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Interactive comment on "Set-up and preliminary results of mid-Pliocene climate simulations with CAM3.1" *by* Q. Yan et al.

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We would like to thank Prof. M. Krapp for the constructive comments. We have considered all these comments in our revised paper. The detailed responses are listed below:

General comments:

1. "One major point struck my attention: I found the set-up of the reference experiment to be inconsistent. The authors term their reference experiment as "pre-industrial", which is inappropriate, because some boundary conditions are based on modern data, for example, SST and sea-ice climatology from the HadISST data set (Rayner at al.,2003), and ozone concentration from satellite and ozonesondes (Liang et al.,

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1997). In contrast, greenhouse gas concentrations are prescribed with pre-industrial values. The authors should either explain their choice of boundary conditions, or, at best, redo a pre-industrial run with appropriate pre-industrial boundary conditions".

Response: We designed the reference experiment following the PlioMIP guidelines. According to PlioMIP (http://geology.er.usgs.gov/eespteam/prism/ancillary/exp_1_protocol.html), we should use pre-industrial CO2 values and modern SST and O3 concentration in the reference experiment.

Specific comments:

1. "I was wondering why the author use the term "preliminary" so frequently (also in the title)? It reads as if there will be more important results to be presented soon, which I don't think is the case for this study."

Response: In this study, we only present global temperature and precipitation changes in the mid-Pliocene compared to pre-industrial. However, as we have discussed in the PlioMIP workshop, we have a plan to analyze some regional climate changes based on the present study and other simulations in the coming future. Thus, we use the word "preliminary" in our paper.

2. "The conclusions read like a summary and they just repeat what has been written in the abstract. They do not tell anything about the mechanisms of the Mid-Pliocene warming which clearly is the aim of PlioMIP (see page 3341 l.12–13). Instead, the major finding of this study is the poleward expansion of the Hadley cell and the consequences for the climate system. This could to be pointed out in the conclusions."

Response: We agree with the reviewer. First, we change the subtitle "conclusion" to "summary". Second, the mechanism of the Mid-Pliocene warming is certainly important and is the aim of PlioMIP. However, as we have decided in the PlioMIP workshop, papers contributed to this special issue should focus on the methods and boundary

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conditions in simulations. Key scientific questions (e.g., mechanism of the Mid-Pliocene warming) will be discussed in the coming future. Thus, in this paper, we do not analyze the mechanisms of the Mid-Pliocene warming. It remains to be future task in the modeling intercomparsion. Third, we add the following sentence about the Hadley cell to the summary: "Besides, the Hadley cell expands poleward by less than 1 deg in the mid-Pliocene compared to pre-industrial."

3. "Is the poleward shift, by the way, also significant? To me, a difference of less than 1° seems to be very small."

Response: We agree with you. According to recent observations, the Hadley cell has widened by about 2°–5° since 1979 (Johanson and Fu, 2009). Thus, the poleward expansion of the Hadley cell in the mid-Pliocene (within 1°) is not significant. However, our experiments are only AGCM simulations. With fixed SST fields, the simulation may underestimate the poleward shift of Hadley cell. It remains interesting to investigate the shift of Hadley cell in coupled simulations.

4. "p.3340 l.14–15: The statement "The period has been a focus [. . .]" needs some references."

Response: We add the following papers to references.

Dowsett, H. J., Barron, J. and Poore, R.: Middle Pliocene sea surface temperatures: a global reconstruction, Mar. Micropaleontol., 27, 13-25, 1996.

Dowsett, H. J., Barron, J. A., Poore, R. Z., Thompson, R. S., Cronin, T. M., Ishman, S. E. and Willard, D. A.: Middle Pliocene paleoenvironmental reconstruction: PRISM2, US Geol. Surv., Open File Rep., 99-535, 1999.

Dowsett, H. J., Robinson, M. M. and Foley, K. M.: Pliocene three-dimensional global ocean temperature reconstruction, Clim. Past, 5, 769-783, 2009.

Dowsett, H. J., Robinson, M. M., Haywood, A. M., Salzmann, U., Hill, D., Sohl, L., Chandler, M., Williams, M., Foley, K. and Stoll, D.: The PRISM3D paleoenvironmental

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reconstruction, Stratigraphy 7, 123-139, 2010.

Haywood, A. M. and Valdes, P. J.: Modelling Pliocene warmth: contribution of atmosphere, oceans and cryosphere, Earth Planet. Sci. Lett., 218, 363-377, 2004.

