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Climate of the Past Discussions

Interactive comment on "Tropical seaways played a more important role than high latitude seaways in Cenozoic cooling" *by* Z. Zhang et al.

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Review of the paper entitled "Tropical seaways played a more important role than high latitude seaways in Cenozoic cooling" by Zhongshi Zhang, Kerim Hestnes Nisancioglu, Frode Flatøy, Mats Bentsen, Ingo Bethke, Huijun Wang.

In this paper, Zhongshi Zhang et al. deal with climate evolution through Cenozoic. They mainly focus on quantifying the impact of ocean dynamics reorganisation when seaways open or close.

The paper first describes an Early Eocene simulation run with FOAM version 1.5. From these "realistic" climate simulations, they provide sensitivity experiments to seaways (opening deepening or closing during Cenozoic).

A first series of simulations is provided accounting for closing of west Siberian seaway and arctic –Atlantic deepening till 1900 m and with Drake Passage opening (2500 m depth). Second, they also quantified tropical seaways impacts: American and West Tethys.

Major results they describe are the following:

- A rather weak impact of "high latitudes" seaways – especially Drake Passage in shifting climate and promoting the first step of Antarctic glacial inception. This result is in line with recent papers of DeConto and Pollard, 2003, 2008. i.e.: the major player is not change in ocean dynamics but CO_2 decrease.

In contrast, the result on East Tethys closing is very original and exciting and participates to the cooling occurring after the MMCO and to the large glaciation of East Antarctica.

Indeed, during this period (Cenozoic), other important features occurred as mountain range uplifts (Andean, Tibetan, African Uplifts...) and CO2 globally decrease from 4 PAL to 1 PAL (1 PAL= 280 ppm). Therefore, even if Zhang et al did not account for all these variations, they provide an interesting and valuable contribution on the role of ocean dynamics to changes in Cenozoic climate.

Moreover, Zhang et al. developed an original and interesting approach to quantify in the Cenozoic cooling the role of changes in ocean dynamics. The tool, they used for the set of experiments (FOAM) is appropriate, the conditions of the sensitivity experiments are well designed and the analyses they provide are globally convincing. For all these reasons, I strongly recommend to publish this manuscript in Climate of the Past accounting for minor comments / suggestions that I made in the detailed of section provided below.

Detailed review:

1. Introduction

I agree with the authors that there is inconsistency in symmetric pattern of cooling (Moran, 2006; Tripati, 2008) and attribution of these cooling's to DP opening. Nevertheless, as the symmetry is still an open question, it does not rule out the role of DP opening.

2. Model and Experimental design

2.1Model Introduction

Fine

2.2 Boundary condition

The authors should explain why they account for both seaways closing in only one experiment (TSCN): whereas they could have provided 2 sensitivity experiments to test the impact of each closing separately.

The authors should explain the choice of keeping the CO2 constant to 8 PAL. They could use 3 / 4 PAL for 34Ma and 2 PAL at 15Ma which would be much realistic. The point is that all the sensitivity experiments are now run with a very high CO2 and therefore in a strong greenhouse world which, indeed, was not the case all along Cenozoic. Therefore, this choice that I accept has to be strongly explained.

2.3 Initial Condition (spin up)

Where do these empirical equations come from? The authors should explain this in the text.

It would be interesting to have the initial 2D temperature field to compare with the final average early Eocene 2D temperature field, as well as vertical profiles of temperature (initial and at equilibrium) to make a comparison.

What means quasi-stationary? Is there still a bottom temperature drift?

3. The Early Eocene simulation

What is exactly the disagreement with TEX_86 reconstruction over Arctic?

This bottom temperature is derived from the initial condition. Therefore, the comparison to data is biased. The authors should comment on this point.

4. The sensitivity experiments

This is the very interesting part of the paper because the authors simulated the shift from a dynamics governed by SODW to a world (our world) dominated by NADW. Moreover, they clearly attributed this shift to Tropical seaways closing or narrowing. It would have been clearer if they provide 2 sensitivity studies (one for each seaway) but the results are very convincing, but indeed this is not a major criticism, reviewers always claim for more experiments.

5. Discussion

5.1 Cooling of East Antarctica

The discussion is interesting, but the analysis of the results could be enhanced by a discussion on mass balance over Antarctica (East and West) including analysis of the key terms:

Is it a drastic cooling which decreases ablation or a drastic change in hydrologic cycle which increases accumulation?

I would like to know more about results over Antarctica.

5.2 Implication for Cenozoic cooling

This is also an interesting overview of the Cenozoic. The hypothesis of the authors on the relationship between CO2 decrease and changing modes of ocean dynamics is indeed novel and exciting.

6. Summary

Fine

Final conclusion

This paper copes with a very open question: What explains the Cenozoic cooling? The authors bring interesting contribution to pinpoint the shift from SODW to NADW as a key factor to account for the cooling of Cenozoic and may be for the CO2 drawdown.

This manuscript gives a new and interesting vision of the role of ocean dynamics during Cenozoic, therefore it worth certainly to be published in Climate of the Past.

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