

## Review of cp-2021-40

Chris Brierley (Referee)

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Referee comment on "Simulation of the mid-Pliocene Warm Period using HadGEM3: experimental design and results from model–model and model–data comparison" by Charles J. R. Williams et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-40-RC2>, 2021

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Williams et al describe a HadGEM3 simulation run using the PlioMIP2 protocol. They document many technical details associated with this simulation that may be important for subsequent researchers. They provide some headline results from the simulation and place it in context within the literature. This is a manuscript that is certainly worthy of publication in Climate of the Past. Naturally, I have some comments about the manuscript and propose some edits that would make the manuscript more appealing to readers. However, I see them as potential improvements rather than obstacles.

### Content-related comments

- I was surprised that there was no mention of “hydrological sensitivity” within this manuscript. Given the focus on both the global mean precipitation change and the global mean temperature changes, this seems like an oversight. This approach in effect normalizes precip changes by the warming, resulting in units of %/oC. It is the most common metric to intercompare global mean precipitation changes.
- At no point is there any discussion as to whether the climate of modified control simulation is the same as the standard control run. This is potentially important for future researchers, as the manuscript only describes changes w.r.t. piControl\\_mod, whilst the data available on the ESFG only allows a calculation of changes w.r.t. piControl.
- The discussion of the sea ice changes does not explain to the reader some key features – such as the fact that the model is seasonally ice-free in both hemispheres. Replacing Fig. 8 with something more pertinent would go a long way to improve the discussion. Please consider polar stereographic plots (perhaps without the annual mean), along with some time-series of sea ice area/extent in both simulations.
- Remove the table which is masquerading as a panel in Fig. 14
- L761. “excess warming”. You have not provided any evidence that the warming in HadGEM3 is excessive. Your focus solely on RMSE during your data-model comparison does not provide a direction. If you want to make this kind of statement (which would

enhance the overall reach of the publication), then you need to look at other metrics as well.

## Technical comments

- Sect 2.3.2.2: please include some text about how you are specifying vegetation over West Antarctica. Some stuff about this emerges in later sections, but I was expecting something here. Is there a reason you didn't specify it all as lake?
- L306. Here we reach something about Antarctica, but it was unclear at this point whether you meant dominant vegetation in the piControl or mPWP. how had you determined the vegetation in mPWP?
- Sect 2.3.2.4 seems to only discuss the initial conditions for the land model. I presume that the initial conditions for the atmosphere and sea ice models don't really matter. However, the initial conditions for the ocean must play a large role in the distance from equilibrium discussed later. Please be explicit in what initial conditions are being used.
- Sect 3.1.2 I feel that there are criteria specified for equilibria in either the CMIP or PMIP protocols (and possibly both). It would be better to refer to those, than solely compare with a single preindustrial control simulation value.
- L447. Why are only the extratropical temperatures considered to make assessments about the whole hemisphere?
- L611 What are the "warmest PI anomalies"? The manuscript shows no assessment of the piControl\_mod simulation.
- L766. Do you really mean 'climate sensitivity' here – or should it be Earth System sensitivity?
- L770. "such as" is inappropriate as only the 3 named variables are available.
- L775. I get "authors of the appropriate publication" for the models in section 4.1. However, it is not clear who readers should be contacting for output from models included in section 4.2. If this is Alan Haywood (because of H2O) then please state explicitly.

## Text/presentation comments

- Remove section headers 2.2.1 and 2.2.2. Just add the single sentence about other models to the end of the previous paragraph
- L232. replace comma before JULES with a bracket.
- L257. preindustrial
- Fig. 4. It is hard to read the text in this image, or in fact really grasp the details of the upper 5 panels. Is there a way to condense this down, so it is more visible? Consider only showing a single PFT and increasing the panel size.
- L315/316. such as is repeated.
- Fig. 5. It is nigh-on-impossible to read the text in this figure when it is printed out. Please consider whether all panels are necessary. I believe the snow depth at least should be removed as the values shown may not have much physical meaning (1000 snow-water-equivalent in kgm<sup>-2</sup> is roughly equal to 3m depth of fresh-ish snow).
- L359. "the thousands of years ideally needed" -> "thousands of years". Let the reader judge whether this is appropriate.

- L361/362. Please confirm that there is no typo here with the number of years. They both contain the same digits, but in a different order.
- Table 1. Some, if not all, the units stated in this table are incorrect. They should include "/century".
- Table 1. Please revise the caption of this table. Firstly, it does not show "trends in ... measures of climate equilibrium". Secondly, please write your TOA statement as a full sentence, and be more explicit about its relation to warming. For example, "A positive TOA imbalance indicates a net loss of energy from the Earth System".
- L425. Little is gained by abbreviating OceTemp and OceSal? Please remove.
- L439-468. This paragraph is both long and dense. Consider splitting the sea ice discussion into its paragraph.
- L444-449. This sentence is rather long. Consider subdividing.
- L477-482. This sentence is rather long with many subclauses. Consider subdividing.
- L480. The sudden reappearance of H<sub>2</sub>O confused me (in part as it looks like the chemical symbol for water). I suggest removing the abbreviation.
- L517. Can you move "for comparative purposes" to the end of the sentence to improve readability?
- L522. Remove hanging data availability sentence.
- Fig. 11 Do you mean "annual mean" instead of "climatology"?
- L548 and onwards. Consider replacing your PA abbreviation with just "amplification" if polar amplification is really too long.
- L550. "from" seems the wrong preposition
- Table 4. Can you put the ECS into this table as well, please?
- Fig 12. Label all the panels, not just over half them.
- L608. Clause about being at top-end of range felt overly repetitive.
- L627. Be consistent in your terminology. In the previous sentence "wettest" related to absolute rainfall. Here it appears to relate to a change in rainfall.
- L653-4. Please rephrase this sentence.
- L663-671. This additional discussion got actually me more confused. Is it possible to rephrase it?
- L676. The RMSE is given in Table 3, please cite it.
- L676-686. Personally, I would chop everything after "halfway amongst them". The subsequent description provides list insight into the reason.