

General Comments

This manuscript presents new simulations of the Pliocene warm period using the CESM model. The authors present simulations using a range of different CO₂ levels, using both modern and Pliocene boundary conditions. They find significant warming due to changing the boundary conditions, mainly because of ice-albedo effects that allow a larger insolation, independently of greenhouse forcing. The model's climate sensitivity to CO₂ is roughly the same under both boundary conditions. The model achieves a generally very good fit to Pliocene proxies, and the remaining discrepancies are examined in an appropriate manner. The paper is mostly about describing the model and its main features of variability, and it is generally well written, so I suggest mainly minor revisions to clarify the data presentation.

My biggest recommendation for change is to revise the colormaps in the anomaly plots. I suspect the authors have put significant effort into the color schemes, so I'm sorry to insist upon changes here. However, I find that the color scheme used for most of the manuscript figures does (a) a good job of representing absolute values, and (b) a poor job of representing anomalies. There are several reasons for this:

The banded color regions tend to create "critical values" when changing to different colours. This is ok when there is no particular critical threshold in the data, but with anomaly plots, there is a critical value of zero that must be highlighted. Having 6 different colour bands in the anomaly scale means there seem to be critical values jumping out everywhere, and it's hard to get an intuitive sense of the positive and negative changes. The second reason is that some colours have a highly suggestive nature that can be deceptive. For example, most papers use red for a warm anomaly and blue for a cold anomaly, which makes intuitive sense. The authors have in many places used blue shading for warm anomalies, which is very jarring to interpret. (E.g. Fig 4b, 5b, 9c, 10, 11). I suggest for all of the anomaly plots (especially temperature and precipitation) either use:

- A) only one colour (with intensity shading) either side of the zero value, so that the critical values are very obvious, e.g. red for warming, blue for cooling;
- B) use two colours either side of the zero, but choose them to be carefully matching in tone and intuitive, e.g. purple and blue for cooling, brown and red for warming. Or: green and blue for wetting, brown and red for drying.

Apart from this, I have a couple of scientific suggestions:

1. Why is there a large change in direction of the temperature trends at around 1000 years in the Eoi400 run? This is a curious feature of the spinup that deserves a stronger explanation.
2. Since the main result is that Pliocene boundary conditions cause significant warming (independently of CO₂), it would be good to examine the radiative forcing changes in more detail. This can be done using a framework such as in Lunt et al (2021, <https://doi.org/10.5194/cp-17-203-2021>) and Heinemann et al (2009, <https://doi.org/10.5194/cp-5-785-2009>)

Line Comments

L29: “foe” typo

L93: This equation looks a bit ugly in current format. Is it possible to use nicer labels, such as “d” for depth rather than “dpth”, and why do “vdc1” and “vdc2” need so many characters? Why not “c1” and “c2” for instance, and use subscripts for a nicer appearance?

L182: TOM has not been defined in the main text. It was defined in a Figure caption but it should be spelled out in the main text as well.

L210-211: “to not select a mode?” is a strange way of phrasing this. Are the authors trying to say that they (a) calculated EOFs for the North Atlantic, and then (b) disregarded leading EOF modes that correlated highly with ENSO or the PMV? I don’t understand, please clarify.

L219: “more easy” → easier

L321: “Straight” → Strait

Figure 5 caption: I think it’s better to use “variables” rather than “observables”

Figure 7a,b: There is too much information stacked in the overturning plots. The contours can’t be seen properly on top of the colours. I suggest expanding this plot to put the Eoi560 overturning on separate panels - there is plenty of space to do so.

L357: “clearly reflected atmospheric MHT difference”: there’s a word missing here, please clarify

Figure 8a,b: Again please expand the overturning plots to use separate plots for different streamfunctions. The contours are too difficult to read over the colours - it is information overload.

Figure 9c: Here the use of blue to signify warming is really jarring, especially the blue proxy circles. Please revise the anomaly colorbars (as in my general comments).

L409-410: Here it might be useful to reference Li et al (2019, <https://doi.org/10.1029/2019PA003760>) which shows the impact of changes to coastal upwelling on large-scale Pliocene SSTs

L414: This sentence would be improved by deleting “It is noteworthy that”

Figure 10: As noted above on colorbars: there are large swathes of blue used to represent warm anomalies. Please revise.

Figure 12c: The contours overlaid on colours here are very difficult to interpret (as in Figs 7, 8). Please expand the number of panels to separate the clashing information.

L483: “there is a lot more”: perhaps delete “a lot”, since this a vague descriptor.

L523-524: “this differential warming patterns” : fix grammar. Also, instead of saying “different parameter choice”, can you be more specific and say “enhanced diffusivity”?

L532: “dryer” → drier