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Interactive comment on "Boundary conditions for the Middle Miocene Climate Transition (MMCT v1.0)" *by* Amanda Frigola et al.

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The presented paper describes and provides a set of boundary conditions to be used to force Middle Miocene global climate model simulations. This work focuses on two periods before and after the Middle Miocene Climate Transition (MMCT), the Middle Miocene Climatic Optimum (MMCO) and Middle Miocene Glaciation (MMG). A review of topography, bathymetry, sea-level, Antarctic ice-sheet configuration, atmospheric CO2 concentration, palaeovegetation for the two periods is also presented. The boundary conditions for the MMCO and MMG periods are tested with the Community Climate System Model version 3 (CCSM3). The results of two CCSM3 simulations, for the MMCO and MMG respectively, are briefly presented.

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Discussion paper

The manuscript is well written and structured. The selection of boundary conditions is described clearly and comprehensively. However, I think that the presentation of the vegetation reconstruction needs to be revised and shortened. The last section presenting the CCSM3 simulation results also lacks discussion, and a comparison with previous General Circulation Model (GCM) simulation results. I therefore recommend this manuscript for publication in GMD, if the authors address the comments listed below.

General Comments

1. Due to the scarcity of palaeovegetation records and the difficulties linked to the identification of plant taxa and correspondence to larger vegetation classes (Plant Functional Types (PFTs) or biomes), the reconstruction of a global vegetation distribution for the Miocene is certainly not easy and subject to many assumptions. Simple and static vegetation maps, mainly based on the reconstruction by Wolfe (1985) have been prescribed in previous modeling studies (Herold et al., 2010; Hamon et al., 2012; Goldner et al., 2014). In that way, deriving a global vegetation map from the reconstruction of Pound et al. (2012), based on the latest palaeovegetation data available, can improve the quality of the vegetation cover to be prescribed. However, the numerous simplifications in the biome classification applied here mask the improvements that could be added to the vegetation reconstruction. The authors end up with a very coarse vegetation distribution, with no differences, except tundra in Antarctica, between the two studied periods, and lack the potential feedback on climate of vegetation change. Wouldn't it be possible to directly interpolate the point-based vegetation reconstruction proposed by Pound et al. (2012) for the Langhian (representative of the MMCO) and for the Serravallian (representative of the MMG) to a 2° map, without so many simplifications, and to keep a maximum of the different biomes listed by Pound et al. (2012)? Corrections could be applied in function of more detailed regional information from Wolfe (1985) and Morley (2011). Then, a translation from BIOME4 to LSM biome classification could be done. However, the number of biome classes should not be too

restricted in order to not loose the distinction between warm/cool and drier biomes, helping to better represent the transition to drier and cooler landscape in the Serravallian (MMG here). If this first option is not possible, I would suggest to extend the number of LSM biomes used here to better represent the vegetation changes between MMCO and MMG. Deriving the vegetation cover from an off-line vegetation model simulation could also be an option to get a global and gridded vegetation map consistent with the model set-up. Previous modeling studies have already done so (Krapp and Junglaus, 2011; Henrot et al., 2017).

2. The last section of the paper, presenting CCSM3 simulations, is too short in comparison to previous sections describing the boundary conditions and lacks a discussion of the simulation results. Evaluating the reliability of the climate simulations would help to prove the suitability of the boundary conditions for Miocene climate modeling. What are the global surface air temperature and precipitation differences between the MMCO, MMG and PI runs? What are the impacts of the boundary conditions changes on the simulated climates? Sensitivity experiments testing separately the impact of boundary condition changes are not presented here, but would it be possible to distinguish or at least discuss the possible impacts of the different boundary condition changes on the simulated climate. The discussion would also benefit from a comparison with previous modeling studies, at least for the MMCO (and even with the same model, see Herold et al. (2010)), and/or with available proxy-data (e.g., for SSTs).

Specific Comments

Introduction: the Introduction would benefit from some description of the climate state of the Middle Miocene, to highlight the differences between MMCO and MMG climate and between the boundary condition sets that will be presented later in the paper.

Lines 36-37: this effect should be taken into account in the vegetation cover reconstruction provided in Section 6.

Lines 43-45: please give the resolution of the boundary conditions and the format they are available in.

Lines 52-53: the vegetation reconstruction proposed here is not exactly an update of Wolfe (1985). The sentence should be rephrased.

Section 2: a discussion explaining the use of a previous Antarctic topography corresponding to the Oligocene instead of previous published Middle Miocene topographies is needed in Section 2. Some precision could be given concerning the Oligocene configuration and how it is suitable for the Middle Miocene.

