

Review of Frigola et al., 2017

This study presents a set of boundary conditions for simulating the climate state before and after the Middle Miocene Climate Transition: the Middle Miocene Climatic Optimum (MMCO) and Middle Miocene Glaciation (MMG), respectively. It also presents an overview of literature on the Antarctic ice sheet configuration, related sea level, atmospheric CO₂, paleogeography, topography/bathymetry and vegetation of these time periods.

The manuscript is to a large extent well written and clear. However, certain sections would benefit from more information, while others provide too much detail. I have listed my feedback and suggested changes below.

GENERAL COMMENTS

1. More discussion is needed on section 2 Antarctic ice-sheet geometry. There is a nice overview of literature, but no discussion on why the ice sheet configurations of the previous Miocene studies are discarded, and why Pollards Oligocene configuration was used instead. You probably prefer to not use the configurations of Langebroek and Oerlemans, as they use rather simple model configurations. But why do you discard the geometry of Gasson et al.? Related: what forcing and boundary conditions are used in Pollards simulations? How does that compare to the Middle Miocene?
2. Section 4 describing the different published atmospheric CO₂ levels is somewhat difficult to follow. A figure showing all the different published records over the Middle Miocene, in combination with horizontal lines indicating your suggestion, would clarify this section. Additionally a discussion on why these values are all so different is needed.
3. Section 5.3, especially lines 204-214 are too detailed. Please make this section more concise. Maybe "We used ArcGIS to convert ... to ...".
4. Concerning the global topography/bathymetry section: a difference plot to the Herold et al reconstruction (or at least additional information on this) would be highly relevant.
5. Now my biggest concern: The description of the vegetation (Section 6). This section is very lengthily, and to be honest not very useful. In many subsections the vegetation patterns from literature are stated, but then subsequently ignored because you prefer to have a low resolution, simple, distribution. I have no problem with the latter, but I then do not see the use of discussing in detail the vegetation in each continent. I also do see that vegetation might be an important boundary condition, and suggest applying an offline vegetation model (e.g. BIOME4) in order to get a more consistent vegetation pattern within your model set-up. This could then be compared and discussed with previous studies, also previous modelling studies (for example Bradshaw et al., 2012).
6. The final part, the model simulations, are interesting, but need discussion:
 - a. How is the grid extended to reach higher southern latitudes? Does this mean that the resolution is lower in the Miocene simulations compared to

the PI simulation? How do you make difference plots then (regridding)? Does this have an impact on the results?

- b. Are the simulations run long enough? What are the trends in the deep ocean (temperatures, salinity, ...)?
- c. The comparison of the precipitation needs to be rewritten. The lower/higher precipitation along the coast of South America seems to be due to the movement of the continents. Maybe more interesting would be to discuss the apparent shift in the ITCZ. Why?
- d. Also the temperature comparison lacks discussion. Why is the MMG simulation warmer than PI? CO₂ is lower (200 ppm), right? How different is the Antarctic ice sheet compared to today? Is the cooling in the Pacific caused by changes in gateways/geography/topography? Please discuss.
- e. During this discussion please list again the differences between the Miocene simulations (400 vs 200 ppm; different Antarctic ice sheet and vegetation). What is the climate sensitivity of this model? A 200 ppm decrease in CO₂ would cause a reduction in temperature of about 2-4°C? Why is there only a difference of 1.6°C? Is the difference larger when you take the global mean surface air temperature? And how much of the cooling is due to the ice expansion (and related albedo changes)? Please discuss.

SPECIFIC COMMENTS

1. The start of Section 3 is somewhat confusion, because of the connection between Antarctic ice volume (defined for the Middle Miocene at the end of Section 2) and sea level. Maybe it would be better to start Section 3 with lines 132-136, followed by the discussion of other literature values.
2. Why is the topography over Greenland so high in the Middle Miocene? It looks much higher than a present-day isostatically rebounded topography.

TECHNICAL COMMENTS

Line 12: add “successfully” to applied

Lines 20-21: rewrite. $\delta^{18}\text{O}$ could also reflect a combined change in ice volume and temperature

Line 25: change “would have been” to “were”

Line 28: explain “important”

Line 40: add “e.g.” before references. Using an intermediate complexity climate and ice sheet model, Langebroek et al. (2010) showed that a combination of pCO₂ decrease and orbital forcing causes an Antarctic ice sheet expansion that can explain the majority of the benthic $\delta^{18}\text{O}$ increase.

Line 54: change “data” to “boundary conditions”

Line 61: change “studies” to “sediment core data”

Line 67: change “simulations” to “study”

Line 93: “This estimate” instead of “This 6 estimate”

Line 104: change “very few” to “little”

Line 190: change “Some” to “Additional”. And make clear in this sentence that the modifications will be discussed below.

Line 198: “64” where does this number come from?

Line 443: what does “T42x1” mean? Especially the “x1”?

Line 459: rephrase to “ were set to PI following Otto-Bliesner”

Line 471: change “observed” to “simulated”

Line 477: change “complete compilation” to “complete set”

Line 481: change “treated” to “discussed”

Figure 1: caption: change “total elevation” to “surface elevation”

Colours: The colour scale is not great. By colouring 0 to -1000m white, it seems to belong to land, while it is actually ocean. Please change this. Also ice thickness cannot be negative, please update colour bar.

Figure 4: Please make the order of the abbreviations in the caption consistent with the order in the colour bar.

REFERENCES

Bradshaw, C. D., Lunt, D. J., Flecker, R., Salzmann, U., Pound, M. J., Haywood, A. M., and Eronen, J. T.: The relative roles of CO₂ and palaeogeography in determining late Miocene climate: results from a terrestrial model–data comparison, *Clim. Past*, 8, 1257-1285, <https://doi.org/10.5194/cp-8-1257-2012>, 2012.