Haywood, A. M., Valdes, P. J. and Sellwood, B. W.: Global scale palaeoclimate reconstruction of the middle Pliocene climate using the UKMO GCM: initial results, Global Planet. Change, 25, 239-256, 2000.

Lunt, D. J., Haywood, A. M., Schmidt, G. A., Salzmann, U., Valdes, P. J. and Dowsett, H. J.: Earth system sensitivity inferred from Pliocene modelling and data. Nature Geosci., 3, 60-64, 2010.

5. “p.3342 l.2: I don’t know what a “data ocean” is, rephrase or explain.”

Response: The data ocean means fixed SSTs are employed in the CAM3.1. We add an explanation in the revised text: “data ocean (fixed SSTs)”.

6. “p.3342 l.16–20: As far as I can read from the provided references, the preceding version CAM3 has been used in these articles. This needs to be corrected, either by adding information about differences between CAM3 and CAM3.1, or by referencing studies that use CAM3.1.”

Response: We add some references (CAM3.1) in the revised paper.

You, Y., Huber, M., Muller, R. D., Poulsen, C. J., and Ribbe, J.: Simulation of the Middle Miocene Climate Optimum. Geophys. Res. Lett., 36, L04702, doi:10.1029/2008GL036571, 2009.

Wei, T., Wang, L., Dong, W., Dong, M. and Zhang J.: A comparison of East Asian summer monsoon simulations from CAM3.1 with three dynamic cores. Thero. Appl. Climatol., 106, 295-306, 2011.

Huber, M. and Caballero, R.: The early Eocene equable climate problem revisited. Clim. Past, 7, 603–633, 2011.

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7. “p.3345 l.1–7: Why not directly interpolating the Mid-Pliocene topography to T42?”

Response: PlioMIP guidelines suggest that “To ensure that the climate anomalies (mid-Pliocene minus present day) from all PlioMIP climate models are directly comparable, i.e. that they reflect differences in the models themselves rather than the differences of modern boundary conditions, it was decided to implement both the Pliocene topography and SSTs as an anomaly to whatever standard modern SST and topographic data set is used by each modelling group in their own model.” (Haywood et al., 2010). Thus, we do not interpolate the Mid-Pliocene topography to T42 directly in our simulations.

8. “l.6–7: Is the resulting land-sea mask similar because of the T42 resolution?”

Response: No. We keep the land-sea mask same in both the reference run and the mid-Pliocene run, not because of the T42 resolution. We do this according to PlioMIP experiment design.

9. “Fig. 5: Highlighting regions of statistical significance (as in Fig. 3 and 4) would simplify a comparison to the annual mean temperature and precipitation difference plots (Fig. 3a and 4a)”

Response: We modify Fiure.5 by highlighting regions of statistical significance.

10. “Table 2: Can you explain the TOA difference between Pre-industrial and Mid-Pliocene?”

Response: In our manuscript, we defined heat flux upward to be positive and calculated the energy balance at the top of models. It caused some misunderstandings. In the revised version, we defined heat flux downward to be positive and calculated the energy balance at the top of atmosphere instead of at the top of models. This was the normal way to calculate TOA. In this way, the TOA is 1.2 W/m2 in the pre-industrial experiment and 4.1 W/m2 in the mid-Pliocene experiment. The changes show that more energy entered into climate system in the mid-Pliocene experiment relative to pre-industrial. The positive TOA anomaly (+2.9 W/m2) is then consistent with the sim-

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ulated mid-Pliocene warming (+2.0 °C).

11. “p.3346 l.19–27: What are the causes of the warming over Greenland and Antarctica? Is it due to removed land-ice or a lower elevation, or is due to vegetation? This needs to be explained.”

Response: Ice volume in the mid-Pliocene decreases by 50% on Greenland, by 33% on Antarctic. The retreat of ice-sheet leads to decreased topography there. The land cover is changed to tundra or bare land. All these changes contribute to the warming over Greenland and Antarctic. However, to distinguish the influence of changes in topography or land cover, we need more sensitivity experiments, which are beyond the scope of this paper.

12. “p.3347 l.5–18: Interestingly, high latitude warming is stronger during boreal winter than during summer. Why is that?”

Response: In high latitudes of Northern Hemisphere, heat flux transports from atmosphere to ocean in boreal summer, and heat is stored in ocean. Inversely, heat flux is released from ocean in boreal winter. In a warmer climate, more heat is saved in ocean in summer, and then more heat is released to heat atmosphere in winter. In this way, we can observe the strong high latitude warming in boreal winter in our mid-Pliocene simulation. This stronger winter warming is also simulated by other mid-Pliocene simulations (e.g., Koenig et al., 2012).

