

Review of Hunter et al. 2019

Points of broadest significance

While I have not come across any obvious and significant scientific issue, the quality of writing is not very good. The writing issue persists not only in the English but it also with regards to clarity, the quality of discussion and with regards to several technical errors. There are notable instances where the authors are themselves confused. There are sentences that are incomplete, and entire sections go by without referencing corresponding figures. Figure captions are sometimes wrong and in some instances the authors refer to figures regarding issues that the figure itself does not address. It appears that the manuscript has not at all undergone a rigorous internal review before its submission to CP.

The review provided here is only for the first 12 pages. I stopped reading after that because it is clear in my opinion that the paper needs to be entirely re-written anew and there was no need for further comment before seeing a revised paper. I hope that the comments that I and the first reviewer have provided are sufficient to help the authors with this revision. I appreciate the effort that goes into writing a paper, but I do feel that I would be doing a disservice to the authors, whom I know to be very smart people, by allowing the paper to proceed in the present form.

Confusion over the number of experiments

It seems that the authors themselves are unsure how many experiments they have performed. Consider the following:

- i. Lines 4–5 on page 5 suggest that the authors have conducted two sets of “Pliocene experiments” with CO_2 at 280, 350, 400 and 450 ppmv (for a total of 8 Pliocene experiments) and where one set uses modern orbit whereas the other uses orbit for 3.205 Mya.
- ii. In Lines 12–13 on the same page the authors talk about two new insolation sensitivity simulations ${}_{1361}E^{280}$ and ${}_{1361}Eoi^{400}$ therefore giving a total of 10 simulations so far. If we include the obligatory PI control, then we should be currently at 11 simulations.
- iii. Further down that page, under section 3.1, new control experiments E^{400} and E^{560} are introduced. That brings us to 13 simulations which appear in Table 1. So far all good.
- iv. On page 7 at the end of first paragraph under section 3.3, the authors talk about 8 experiments which are the two sets of orbit based simulations. That’s fine. But the following line at the start of next paragraph talks about “the ten Pliocene experiments”. How can that be? In the author’s nomenclature, the Eoi experiments are Pliocene, so we have 8 experiments and the experiment ${}_{1361}Eoi^{400}$ giving 9 Pliocene experiments.
- v. In the same line, to give an accounting for the ten experiments the authors say “(Core and Tier 1 detailed in Table 1 as well as ${}_{orb}Eoi^{400}$, ${}_{1361}E^{280}$ and ${}_{1361}Eoi^{400}$)” but if we look at Table 1, there are 5 Core and Tier 1 experiments, so those five along with the three experiments ${}_{orb}Eoi^{400}$, ${}_{1361}E^{280}$ and ${}_{1361}Eoi^{400}$ add to 8 experiments! Not 10!!! Furthermore not all Core

and Tier 1 experiments are Pliocene!

To add to that, I am confused why ${}_{1361}E^{280}$ is called Pliocene in this sentence, but is referred to as “Pre-industrial control” on page 5. Based on the notion of PlioMIP, I too would assume it is pre-industrial-like.

Lack of significant connection to existing literature

A notable shortcoming of the paper is the general absence of connection between the author’s own work and the literature on the Pliocene. One can get that sense even without reading the paper by simply looking at the length of their reference section. There are several missed opportunities in the paper for the authors to connect their findings to those from other studies – published results from other groups for PlioMIP2, published results from PlioMIP and other studies outside of these collaborations. As it currently stands, the authors almost exclusively compare, whenever they do, to their results from PlioMIP. While that is obviously required and good, they should put some effort into connecting to other literature as well.

Analysis in this paper and author’s plans for future papers

The authors mention that a future paper will describe the results from P4P Tier 2 experiments that will directly lead them into discussing the nature of forcing from different boundary conditions using the factorization methodology discussed in Haywood et al. 2016. In that case why do the authors preempt that effort here, by discussing in a limited way, contributions from CO_2 and paleogeography as the specific and restricted differences $Eoi^{400} - Eoi^{280}$ and $Eoi^{280} - E^{280}$ (see also my points 2 and 3 in the scientific comments section). By the time of the second paper, the authors will have all the experiments that will be useful for them to do a more thorough discussion of the forcings by taking into account dependencies on the background state and so they will be compelled to revise the findings from this paper anyway. So, why not put all that discussion together in one related paper? Why confuse a prospective future reader by providing them a paper with some results, and then presumably soon after another paper with related and potentially revised results? I think that given their plans for future papers, I recommend the authors to focus more on the climatology of Pliocene in this paper and to focus on forcings in a future paper.