Section 4: the presentation of the atmospheric pCO2 estimates is rather confused. A distinction between marine and terrestrial proxy-based reconstructions of atmospheric pCO2 has to be done and discussed. Giving only the pCO2 estimates before and after the MMCT transition (corresponding to the two periods studied, MMCO and MMG) rather than the decrease throughout the transition (lines 155-161) would help to clarify the text. I also suggest adding a graph showing the pCO2 estimates in function of time in Ma. This will help to visualize the uncertainties on pCO2 estimates and the suitability of the two concentrations proposed here for MMCO and MMG.

Line 163-164: 400 ppmv is not a maximum value of pCO2 for the MMCO if you take into account the reconstructions based on stomatal indices (Kürschner et al., 2008), pedogenic carbonates (Retallack, 2009) and recent estimates based on boron isotopes and alkenones (Foster et al., 2012).

Subsection 5.3: the description of the gateway reconstruction is too detailed. I suggest putting lines 204 to 214 to the Appendix.

Section 6:

Line 249: Herold et al. (2010) prescribed a vegetation distribution derived from Wolfe (1985) using a biome classification for CCSM3 adapted from Bonan et al. (2002). Did you use the same classification here? Could you please discuss the eventual differences between the classifications as they are used with the same land-surface model? I think it could be interesting to add a comparison of your MMCO vegetation reconstruction to the reconstruction proposed in Herold et al. (2010) and to highlight the differences induced by the use of the Pound et al. (2012) dataset.

Line 263-273: I do not agree with the argument proposed here by the authors. The cooling and drying at mid-latitudes has a non-negligible impact on the vegetation distribution (as also stated by the authors in the Introduction, lines 36-37). This effect could be seen on a 2° x 2° resolution map, or even at the T42-resolution used in the CCSM3 simulations with a more detailed biome classification. This vegetation changes can in turn affect the climate-vegetation interactions (even only via the surface albedo changes) and significantly impact on the global climate. I suggest at least revising the vegetation distribution for the MMG and to detail the biome classification used here in order to better represent the changes between MMCO and MMG vegetation distributions (see General Comment 1).

Lines 273-274: how much does the Miocene vegetation distribution differ from the pre-industrial vegetation distribution, as used in CCSM3. It can be useful to briefly list the differences here to better highlight the potential impact of vegetation on the Middle Miocene climate if using the boundary condition set proposed here. I also suggest adding a figure showing the PI vegetation distribution with the same biome classification (maybe in Figure 4).

Subsections 6.1 to 6.9: I suggest making these subsections more concise. I would prefer to have only one paragraph focusing on the major vegetation patterns that are taken here into account for the MMCO and MMG. The detailed description of regional vegetation patterns is useless because most of them are neglected for simplification. The authors can directly refer to Pound et al. (2012) for more detailed information.

Section 7:

Lines 467-475: the presentation and discussion of simulation results need to be reworked and extended. What are the global mean surface air temperature and precipitation differences between the two Miocene runs and the PI run? How do you explain that the MMG run is warmer than the PI run? Is it linked to the absence of ice in the Northern Hemisphere? What is the contribution of the boundary condition changes to the climate differences that the model simulates? A brief comparison with previous modeling studies is highly welcome here. A comparison with some proxy-data (e. g. for SSTs) can also be added.

Concluding remarks: this section needs to be reworked in function of the amendments of the previous sections.

Figures and tables:

Figure 5: I would suggest adding maps of mean surface air temperature differences (MMCO and MMG - PI). It could also be interesting to show the temperature differences between MMCO and MMG.

Table 2: is the correspondence between cool-temperate mixed forest (BIOME 4) and cool mixed forest (LSM) really suitable, since you mention in the footnotes that the cool mixed forest represents only boreal trees? Isn't it another possibility of correspondence?

Table 3: could you please give explicitly the values of the model parameters instead of citing a reference paper? Same for the PI orbital parameters.

Technical comments

Line 50: replace "passages" by "seaways"

Line 51: add the precision "most previous Middle Miocene studies with prescribed vegetation"

Lines 56-57: could you please rephrase this sentence? There are other ways to produce boundary condition assemblages.

Line 93: replace "6 estimate" by "volume estimate"

Line 133: write “previous Section”

Line 165: delete the space between “p” and “CO2”

Line 178: “ice-free conditions”

Line 191: replace “passages” by “seaways”

Line 194: write “Section 2”

Line 230: could you please use “seaway” instead of passage or Central American seaway.

Line 312: “Northeast Australia”

Lines 318, 320: “East Australia”

Line 322 and after: I always put a caption letter to subregions or continents “West Australia”, “Southern Africa”, etc.

Line 448: please explain configuration T42x1 or detail.

Line 464: “archived as b30.043” does this information really need to be mentioned?

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