

# Author response to comments by anonymous referee#2

## Major comments

**“Firstly, the language needs to be improved and simplified to make it more understandable.”**

We very much appreciate the reviewer’s effort in pointing out various locations where the language needs to be overhauled. Those locations, where the reviewer gives suggestions, have been already fixed in a revised version of the manuscript. Furthermore, we will carefully check other locations prior to submission of the revised manuscript. Does the editor suggest submission of the manuscript to a language editing service?

**“Secondly, and probably most importantly, although there is a good data-model comparison, this is only done against PRISM3, rather than the more up-to-date and probably more appropriate PRISM4 dataset. There is some utility in doing this comparison, partly as there is a long legacy of doing so, enabling comparison with previous data-model comparisons. However, in PlioMIP2 the move is towards simulating a timeslice within the mid-Pliocene, trying to select an appropriate set of boundary conditions to one particular time and refining the proxy datasets to allow a more appropriate data-model comparison (Haywood et al., 2013b). There are now two datasets that allow for data-model comparison with the marine isotope stage KM5c timeslice, the PRISM4 reconstruction of the North Atlantic (Dowsett et al., 2016), as set out in the experimental design (Haywood et al., 2016) and the global reconstruction of McClymont et al. (2020). The discussion of the data-model comparison, covering the second half of page 21, will need to be updated considering the timeslice and the subsequent data-model comparison. [...] If a PRISM4 comparison is done, it would be useful to include this in Figure 21 (or a new figure).”**

We thank the reviewer for highlighting that our model-data comparison could be more up to date. In the revised manuscript we will, in addition to the model-data comparison based on PRISM3 that is already part of the manuscript, also consider the reconstructions by McClymont et al. (2020) and by Foley and Dowsett (2019). To this end we will create an additional figure panel that presents a similar model-data comparison as done with PRISM3 data in Fig. 21. We propose to do this only for the CORE simulation Eoi400 to not create the need for more than one additional figure panel. The updated proxy data sets contain six different individual data sets - those by Foley and Dowsett (2019), with both a 10 ka and a 30 ka time window; and the BAYSPLINE and BAYMAG data sets by McClymont et al. (2020), as well as the respective previous data sets based on the calibration by Müller98 as outlined by McClymont et al. (2020) in their manuscript. We will treat these data sets in the model data comparison independently from each other. Table 6 will be extended to also convey information on model data comparison results based on the updated proxy data. Our discussion will be updated accordingly, where we will focus on results of our model-data-comparison that differ in dependence of the employed proxy reconstruction.

Please note, that we will need a bit more time to finish this part of the manuscript update, as the final PlioVAR synthesis product by McClymont et al. (2020) has not yet been released (Erin McClymont, pers. comm.).

**“A number of times in the figure captions you refer to SIC as sea ice compactness. In the standard CMOR variable names SIC is sea ice coverage (or sea ice area fraction) and the images look like they are indeed this variable.”**

The variable “SICOMO” in the COSMOS is called “sea ice compactness” and it indeed represents sea ice concentration, or sea ice area fraction. To maintain consistency with other publications, we have replaced all occurrences of the term “sea ice compactness” in a revised manuscript by the term “sea ice coverage”.

**“In Figure 6 and 16 it is very hard to see changes in the North Atlantic Deep Water (NADW). Consider showing these in both anomaly and absolutes, so that the magnitude of changes can be seen even if they are small.”**

We agree with the reviewer that showing anomalies in addition to absolute values of the AMOC would improve the visibility of changes between simulations. We hence have created two additional Figures: a new Fig. 7, that is like Fig. 6, but shows AMOC anomalies, and a new Fig. 18, that is like Fig. 16 in the discussion manuscript (Fig. 17 in the revised manuscript), but shows AMOC anomalies. We have added additional text to section 3.1.2, 3.5, and 3.9 that describe results derived from these figures.

**“Figure 13 would be improved by plotting the pre-industrial (E280) sea ice, probably as a first row at the top of the figure.”**

We have created an updated version of Fig. 13 where we show the results from E280 in the top row.

