

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-72

Anonymous Referee #1

Referee comment on "Evaluating the large-scale hydrological cycle response within the Pliocene Model Intercomparison Project Phase 2 (PlioMIP2) ensemble" by Zixuan Han et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-72-RC1>, 2021

This paper evaluates the contribution of thermodynamical and dynamical effects to changes in P minus E in the simulated Pliocene warming. It decomposes the moisture budget into thermodynamical and dynamical contribution, which are further decomposed by applying the 3-pattern decomposition of the atmospheric circulation. The authors find that both mechanisms have significant contributions in explaining changes in PmE. In general, they find that thermodynamical effect can explain the wetter tropics and drier subtropics, however, when looking to more regional changes within the tropics and subtropics, dynamical effects have an important contribution. The paper goes on to explore possible reasons for the changes in the moisture budget components.

I think that the methods applied to achieve the main objective are appropriate and that the paper shows an interesting contribution to the research in the field. Therefore, I recommend the publication of this manuscript by the journal Climate of the Past, but I see some major issues that need to be addressed before publication.

General comments:

- The main objective of the study is to evaluate the relative contribution of thermodynamical and dynamical effects in the PlioMIP models. However, the paper does not compare the relative contributions of the two. The authors correctly applied the moisture budget decomposition, but they do not quantitatively compare how much of each of the components contributes to the total PmE pattern. I think this analysis is crucial to this evaluation and would greatly improve the manuscript.
- The authors have produced interesting results that should be introduced more carefully. There is a contradiction in the abstract. The authors initially exemplify the changes in PmE over the Pacific ITCZ as a result of the thermodynamical effect. And a few lines below, they evaluate that the ITCZ shifts 1° northward (which is a result of dynamical changes). To me, the results show that in a very general (large-scale) manner the

thermodynamical effects explain the wetter deep tropics and drier subtropics. But when looking to regional changes within the tropics and subtropics the dynamical effect plays an important role (i.e. northward ITCZ shift, southward SPCZ shift, wetter north Indian ocean).

- It was not clear to me what boundary conditions the PlioMIP2 models have applied. For example, did they apply 400 ppm CO₂? Are there changes in the extension of the ice sheets in both hemispheres? Vegetation? Changes in the configuration of the continents? Also, I think there should have a final discussion as how these boundary conditions could have affected the simulated PmE changes.
- Section 3 is an important section of paper that introduces the simulated PmE changes that will be further explored in the next sections and should be carefully revised. To me the key message of section 3 is that, in a first look to changes in PmE, there seem to have important contributions from both TH and MCD, but the authors mainly discuss TH (see comment 2 and detailed comments below).
- Section 5.1: it is interesting to examine the global pattern in wind divergence and humidity. But SST pattern must be analysed more thoroughly, especially in the tropics where local SST will probably help to explain the thermodynamical effect.

Xie, S.-P., C. Deser, G. A. Vecchi, J. Ma, H. Teng, and A. T. Wittenberg, 2010: Global warming pattern formation: Sea surface temperature and rainfall. *J. Climate*, 23, 966–986, <https://doi.org/10.1175/2009jcli3329.1>.

Specific comments:

Line 54: Changes in the hydrological cycle are a response to regional and global climate anomalies. I would rephrase to "Global warming can induce regional and global anomalies in the Earth's hydrological cycle..." or similar.

Line 203: Figure 1a indicates that changes over the Maritime Continent are not consistent across models. I suggest removing mentions to Maritime Continent and rather focus on the North Indian Ocean, where changes are significant.

Line 207: When discussing changes in Southeast Asia and Sahel the authors must discuss the effect of vegetation. Do the PlioMIP models apply changes in vegetation?

Line 213: It is not clear to me why a drier extratropical North Atlantic is related to increased SST. Wouldn't an increased SST drive increased precipitation (note increased humidity in the north Atlantic in Figure 6b)? Also, Figure 5a does not show SST. Do you mean Figure 6a? I suggest leaving this discussion to Section 5.1 to avoid referencing figure 5 without mentions to figure 3 and 4.

Line 215: I suggest a reformulation of this paragraph to include that both TH and MCD

seems to be important for the PmE changes, as it shown later in the manuscript.

Figure 1b: Why the authors choose to show the models' standard deviation? To be consistent with your choice of showing significance based on model agreement in Figure 1a, it would be more appropriate to show interquartile range (non-parametric statistics).

Line 396: Figure 9a indicates that the intensification of the PWC is not significant. I wouldn't mention the value.

Lines 395-405: I think that the key message of this paragraph is that the change in the intensity of the PWC does not explain the change in PmE in the Indian Ocean. As such, here it should be clearer for the reader that the changes in PWC intensity, dSST and dSLP are not consistent (nor significant) across models. Nonetheless, changes in dSST and dSLP can explain changes in PWC intensity. This paragraph needs to be reformulated.

Figure 9: Panel 'b' seems lost in this Figure. I would consider moving it to Figure 10. This way, all results explaining the shift in the zonal circulation would be clearly shown in one figure. There is no mention to Figure 9b in between lines 395-405.

Line 422: Do you mean a westward expansion of the PWC and a westward displacement over the Indian Ocean?

Line 437: westward 'expansion' of the PWC?

Section 6: the authors must discuss the main results on the light of the boundary conditions applied by the PlioMIP models and their uncertainties, to guide future research.

References: I recommend not referencing papers that are not publicly available (i.e., references 'in prep').

Technical corrections:

Line 68: Redundance. "enhance the increase in atmospheric...".

Figure 1a: I recommend changing the colour of the stiplings. It is hard to see even when zooming.

Line 364: include a reference to Figure 8 for clarity.

Figure 10a: indicate the intensity of the PI contours.