

## ***Interactive comment on “Contribution of the coupled atmosphere–ocean–sea ice–vegetation model COSMOS to the PlioMIP2” by Christian Stepanek et al.***

### **Anonymous Referee #2**

Received and published: 31 March 2020

Stepanek et al. have produced a very thorough coverage of their contribution to phase 2 of PlioMIP and associated climate model simulations. This is an important individual contribution to a significant undertaking of the international palaeoclimate modelling community and there is lots of great science contained within this manuscript. With the inclusion of more than the PlioMIP phase 2 simulations, I do think this work could easily have been split across more than one paper, particularly the more detailed analysis of some of the extra simulations. However, having them all in one place also has some advantages, even if this makes it a long paper. Although it is generally a very good manuscript, there are a few things that could be improved. Firstly, the language needs to be improved and simplified to make it more understandable. In the detailed

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comments below are some suggestions of sentences that need changing, but many more could be improved.

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.

There are several figures that could be changed to make things clearer to the reader. 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. 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. Figure 13 would be improved by plotting the pre-industrial (E280) sea ice, probably as a first row at the top of the figure. If a PRISM4 comparison is done, it would be useful to include this in Figure 21 (or a new figure).

Minor corrections:

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

C2

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

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

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

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

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”.

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

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

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

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

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 . . .”

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

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

Page 8, line 31: Remove “as well”.

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

C3

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

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.

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.

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

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

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

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

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

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 . . .”

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

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.”

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

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 . . .”

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

C4

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

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

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.

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

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

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

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

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

New references:

Haywood, A. M., Dolan, A. M., Pickering, S. J., Dowsett, H. J., McClymont, E. L., Prescott, C. L., Salzmann, U., Hill, D. J., Hunter, S. J., Lunt, D. J., Pope, J. O., and Valdes, P. J., 2013b. On the identification of a Pliocene time slice for data-model comparison, *Phil. Trans. Roy. Soc. A*, 371, 20120515.

McClymont, E. L., Ford, H. L., Ling Ho, S., 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., 2020. 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.

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Interactive comment on *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2020-10>, 2020.