Quality of figures

1. Labels and legends on several figures are barely readable. The font sizes need to be increased.
2. The figures in Fig 2 should have a wider aspect ratio. As it currently stands the figures will not be single column, so might as well make it as wide as the text. Its hard to read anything.
3. Title for Figure 4 is incorrect
4. Features in Figure 8 are barely visible, and the fact that the authors are using polar projections with two different outer bounding latitude lines for different plots creates a lot of confusion and difficulty in interpreting the figure. The authors are encouraged to use just one value of outer bounding latitude line and increase the size of each of the sub figures.

Scientific Comments

1. There is confusion about what is a Pliocene and a pre-industrial experiment. For example, why are E^{400} and E^{560} called pre-industrial? The pre-industrial was a 280 ppmv world. These two experiments are sensitivities to CO_2 and not at all pre-industrial.
2. A similar, issue arises with the authors calling all their Eoi experiments as Pliocene. Although the issue is less severe here because of the uncertainties in Pliocene CO_2 , but since the word “Pliocene” is used throughout the paper in regards to their experiments with very rare reference to the specific experiment code, the authors should clarify to the reader what does the word “Pliocene” means in general in the context of the paper. When the authors say something to the effect of “the Pliocene is so and so” do they mean that the result they are discussing is robust in all of their Eoi experiments regardless of the CO_2 or do they mean a specific experiment? Their sloppy terminology here gets a little messy at some places, for example on line 3, page 9, while discussing the impacts of various boundary condition changes, the authors say they they diagnose the increase in CO_2 as $Eoi^{400} - Eoi^{280}$. So does this mean that Pliocene is 400 ppmv? Because otherwise they could have also used $Eoi^{450} - Eoi^{280}$ or $Eoi^{350} - Eoi^{280}$.
3. Why is change due to paleogeography always inferred as $Eoi^{280} - E^{280}$ and not alternatively/ simultaneously as $Eoi^{400} - E^{400}$. The authors should make clear why they are favouring this difference, after all we know from other studies that there should be background dependence on CO_2 .
4. On page 4, the draft says “The land-sea mask is effectively 3.75 x 2.5 resolution in the top 200 m but beneath increases to 1.25 lateral resolution.” I don’t follow this. Didn’t the previous line say that the horizontal resolution is 1.25?
5. Page 9 first para on precipitation says:
 “Regions that have little (< 0.1 mm day-1) change in precipitation are regions that receive little precipitation within E^{280} – North Africa and the East Antarctic Ice Sheet. Therefore, the models response to elevating CO_2 in the Pliocene context seems to largely follow the wet get wetter paradigm.”
 There are two things wrong with this. Firstly, the conclusion in the second sentence does not follow from the first. In the first sentence you are saying there is no change over dry regions, which is not the same as saying wet gets wetter (or that dry regions get drier; which you haven’t said directly, but is part of the same paradigm). Secondly, I don’t agree that the model necessarily follows that paradigm – the anomaly over Australia for example is wet, whereas it is a desert today. There is also significant drying over the entire Amazon as implied by the anomaly, but today it is very wet. So a dry Australia has become wetter and a wet Amazon has become drier.
6. The authors should give more details about this “diffusive pipe” (page 4) that is used along the Strait of Gibraltar. An important oceanic phenomena there is the flow of extremely dense and saline waters from the Mediterranean to the Atlantic after crossing the strait and which has important implications for the Atlantic overturning circulation. How do the authors expect the lack of such transport to affect the climate in their simulations?
7. I don’t follow the comment “Observation derived upper-boundaries to Arctic and Antarctic sea ice concentration of 0.995 and 0.980 are used” regarding the conversation on the sea ice model on page 4.

