

Second Review of: Mid-Pliocene not analogous to high CO₂ climate when considering Northern Hemisphere winter variability (Oldeman et al., 2023)

Authors: Arthur M. Oldeman, Michiel L.J. Baatsen, Anna S. von der Heydt, Aarnout J. van Delden, & Henk A. Dijkstra

This is my second review of this study. I congratulate the authors on strengthening their manuscript. I found the overall study had a much more coherent storyline, the figures were easier to read, and I thought the added tropical Pacific discussion was interesting. I have only a few minor comments remaining before this study is accepted for publication.

Energy budget: In your response to the Editor you mentioned you would be completing an energy budget analysis to respond to his concern about why SAT changes in response to changing BCs. I either missed this, in which case it needs to be made more obvious, or it wasn't included. Either way, I think this concern needs to be addressed more clearly.

L321 & L333: I didn't follow why you think the changes in precipitation around Greenland are related to sea ice.

Figure 3: This isn't major, but I suggest flipping the color axis on the contours so that blue is wetter and red is dryer for panels b and c. I think it's then a bit more logical to quickly read the plots.

Figure 6: I had a hard time differentiating between bold and not bold font in these squares. I suggest using underlines or asterisks to show the $p < 0.005$ values instead.

Typos:

L203: Should be a colon rather than a semicolon.

L349-350: "a lot more" and "a bit less" are both qualitative phrasings. You have statistical significance here, I suggest sticking to the quantitative descriptors.

L370: "differences are that" is awkward grammar.

L378: "the northern node is retreated polewards" is awkward. Maybe it should be "has retreated" instead.

L394-396: I got confused with your use of parentheses here and missed the message you were trying to make. This isn't a case of "the mode is positively (negatively) correlated with..." sort of use you use slightly later in the manuscript. Please revisit this sentence.

L400-401: Similar strange parenthetical structure as comment above.

L476: "a jet stream weak in strength" should be "a weak jet"?

L478: Similarly, "a jet less variable in strength" and "a jet more variable in latitude" is strange phrasing.

L483: "indexc"

L485: "WEP is established before" should be "WEP has been established"

L498: "summarizing 2. - 4b." -- what are you referring to? Figures?

Figure 9 Caption: "correlation coefficient in the caption" -- I think you mean in the legend.

L510: "that shows" rather than "that show" since the subject of that sentence is the "study."

L577 & L281: You've referred to it as "Supplementary" material more throughout, so I suggest changing "Supplement" here.

L654: I feel like there should be a "can" or "should" between "climate" and "be" in this sentence.

L679: "might not be" is rather weak language compared to the rest of your conclusion which says the Mid-Pliocene should not be used as an analogue.

L683: "we think that it might" can just be "it may"

Supplementary Material S6: I believe the second Figure S10 at the end of the section should be Figure S11.

Reviewer #2: comments on the revised manuscript

This study is much improved from the initial submission, and the authors have done an excellent job at addressing my concerns, including substantial new analysis, a section dedicated to the likely role of tropical SSTs, and substantial restructuring of the paper. The new title now accurately represents the findings. I am happy to recommend publication, subject to the following minor suggestions:

Line 17. How is the response of the climate to increased CO₂ determined by natural variations?

Line 59. ‘lowering of the Rocky mountains’ implies to me that the mountains reduced in height over time, rather than, as I think you mean, that the mountains were lowered in the model simulations of the Pliocene.

Line 130. I know you are focussed on the atmosphere, but given your results on the impacts of the tropical convection, which is almost certainly related to tropical SSTs, I think it is useful to also given information on the ocean model and resolution.

Line 261: “The weak but distinct eastern node with opposite sign in the CR20 disappears in the E280” – from my interpretation of figure 1g, the eastern opposite sign node is present in the shading, but not the black/white contours, which from the caption means it is present in E280 but not the CR20, the opposite to the text.

I recommend being slightly more clear that Eoi280 is mid-pliocene boundary conditions, not mid-pliocene conditions, as stated in, for example, line 293.

Fig. 6. I understand that you don’t need the AO column in panels b and c, but then you also don’t need the top row – it’s a little less clear to me why you would make the different panels a slightly different shape rather than just retain the triangles for the auto-correlations.

Line 455. Suggest to add (‘blue line’) to help readers.

Section 3.3.3

Point 1a. Suggest ‘...Walker circulation, and lead to a northward shift...’ for clarity that the northward shift isn’t being reduced.

Point 3. It isn’t clear to me why reduced Rossby wave forcing from the tropics would lead to a North Pacific jet that is more variable in latitude – is this from the literature or from your results?

Careful with correlations vs causality here – I’m not sure you can conclusively say that the change in Rossby wave tropical forcing causes changes to the jets, which cause the changes in the NPO/PNA patterns instead of changes in the Rossby wave tropical forcing causing changes in the NPO/PNA patterns which lead to change in the jet, can you? The zonal wind changes in Fig 9b and c look like they are likely approximately geostrophic if the pressure changes are equivalent barotropic.

Line 503. 'thus lead to'

Line 505. I like that you have included the RWS analysis, but I think it is worth mentioning in the main manuscript that you include RWS analysis in the supplementary material, rather than just "more extensive analysis"

Line 513: dates for citations shouldn't be in parentheses within parentheses

Line 533: in E560 the warming is 'mostly' due to greenhouse gases? Is there any other forcing in this simulation?

Line 621. Can you clarify that those 3 changes seen by 'most' PlioMIP2 models (and thus, I assume, in the multi-model mean), are also seen in the CCSM4-Utr model?

Line 631. How does orography adjust as a feedback in response to climate change?

Line 654. Grammar: ... we address the question of whether the mid-Pliocene climate can be...

Supplementary: S5.3. I'm unsure how the RWS can be a wave guide for the jet stream. We typically think of the jet stream as waveguides for waves from a RWS.