et al., 2013) or fixed to minimum or maximum forcings (Dolan et al., 2011)." Feng et al., (2017, EPSL) further demonstrated the regional warming/cooling patterns induced by mPWP orbital variations in a statistically meaningfully way.

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