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Climate of the Past Discussions

Interactive comment on "Constraining atmospheric CO_2 content during the Middle Miocene Antarctic glaciation using an ice sheet-climate model" *by* P. M. Langebroek et al.

Anonymous Referee #1

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Constraining atmospheric CO2 content during the Middle Miocene Antarctic glaciation using an ice sheet-climate model.

This is an interesting contribution which aims to determine what levels of atmospheric CO2 were likely to have been before and after the mid-Miocene climate transition by forcing a climate-ice sheet model with various CO2 scenarios and examining the model-predicted volume of the Antarctic ice sheet.

Model predicted ice volume changes are then compared to benthic oxygen isotopes in an effort to constrain the most likely CO2 scenario for generating an appropriate mid-Miocene Antarctic ice sheet volume.

The rationale is that Miocene CO2 proxy data is scare and uncertain and that a modelling study may help guide us as to likely CO2 levels for the mid-Miocene.

For a time period such as this I concur that modelling has a role to play in suggesting what is more or less likely, but as the authors honestly say themselves the absolute results have to be taken with a very healthy pinch of salt.

The results from such a study are likely to be highly model dependant. On top of this I think the relative simplicity of the climate-ice sheet model employed, combined with a simplistic experimental design which lacks realism in a Miocene sense (lack of Miocene boundary conditions), makes the overall results of the study more uncertain then they could have been.

I am surprised by the apparent sensitivity of the climate-ice sheet model to CO2 change and surprised that with a constant level of CO2 slightly above 400 ppmv the model predicts the almost total deglaciation of Antarctica. Other studies in which a full complexity GCM linked to an offline ice sheet model display a lower sensitivity to CO2.

For example the modelling work of DeConto and Pollard (2003a/b) using an AGCM linked to a slab ocean model for the E/O suggests that an atmospheric CO2 level of ~2.85 times modern is required before a large and permanent ice sheet is predicted by the model. This value is far higher than is needed by the model used here.

There are probably a number of reasons for this. (1) Since the model has not been set up with a full suite of palaeo-boundary conditions (palaeogeography, SSTs, sea-ice etc.) the model may have an inappropriate climate sensitivity for the Miocene. (2) The lack of a realistic representation of the ocean is likely to impact the results and contribute to the sensitive nature of the model and may play a large role in determining the low level of CO2 required to deglaciate Antarctica. (3) The model has been tuned to be more sensitive to account for the missing water vapour feedback.

I appreciate that the tuning provides a predicted ice sheet in reasonable agreement with

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modern and predicted two times CO2 scenarios (i.e. reasonable climate sensitivity) but this does not mean that results from sensitivity experiments are also realistic.

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