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Climate of the Past Discussions

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Interactive comment

Interactive comment on "The middle-to-late Eocene greenhouse climate, modelled using the CESM 1.0.5" *by* Michiel Baatsen et al.

Anonymous Referee #1

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The middle-to-late Eocene greenhouse climate, modelled using the CESM 1.0.5 Michiel Baatsen et al.

This modelling study targets the middle to late Eocene, a time interval important to understand as it represents the close of the Cenozoic greenhouse. This is a great paper, good clear accessible explanations of model aspects, a variety of useful figures and addressing an important and outstanding issue in modelling the warmth of the early Cenozoic, i.e. how to get Antarctica as warm as proxies suggest without cranking CO2 up to levels above most proxy constraints.

Modellers will likely have technical questions about the methods but my general feeling is that this paper is backed by sound theory, it uses appropriate methods and is appropriately careful in producing the data model comparison, considering different proxy

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Discussion paper

calibrations, seasonal biases etc. If anything, I think the abstract falls short of communicating some of the key findings of this paper, and its transferability to other warm climate phases, i.e. warming the poles without warming the equator too much.

My overall recommendation is publish after minor revision.

Abstract: This could better highlight some of the important tangible climate signals. It's a bit mechanical as is.

e.g.

-Highlight the gap in knowledge: i.e. What has been missing in other models, identify gap, need for different models. Remaining proxy-model mismatch at high latitudes especially. This is there in the introduction but not in the abstract.

- Emphasize that you have come some way to addressing the long-standing problem of warm poles at 2 x CO_2. This is a big step forward.

-and connected . . . .emphasize that by optimizing treatment of clouds etc, and having a carefully considered and time-appropriate paleogeography you manage to warm the poles, especially Antarctica, in a way that is consistent with proxies. This has important implications for the future. . .

- Emphasize your finding of strong seasonality in the precipitation and the importance of monsoons in this warm Eocene climate

- You find variable/reduced climate sensitivity compared to today – summarize why.

Introduction and implications The paleogeography used in this model is very similar to Hutchinson et al., 2018. But you use a different model. This is thus a really good experiment opportunity to see what effects are model dependent and what are robust features. This could be emphasized better throughout. Kennedy-Asser et al., 2019 explored this idea.

Good description of the general conditions. Experiments at 4 x and 2 x modern CO_2

are appropriate for the time interval.

Line 45: Add the Goldner et al., 2014 ref here.

Lines 65: add Hutchinson et al., 2018; 2019 here. Also Kennedy-Asser et al., 2019; 2020;

Line 75: The considered period is suitable to investigate both the warm greenhouse climate as the conditions leading up to the EOT. Should be and, not as?

Elsworth et al., 2017 also specifically explored the late Eocene in a model, so that's another one.

Justify why there's a need for a customized middle Eocene paleogeography between say the early Eocene (warm optimum) and late Eocene. What changes and what could make a difference?

Explain that its crucial to have different models doing the same thing to explore what features are robust between models. Kennedy-Asser et al., 2019.

Methods Model resolution; How does the model resolution compare with other models, e.g. with the Hutchinson et al., 2018 DFDS model, which professes to have a relatively high-resolution ocean? Mention this upfront. If your ocean is 1°, what kind of process should this improve upon compared to previous models?

Hutchinson et al., 2018 have proposed that the Arctic was important for some middle to EOT ocean changes. Therefore, can you add an Arctic-focused map view to fig. 1 (or SI section) to ensure its clear how this 38Ma geography treats the Arctic.

Fig. 1 caption: and corresponding text. To the caption, add where the vegetation constraints come from i.e. proxies or modelled. Worth mentioning in the caption.

"note that neither desert nor land ice are implemented"?, later on in the text the word 'incorporated' is used.

What does that mean? Do you mean that proxies and or models find no evidence for these biomes? Please clarify because this is important since any ice will have a strong albedo effect so we need be clear on this.

Some would argue that there should be small amounts of Antarctic Eocene ice. Do you think this would make a difference in your model?

Why is the BDT biome (seen in the Fig. 1c) more extensive in the northern hemisphere than on Antarctica? Is it because Antarctica is warmer than the high northern latitudes?

For the pre- industrial control – I'd like to see how the vegetation biomes are conceptualized for comparison with the 38 Ma version. Add as a supplementary figure?

More on figures:

Fig. 3 and Figs. S3 and S4, can you use the same scale increments/range and colours between the 38 Ma and PI controls -that way the differences are much clearer visually. Figure 3. Clarify in the Fig. caption that this is 38Ma. Figure 4. Explain MSLP in the caption.

LINE 380: Describes extreme seasonality on Antarctica. This is key but we are not directed to a figure/result that shows this. A reference to the supplementary figures showing seasonality at the end of this sentence would fix this.

Please keep the matching x 2 CO_2 version (SI Fig S6) with the same axis temperature scale for comparison. This applies to other figure sets.

Fig. 7. This is a very useful comparison figure!

A difference between the H18 modelled 38 Ma ocean is that H18 gets Pacific overturning and you do not. This means that H18 has some northern hemisphere ocean heat transport, while you do not. Does this make a difference anywhere? Do you find compensation by the atmosphere?

Fig. 8 There is surprisingly little continental proxy data. Is it worth including data even from a little wider time frame (early Eocene?) to get a sense of whether the temperatures on land are close to sensible for this epoch? This would be useful for the Antarctic and Arctic.

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