

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 #1

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The authors present new results from EECO simulations from seven different climate models. The simulations have been carried out in the framework of the DeepMIP project. The study considers large-scale climatic features (global surface temperature and meridional temperature gradients in relation to CO₂) and performs some basic model-data comparison. My main criticism is that this article is largely descriptive. The authors state that "the aim here is not to fully understand the whole ensemble from a mechanistic viewpoint, but to document the large-scale features". Though I understand that this manuscript is probably only a prelude to further DeepMIP studies, this study

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should be improved by adding at least a minimum of analysis that provides some insight into mechanisms and processes. I therefore suggest to add some analyzes regarding the polar amplification in both hemispheres, which is obviously very different in the different models. Why do CESM and GFDL show much stronger polar amplification than COSMOS, HadCM3B and IPSL? What is the role of sea ice loss and at which CO₂ concentrations does the sea ice disappear in the different models? What is the role of increasing water vapor and clouds, what is the role of a changing polar temperature profile, etc.? The authors should provide at least some basic analysis (e.g., see Dai et al., 2019, Nature Comm., <https://doi.org/10.1038/s41467-018-07954-9>) since the polar amplification is a key aspect in these EECO simulations. Such analysis would not only substantially improve this manuscript, but also our understanding of Eocene and future climate.

Minor points: COSMOS was initialized with a homogeneous ocean and integrated for only 1000 years. This is probably too short and trends are still likely to affect the results. How large are these trends? Please provide some numbers or a supplementary figure showing e.g. temperature and salinity time series, or – even better – continue the integration until equilibrium is reached.

Figure 1 is a mess. Please revise the figure such that model names become readable or – if this is not possible – remove the model names from the diagram and use colors and symbols instead. As it is now, this figure is not publishable.

Figure 3: "GFD" should be "GFDL".

Line 421: I guess HCO₂ and LCO₂ are not CO₂ concentrations but multiples of the pre-industrial concentration.

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