**Climate
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Discussions

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Interactive comment on "DeepMIP: Model intercomparison of early Eocene climatic optimum (EECO) large-scale climate features and comparison with proxy data" *by* Daniel J. Lunt et al.

Anonymous Referee #2

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Review of the manuscript by Lunt et al. entitled "DeepMIP: Model intercomparison of early Eocene climatic optimum (EECO) large-scale climate features and comparison with proxy data"

The manuscript provides a nice overview of state-of-the-art climate modelling of the EECO and comparison with proxy reconstructions. It is well written and structured. Below I will list my main concerns that I think should be remedied before publication,

together with a number of minor and technical comments.

Main comments:

The interval that is given for reconstructed CO_2 concentrations is 900-2500ppm (95To circumvent this issue, a methodology is applied to estimate the simulated temperature response at CO_2 values that have not actually been simulated, an interesting idea. However, extrapolating too far outside of the range of simulated CO_2 concentrations is difficult because of the possible non-linear relationships in the models, as clearly explained in the manuscript. For this reason, the authors limit the amount of extrapolation, introducing quite some ambiguity. In turn this leads to the situation that even using this extrapolation method, most models cannot estimate the 'best' CO_2 value, only a 'minimum estimate' as the authors call it. However, in the remainder of the results section these simulations are presented as 'tuned to best fit the SST proxy data', which I find misleading. Moreover, using these extrapolations as if they where actual fully coupled climate simulations and compare them with site specific SST records, as is done for the southwest Pacific, New Zealand and Australia, really seems a bridge too far for me. This seems to be acknowledge by the authors in the subsequent analysis that they present on lines 431-440, however, still the regional model-data 'mismatches' are presented and even listed in the abstract and conclusion section. Please clarify the validity of this approach and the 'weight' that seems to be given to these regional model-data comparisons.

Minor comments:

What is the reason that simulations with higher CO_2 levels are often not per-

formed? For some models it is mentioned that they become unstable for such high CO2 levels and if this is a general problem, it seems that this is worth mentioning.

Lines 20-21: 'equivalent models' is a somewhat vague term that could hide the fact that only 1 out of 7 models is used in CMIP6 and only 3 out of 7 in CMIP5, the other four models are CMIP3. This should me mentioned more clearly.

Lines 70-72: Similar to the comment above, you mention that many of the current-generation models include improved treatment of cloud processes, however, most of the models that are used are not current-generation models. Please clarify.

Lines 452-255: These are again the minimum CO_2 levels estimated from the models, not the 'best' ones? Please clarify.

Line 461: Uncertainty in the reconstructed CO_2 concentrations is only one of the reasons to apply interpolation and extrapolation of the model results, just as important or perhaps even the most important reason is that only four simulations with appropriate CO_2 levels are available (from a total of only three different models out of seven).

Lines 463-467: CESM and GFDL are also the only two models that did high CO2 simulations (6x and 9x), with 6x being close to the middle of the estimate CO2 range of 900-2500ppm. The only other simulation that is within this range (NorESM with 4x CO2) is at the lower end of this range. So it seems that this is a must simpler explanation for why CESM and GFDL are the 'best' models, without the need for a statement about the implemented modified aerosol schemes.

Technical comments:

Line 224: "step-wise using", word missing?

Line 346: correct "abd"

Line 356: the word 'also' seems strange here since the previous sentence discusses differences between models, not similarities.

Figure 1: The labels cannot be read this way, another way of presenting that information must be found. The CCSM3 data is difficult to read, please update.

Data availability: I was not able to find any netcdf files in the supplement, but perhaps that is still to come?