

Interactive comment on “Early Eocene vigorous ocean overturning and its contribution to a warm Southern Ocean” by Yurui Zhang et al.

Anonymous Referee #2

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I also reviewed the paper for another journal and the line numbers below refer to that version.

The study by Zhang et al. presents new model simulations of the early Eocene based on paleo-geographic reconstructions from the DeepMIP initiative, using the AOGCM IPSL-CM5A2. A comparison to simulations with modern conditions is used to investigate to role of ocean circulation changes and meridional heat transport for high latitude warmth in the Southern Hemisphere. The authors find a strong abyssal overturning circulation in the Southern Hemisphere (SOMOC) that leads to enhanced poleward heat transport that maintains warm Southern Hemisphere high latitudes. Additionally, in contrast to earlier studies no deep water is formed in the Northern Hemisphere in the early Eocene simulations. These are novel points worth to publish and the authors

C1

provide an elaborate analysis of factors (e.g. tidal mixing scheme and CO₂ changes) controlling the vigorous SOMOC in their early Eocene simulations. Nevertheless, the current manuscript could be improved by testing their findings in the context of North Pacific deep-water formation as this might be the most important modulator of the presented results. In that sense, the absence of North Pacific deep-water formation might be inherently linked to the basic question ‘What does explain such a strong SOMOC?’ (line 275).

Comments & Suggestions:

- To address this point, it might be helpful to include an additional experiment with a preindustrial CO₂ concentration in the atmosphere. If this scenario is unlikely to give North Pacific deep-water formation, an artificial modification of the continental run-off distribution in the Pacific might help.
- Line 234: In the Weddell Sea surface density is much larger than in the North Pacific (+0.51 kg/m³). Is it trivial from this value that North Pacific deep-water formation is absent? Do you expect a critical value?
- It is recommended to include the CO₂ sensitivity into the section ‘3.3 Factors contributing to the vigorous SOMOC’
- Please revise Table 2: the mean values and the relation to the uncertainty ranges is unclear, use units within the table for clarity, is the uncertainty range one or two sigma? Summary: Although the study is already at a reasonable level, the authors are encouraged to address the potential influence of North Pacific deep water on the presented findings. I would be happy to have a look at a revised manuscript version.

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C2