## **Specific comments**

Page 1, line 5: Should read “With this manuscript we present . . .”

fixed

Page 2, line 2: Should read “They deliver knowledge that is key to preparing humankind for future environmental conditions . . .”

fixed

Page 2, line 14: Should read “. . . furthermore enables us to test our model against climate states that are warmer . . .”

fixed

Page 2, line 16: Should read “Successful reproduction of past climates increases confidence in a climate model . . .”

fixed

Page 2, line 18: Should read “. . . a warmer-than-present climate state has been found.

fixed

Page 2, line 22 and throughout the manuscript: The mid-Pliocene is not a formal stratigraphic unit, so it should not be capitalised. All “Mid-Pliocene” occurrences should be changed to “mid-Pliocene”.

fixed

Page 2, line 24: Remove “respectively disagreement”.

fixed

Page 4, line 10: Should read “One difference is the utilization of the dynamic vegetation . . .”

fixed

Page 4, line 16: Should read “Yet, the COSMOS has characteristics . . .”

fixed

Page 4, line 21: Should read “Furthermore, in PlioMIP1 the COSMOS was shown to predict . . .”

fixed

Page 5, line 28: Should read “It is able to adapt global vegetation distribution and related albedo- and evapotranspiration-feedbacks in the presence of changes in ambient climate . . .”

fixed

Page 6, line 12: Should read “As an important process for breaking stratification, the MPIOM . . .”

fixed

Page 8, line 15: Should read “The starting points are the PRISM4 . . .”

fixed

Page 8, line 31: Remove “as well”.

fixed

Page 11, line 15: Should read “we follow the extended modelling protocol”.

We mean here that we follow a modelling protocol that is extended in comparison to the one provided by Haywood et al. (2010, 2011). We have clarified the sentence accordingly.

Page 12, line 31: Should read “results presented below are based on an averaging period”

fixed

Page 13, line 5: Is the 2.13°C surface air temperature (SAT) at the ocean surface or sea surface temperature (SST)? I suspect the latter, but it is not entirely clear at the moment.

You are right – fixed.

Page 13, line 13: I'm not sure what albedo changes are being compared here (-16.6% vs -15.6%) is this ocean vs land? Whatever this is, it needs to be made clear.

You are right – fixed.

Page 13, line 20: Should read “There are only a few regions . . .”

fixed

Page 14, line 15: Should read “Predominant drying is apparent . . .”

fixed

Page 14, line 20: Should read “In contrast, changes in the boreal autumn . . .”

fixed

Page 14, line 23: Should read “Low latitudes of the oceans also have different characteristics . . .”

fixed

Page 14, line 23: Should read “We demonstrate this with the example . . .”

fixed

Page 14, line 32: Should read “. . . confirms in our model, as suggested by Raymo et al. (1996) and Dowsett et al. (2009), that mid-Pliocene . . .”

fixed

Page 16, line 13: Should read “. . . temperature gradient are also seen in the annual mean of global SAT anomalies under changes in carbon dioxide”

fixed

Page 17, line 2: Should read “. . . SST, causing global mean values of and SAT to have reached similar values at the end of the simulation.”

fixed

Page 17, line 8: Should read “. . . we find a large impact on the hydrological cycle . . .”

fixed

Page 18, line 9: Should read “. . . the possibility to go beyond CS and ECS for both modern and mid-Pliocene geography and derive earth system sensitivity . . .”

fixed

Page 18, line 17: Should read “There is a significant difference between these ECS values and those derived . . .”

We are reluctant to state that the difference is significant, as significance has not been shown. Other than that, we have adjusted the text as suggested.

Page 19, line 30: Should read “Yet, high temporal variability . . .”

fixed

Page 21, line 13: Should read “still the case, for example there is a significant mismatch . . .”

We have implemented the suggestion minus the reference to significance.

Page 26, line 3: I don’t think that you should use the verb “confirm” when only some of the models agree with this statement. Many of the models also disagree.

We agree with the reviewer and have adjusted the text.

Page 26, line 24: Should read “The mid-Pliocene combines estimates of carbon dioxide levels . . .”

fixed

Page 27, line 10: Should read “Hence, making inferences from modelled or reconstructed climate conditions of the mid-Pliocene with respect to . . .”

fixed

Page 27, line 12: Should read “This has been stated by . . .”

fixed

Page 30, line 21: Should read “. . . in the context of Pliocene4Future, . . .”

fixed

Page 30, line 25: Should read “. . . with potential threats to the food chain . . .”

fixed

## References

Foley, K.M., and Dowsett, H.J.: Community sourced mid-Piacenzian sea surface temperature (SST) data, U.S. Geological Survey data release, <https://doi.org/10.5066/P9YP3DTV>, 2019.

McClymont, E. L., Ford, H. L., Ho, S. L., Tindall, J. C., Haywood, A. M., Alonso-Garcia, M., Bailey, I., Berke, M. A., Littler, K., Patterson, M., Petrick, B., Peterse, F., Ravelo, A. C., Risebrobakken, B., De Schepper, S., Swann, G. E. A., Thirumalai, K., Tierney, J. E., van der Weijst, C., and White, S.: Lessons from a high CO<sub>2</sub> world: an ocean view from ~ 3 million years ago, *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2019-161>, in review, 2020.