We are grateful to the reviewer for his/her comments which have helped us to identify deficiencies in our manuscript. Below, we reply to each of the comments which are in red font.

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 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.

The conclusion concerning the multi-CO_2 experiments was applicable to comparisons with PRISM3 data only. In hindsight, the difficulties in making a proper and thorough assessment should have been emphasized – not only because of the various regional discrepancies but also, as the reviewer has pointed out, uncertainties related to the proxy data themselves. We have referred to Tierney et al (2019), compared the SST anomalies with those of the multi-CO_2 experiments, and following the reviewer's suggestion, performed a Student's t-test. In the tropical Pacific, Eoi^{400} SST agrees well with the data from Tierney et al (2019). This highlights the continuing need for climate reconstructions from proxy data. We have made some modifications in the abstract and conclusion to reflect our latest results.

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 (Mc-Clymont 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.

A comparison with SST data from PRISM4 sites was shown in supplementary figure 2. This figure has now been moved to the main paper to ensure that there is at least one figure comparing model results with the recent PRISM4 data. In the supplement, we now include a figure documenting a similar comparison, but for all of the multi-CO_2 experiments. For all CO_2 values used in our study, the Pliocene experiments are generally unable to reproduce the degree of warming seen in PRISM4 in the northern North Atlantic and the subtropical South Atlantic. We leave analyses with PlioVAR dataset for the future.

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.

While the Eoi experiments show much greater regional changes in comparison to the experiments with a simple increase in CO_2, we agree with the reviewer that the latter experiments themselves do not show uniform warming. On the whole, there is more warming over the continents, which was already stated in the original text. There is a clear polar amplification signal, albeit smaller than that seen in the Eoi experiments and we have made sure to include this in the revised text.

Other comments

1. line 9: please spell out PMIP.

Done.

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.

The sentence has been modified to refer to possible future studies related to the mPWP outside of KM5c.

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.

Thank you for giving these examples. We have now referred to these papers in the revised manuscript. The volume and page numbers for the first reference differ to those given above.

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 CO2 records, Nature.

Thank you. This has been added to the text.

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

Yes. The sea ice model also acts as the coupled model's air-sea interface, even when the grid point in question is ice-free, in which case the flux is unaffected in the sea ice model.

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

Yes, the sigma levels are pressure levels scaled with the surface pressure. This has been added to the text for clarity.

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?

A prognostic Arakawa-Schubert cumulus scheme and a prognostic cloud water scheme for large-scale condensation are included in the model. Yes, there is microphysics. Direct effects of aerosols are considered in the radiation scheme, making use of hydroscopic growth and refractive indices of aerosols. Indirect effects of aerosols are considered for condensation in stratus clouds. The reader is advised to refer to K-1 model developers (2004) for further details.

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?

We have rephrased this sentence. Within the land-surface model (MATSIRO), water and heat exchange between the land surface and atmosphere is computed. Within the same model, runoff on the land is also calculated and passed over to a river routing model which transports the runoff water to the ocean model at river mouths. The radiation scheme is multi-layer.

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

The sigma level represents a normalised geopotential height and takes the value 1 at the free surface and 0 at a fixed depth above which the sigma coordinate system is applied. We have added this description to the text.

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?

Upward longwave radiative flux is calculated according to the Stefan-Boltzmann law with an emissivity of 0.95. The albedo of bare ice surface is set to a constant value of 0.5, and that of snow-covered surface varies between 0.65 and 0.85, depending on the temperature. The air-sea/ice flux is calculated by taking into account downward shortwave and longwave radiative fluxes calculated in the atmospheric model. Penetration of shortwave radiative flux into the snow or sea ice is not taken into account.

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

On line 135, it was stated that the original value for the Pre-Industrial was set to approximately 285ppm. The exact value is actually 285.431ppm and is now used in the text. Thus, for doubling CO_2, the value is about 571ppm.

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

Done.

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

With all due respect, I think this sentence is needed since we need to distinguish between experiments with Pliocene boundary conditions (Eplio1 and Eoi^{xxx}) and those with simply an increase in CO_2 levels (E^{xxx}), and we refer to the former group of experiments frequently in the text. We have added "Eplio1 and Eoi^{xxx}" to make the sentence clearer.

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

We have changed the sentence to indicate a larger anomaly (ie greater warming) instead of using the word "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).

This section has been rewritten to discuss each of the deepwater formation sites separately, in the order: the Labrador Sea, the Norwegian Sea and the region west of the British Isles.

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

Done. Thank you.

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).

This, along with a reference to another model, has been added to the text.

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.

We have changed the sentence to give a better explanation. At northern high latitudes, as CO_2 is decreased from 450ppm to 350ppm, the magnitude of the discrepancy between model SST anomaly and PRISM3 SST anomaly increases from 1.40°C to 4.43°C. However, a further decrease in CO_2 to 280ppm leads to a reversal and a smaller discrepancy of 3.03°C.

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.

This paper has now been cited in the text.