8. The Persian Gulf is not really present in the PRISM4 reconstruction, but apparently it is in the author's ocean grid shown in Figure 1. Similarly, the Barents Sea is absent in PRISM4 reconstruction (there is a small negative orography depression, but that is just a resolution/reconstruction limitation).

Technical Comments

1. Page 1, Line 6: What does a "control Pliocene" mean?
2. Page 1, Line 7: "integrated surface air temperature"
3. Page 1, Line 11: "by both geographical - and land surface changes, and the increase in CO_2 increase"
4. Page 1, Line 21: "through its uses-a potential as an analogue for the contemporary"
5. Page 1, Line 24 "are required to be completed by all model groups participating in PlioMIP2, while whilst the optional"
6. Page 2, Line 2–4: Rewrite the sentences on these lines as: "Table 1 summarizes the experiments conducted within this study. These experiments include several PlioMIP2 experiments as well as non-PlioMIP2 experiments that explore additional sensitivities. From the set of proposed PlioMIP2 experiments we conduct all core and Tier 1 experiments as well as"
7. Page 2, Line 11: atmospheric shouldn't be capitalized
8. Page 2, Line 27: I don't understand the part "or regional geographical sensitivities were explored"
9. Page 2, Line 29: atmosphere and ocean in small letters
10. Page 2, Line 33: "have been made since 2000" The sentence with this phrase is poorly worded. Please rewrite it as "Subsequent corrections and improvements to the model, as well as a thorough evaluation against observational data has been described in Valdes et al. (2017)."
11. Page 3, Line 6 "pressure-levels at height aloft"
12. Page 3, Line 8: Oasis in capital
13. Page 3, lines 13–14: The last sentence sounds weird and appears incomplete
14. Page 4, Lines 8–9: rephrase the sentence to: "Within the modern boundary conditions, cells overlying important subgrid-scale channels, such as those along the Denmark Strait, the Iceland-Faroe and the Faroe-Shetland Channels, and straits surrounding the Indonesian archipelago, are artificially deepened to improve flow representation."
15. Page 4, Line 3: "in an attempt order to improve representation"
16. Page 4, Line 14: "Hudson Bay outflow Strait" ... "subsequently therefore unrepresented"
17. Page 5, Line 4: "setup of the Pliocene and the pre-industrial experiment experiments"
18. Page 5, Line 8: "and the letters o and o indicate inclusion of PRISM4 orography (including PRISM4 vegetation, soil and lakes) and ice-sheets., the former includes PRISM4 vegetation, soil and lakes."
19. Page 5, Line 10 "giving yielding experiments" "components from the PlioMIP2 experiment design."
20. Page 5, Line 11 "We use a preceding subscript in the name of an experiment to indicate"