Technical corrections:

1. “p.3340 l.11: change to “ [. . .] at low latitudes than at high latitudes.””

Response: Done.

2. “p.3341 l.22: remove “which are””

Response: Done.

3. “l.23: replace “summarize” with “conclude””

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Response: Done.

4. “p.3344 l.1: remove "eventually"”

Response: Done.

5. “l.22: remove “conditions in the””

Response: Done.

6. “Do not use “∼” as a meaning of “to” (p.3346 l.17 and 21, for example), instead use a dash “–”.”

Response: Done.

7. “p.3347 l.23: “greatly” does not add substance and can be removed.”

Response: Done.

8. “p.3348 l.5–6: Rephrase to: “In contrast, precipitation is enhanced over North Africa, the Middle-East region, Indonesia, and the adjacent oceans.””

Response: Done.

9. “p.3349 l.9: replace “expend” by “expand””

Response: Done.

10. “The y-axes in Fig. 1 and 2 need a label: “temperature (°C)”, as well as the x-axis in Fig. 1: “time (years)””

Response: Done.

Mentioned references in the above responses:

Dowsett, H. J., Barron, J. and Poore, R.: Middle Pliocene sea surface temperatures: a global reconstruction, Mar. Micropaleontol., 27, 13-25, 1996.

Dowsett, H. J., Barron, J. A., Poore, R. Z., Thompson, R. S., Cronin, T. M., Ishman,

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S. E. and Willard, D. A.: Middle Pliocene paleoenvironmental reconstruction: PRISM2, US Geol. Surv., Open File Rep., 99-535, 1999.

Dowsett, H. J., Robinson, M. M. and Foley, K. M.: Pliocene three-dimensional global ocean temperature reconstruction, Clim. Past, 5, 769-783, 2009.

Dowsett, H. J., Robinson, M. M., Haywood, A. M., Salzmann, U., Hill, D., Sohl, L., Chandler, M., Williams, M., Foley, K. and Stoll, D.: The PRISM3D paleoenvironmental reconstruction, Stratigraphy 7, 123-139, 2010.

Haywood, A. M., Dowsett, H. J., Otto-Bliesner, B., Chandler, M. A., Dolan, A. M., Hill, D. J., Lunt, D. J., Robinson, M. M., Rosenbloom, N., Salzmann, U., and Sohl, L. E.: Pliocene Model Intercomparison Project (PlioMIP): experimental design and boundary conditions (Experiment 1), Geosci. Model Dev., 3, 227-242, 2010.

Haywood, A. M. and Valdes, P. J.: Modelling Pliocene warmth: contribution of atmosphere, oceans and cryosphere, Earth Planet. Sci. Lett., 218, 363-377, 2004.

Haywood, A. M., Valdes, P. J. and Sellwood, B. W.: Global scale palaeoclimate reconstruction of the middle Pliocene climate using the UKMO GCM: initial results, Global Planet. Change, 25, 239-256, 2000.

Huber, M. and Caballero, R.: The early Eocene equable climate problem revisited. Clim. Past, 7, 603–633, 2011.

Johanson, C. M. and Fu Q.: Hadley Cell Widening: Model Simulations versus Observations. J. Climate, 22, 2713–2725, 2009.

Koenig, S. J., DeConto, R. M. and Pollard, D.: Pliocene Model Intercomparison Project Experiment 1: implementation strategy and mid-Pliocene global climatology using GENESIS v3.0 GCM. Geosci. Model Dev., 5, 73–85, 2012.

Lunt, D. J., Haywood, A. M., Schmidt, G. A., Salzmann, U., Valdes, P. J. and Dowsett, H. J.: Earth system sensitivity inferred from Pliocene modelling and data. Nature Geosci.,

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4, C1466–C1474, 2012

3, 60-64, 2010.

Wei, T., Wang, L., Dong, W., Dong, M. and Zhang J.: A comparison of East Asian summer monsoon simulations from CAM3.1 with three dynamic cores. Thero. Appl. Climatol., 106, 295-306, 2011.

You, Y., Huber, M., Muller, R. D., Poulsen, C. J., and Ribbe, J.: Simulation of the Middle Miocene Climate Optimum. Geophys. Res. Lett., 36, L04702, doi:10.1029/2008GL036571, 2009.

Interactive comment on Geosci. Model Dev. Discuss., 4, 3339, 2011.