**Climate
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Discussions

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comment

Interactive comment on "Evaluation of Arctic warming in mid-Pliocene climate simulations" *by* Wesley de Nooijer et al.

Anonymous Referee #1

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Review of "Evaluation of Arctic warming in mid-Pliocene climate simulations" by de Nooijer et al.

The authors provide a good and well written summary of several aspects of the results of the latest round of Pliocene simulations. These simulations and their comparison with available geological records are important since this period is one of the few that provides an estimate of climatic changes that are to first order driven by changes in greenhouse-gas concentrations.

In the manuscript there are several aspects that should be looked at more closely and some that should be discussed more clearly. Below I will detail my concerns.

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Discussion paper

Main concerns:

Impact and/or importance of values orbital parameters:
Lines 118- 130: The authors mention that for the PlioMIP2 simulations a specific time-slice was chosen in order to have values of the orbital parameters that are similar to today. The shorter orbital cycles are 20 and 40 kiloyears, meaning that an uncertainty in the estimate age of a mPWP temperature reconstruction of 10 kiloyear could already imply quite different values of the orbital parameters. I'm not an expert on that topic, but it seems to me the age constraints that are needed to make a firm statement about the orbital parameters that accompany the climate reconstructions that are used in this work, are very difficult to obtain.

The authors also mention various experiments that have been done for the Pliocene to investigate the impact of different orbital parameters. Could those results be combined with the model-data comparison provided in this paper for a more extensive discussion on the topic?

Uncertainty of proxy-based climate reconstructions:
Lines 301-304: Please shortly reiterate how this maximum uncertainty range is estimated as it is quite important for the discussion that follows. Does it for instance include any discussion on the interpretation of the climate reconstructions? Any seasonal biases? From reading the referenced literature it appears that changes in for instance the growing season are considered important drivers of the temperature reconstructions, but I don't see a discussion on this topic in the current paper. How strong is the evidence that the reconstructed temperatures reflect changes in the annual mean rather than a value that is biased towards certain seasons?
To investigate the importance of this issue, many studies resort to comparing the

temperature reconstructions with both simulated annual mean and simulated summer temperatures, has that been considered?

Robust changes in NAO and/or NAM?
Line 435: Please be more clear about whether the RCP4.5 simulations show robust changes in NAO and/or NAM. Do you have grounds to conclude that this is the case for the PlioMIP2 simulations?
Similarly on lines 436-445: Are the changes in NAM and NAO significant? So it depends on the metrics that is used to calculate these modes of variability whether or not the changes are significantly? What does that mean? And while the temperature changes in the RCP4.5 simulations are smaller, the NAO/NAM changes are larger? Please clarify.

Minor comments:

Lines 124-130: So how many models did actually close the Bering Strait? From figure 2 it can be concluded that not all did, but you mention that this change in experimental design improved the model-data fit so it is important to state this clearly.

Lines 270-271: How is this conclusion reached? Why is it not important to correctly simulate SAT anomalies for the SIE anomalies?

Lines 334-357: Of course the authors realize that having only three data points in the whole Arctic Ocean doesn't make for a particularly strong model-data comparison, but we have to work with what we have. Nonetheless, the text should clearly reflect this. The site in the Iceland Sea appears to be very close to the boundary between the regions that are never covered by sea ice and those that are covered at least one month a year. One cannot expect a course resolution climate model to

put this boundary at the exact right location and thus no strong conclusions can be attached to a model-data comparison at such a site.

Lines 382-390: the authors should more clearly state what the differences are between the paleo and future simulations. Both are forced with greenhouse-gas concentration changes, but the paleo runs are further forced by changes in the ice-sheets, vegetation, gate-ways? As for the changes in ice-sheets, vegetation and also the AMOC, one could argue that these simulation give a true long-term equilibrium response to greenhouse-gas changes. This is not the case for the impact of changing the Arctic gate-ways. Is there a way to quantify the impact of the latter as to make the comparison with future simulations more meaningful?

Lines 391-398: There are a number of studies discussing simulations of the impact of closing the Bering Strait on the AMOC strength, do they also show a moderate to strong increase in AMOC strength?

Line 430: what is meant with an 'active NAO strength'? It appears that the models do not provide robust support of a change in NAO amplitude.

Line 433: Why are RCP6.0 and RCP8.5 simulations not used in the comparison if those provide a better comparison in terms of temperature changes?

Line 455: What would such improvements in boundary conditions be? Don't the authors think that all changes in boundary conditions that are likely to have a significant effect are already included?

Figure 11: limited data availability? The data between 60N and 67.5N is missing?

Technical comments:

Line 110: For me forcings are not part of model physics. Please clarify.

Line 145: missing space

Line 451: "11 out of 16", just for clarity.

Table 1: It would be good to add to this table if the model is also used in CMIP5, CMIP6 or neither of those.

Caption figure 3: shouldn't that be "compared to the annual mean in a given month"?

Figure 6: what does the 'p' stand for?

Figure 11: What is shown for the RCP simulations, an average over year xx to yy?

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