21. Page 5, Line 15 What is the expression at the end? Presumably you want to mention something like “which we diagnose as the anomaly $E_{oi}^{280} - E^{280}$ ”
22. Page 5, Line 16: “Pre-industrial Control experiments description” Again, the various E experiments are not all pre-industrial.
23. Page 5, Line 18: “from the ‘Levitus’ observed”
24. Page 5, Line 22: “In accordance to with the PlioMIP2”
25. Page 5 Line 27: “PlioMIP2 enhanced and modern boundary conditions For PlioMIP2 the boundary conditions for the modern day and the ‘enhanced’ variant of the Pliocene reconstruction” ... “held within”
26. Page 6, Line 7: “despite subaerial extension within PRISM4”. I don’t follow what this has to do with omitting the islands. Aren’t you saying the extensions of bathymetry are subaerial?
27. Page 6, Line 8: What is this diffusive pipe you are talking of?
28. Page 7, Line 8: “First the Atmosphere atmosphere model”
29. Page 8, Line 2: “yet modest, disequilibrium represented departures from equilibrium and are characterized by TOA imbalances”
30. Page 8, Line 4: “occurring at depths of > 2000 of in the ”
31. Page 8, Line 5: Sentence beginning on this line is strangely worded
32. Page 8, Line 6: “equilibrium states”
33. Page 8, Line 6: “Figure 2 presents the time-evolution of ocean temperature” for which simulation? You have several simulations, which one of it is on Figure 2. Even the caption on the figure doesn’t say that.
34. Page 8, Line 11: “We derive base our analysis on climatological averages”
35. Page 8, Line 11: The range of climatology years is not applicable to the pre-industrial controls.
36. Page 8, Line 15: “Modelled mean annual surface air temperatures (hereafter MAT MASAT)” “Tables 3”.
NOTE: Table 3 uses MASAT, and you should use MASAT everywhere just like Table 3 as that is the more accurate term.
37. Page 8, Line 17: “coincide with Greenland and Antarctic regions of Pliocene ice sheet retreat (and topographical reduction) over Greenland and Antarctic.”
38. Page 8, Line 19: “This pattern of warming is in a similar in distribution to HadCM3 results within PlioMIP under using the older PRISM3”
39. Page 8, Line 25: “Figure 4 shows the Aannual and Sseasonal and E_{oi}^{400} compared to the PI control”
NOTE: Figure 4 does not show what you are saying it shows. It shows only annual anomalies.
40. Page 8, Line 26: “the Hudson Bay and the Baltic Sea regions”
41. Page 8, Line 27: “during he the summer”
42. Page 9, Line 1: “From the results in Table 3 it is possible to decompose diagnose”
43. Page 9, Line 4: “The Climate climate system’s Sensitivity sensitivity to a doubling”
44. Page 9, Line 7: “When we neglect geographical changes”. I don’t follow....
45. Page 9, Line 9: “Subsequently Consequently”
46. Page 9, Line 13: “Mean Annual Precipitation metric (MAP; Table 4)”
47. Page 9, Line 14: “and is relatively insensitive to Pliocene the chosen CO_2 changes in the Pliocene experiments”

48. Page 9, Line 21: “plots of precipitation change between the 400 and 280 ppm versions of Pliocene and the PI control are shown in can be seen within Figure 6”
49. Page 9, Line 25: Capital S in South
50. Page 9, Line 26: “more eastward further east”
51. Page 9, Line 28: Last sentence is weird and incomplete
52. Page 9, Line 30: two “the”
53. Page 10, Line 10: “The time averaged, zonal mean, meridional”
54. Page 10, Line 11: “the indirect Ferrel” (the word is unnecessary here)
55. Page 10, Line 13: “Assuming Taking the maximum in of the meridional streamfunction represents as a measure of the Hadley cell strength”
56. Page 10, Line 15: “than the Southern cell which is in contrast to contradiction with observational and reanalysis data (...) that show consistently show the southern cell being stronger”
57. Page 10, Line 17: “stronger than the northern cell” also replace the “for” occurring in the parentheses with “in”
58. Page 10, Line 22: “and Polar Jet streams (PJ)”
59. Page 11, Line 5: While Table 6 does show the MASSTs of the experiments, Figure 9 does not show that. It shows the anomalies of very specific sets of experiments. Please rephrase and rearrange this sentence.
60. Page 11, Line 7: I think you mean $Eoi^{400} - Eoi^{280}$ so as to be consistent with what you say on Line 3 in Page 9.
61. Page 11, Line 9: “Within the North Atlantic sub polar gyre where $Eoi^{400} - E^{280}$ reaches +9.3C” That sentence does not stand on its you. You probably forgot to complete your thought here.
62. Page 12, Line 4: “Here we rely upon the mixed layer depth (MLD) as calculated as a diagnostic variable within HadCM3 climate model” What kind of sentence is that? Not only is there nothing in that sentence, it doesn’t sound proper either.
63. Page 12: Reference the mixed layer figure in the section on mixed layer.
64. Page 12, Line 13: “streamfunctions” “are shown” plural..
65. Page 12, Line 14: Rewrite sentence on this line
66. Page 12, Line 15: “Our AMOC... (put value here) differs to from that in Bragg et al. (2012; strength of 17.6 Sv), a difference that we ascribe to the latter’s use of”
67. Page 12, Line 17: “Fluctuations of the order in the AMOC” huh???