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Climate of the Past
Discussions

Interactive comment on "Antarctic climate and ice sheet configuration during a peak-warmth Early Pliocene interglacial" *by* Nicholas R. Golledge et al.

Anonymous Referee #1

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The fate of the AIS in the future is of great importance owing to its capability to rise global sea-level by ∼60 m. Lack of long-term instrumental records hamper our understanding of the behavior of AIS, especially the EAIS, in the 21st century. Geological evidence and simulations for a past warmer-than-present world could advance our knowledge on how AIS may respond to a warmer climate. Golledge et al. investigated the AIS in the Pliocene that is frequently argued as a potential analogue for future world. Although numerous modeling works have been performed targeting at the Pliocene AIS, ranging from offline to fully coupled climate-ice sheet simulations, their work differs with previous ones mainly in the so-called "tipping point" analysis.

However, I have large concern on effectiveness and implication of the "tipping point"

analysis performed in this work. In my opinion, the level of warming needed to melt an ice sheet completely or a key region (e.g., ice over Wilkes Subglacial Basin in the Pliocene) is considered to be a critical threshold, or tipping point. For example, the tipping point for the Greenland ice sheet is about 1.6 oC (Robinson et al., 2012). The authors performed the so-called "tipping point" analysis, but give no efficient information on the actual tipping point. In addition, the technique used may be inapplicable here as the climatic forcing is constant. In this way, I think the signal detected is the time needed to melt parts of ice sheet for a given forcing, such as these shown in Fig. 8. Besides, as Wilkes Basin is a key region for the stability of the Pliocene AIS, it is necessary to analyze temporal evolution of ice volume over there and perform the "tipping point" analysis. [Robinson A, Calov R, Ganopolski A. Multistability and critical thresholds of the Greenland ice sheet. Nature Climate Change, 2012, 2(6): 429-432]

Other concern is on the uncertainty in the modeled AIS. The values of ice sheet model parameters are poorly constrained due to the limited observations over Antarctica, which may introduce an uncertainty into the simulated AIS. For example, Yan et al. (2016) indicated that the largest source of uncertainty in the modeled Pliocene AIS is derived from ice sheet model parameters, which result in a range of 10.8 m in sea level equivalent. I recommend that the authors should perform several sensitivity runs to test whether the so-called "tipping point" is greatly affected by parameter uncertainty. [Yan, Q., Z. Zhang, and H. Wang (2016), Investigating uncertainty in the simulation of the Antarctic ice sheet during the mid-Piacenzian, J. Geophys. Res. Atmos., 121, 1559–1574, doi:10.1002/2015JD023900].

Additionally, the simulated absolute temperatures with RCM are generally consistent with proxies, though a bias of 1∼2 oC is found. So I think it is useful to drive the PISM with outputs from the RCM directly. However, the authors employ an "anomaly" method to construct the Pliocene forcing used in PISM. The method should be justified. The authors can also compare the simulated temperature anomaly with reconstructed anomaly or compare the newly constructed Pliocene forcing with reconstructions. In this way, they can test which method is better, the “direct method” or the “anomaly method”.

Specific comments:

Page 2, line 4: it should be “2-4 oC” warmer in the mid-Pliocene.

Page 2, line 23: How the sea surface temperature is set over land? It is set to land temperature or others? The temperature over subglacial basins are important and affect the simulated ice sheet retreat.

Page 4, line 25: please add a brief description on the parameterizations of sub-shelf melting in PISM.

Page 5, line 24: how long the model is integrated? 10 kyr? Does the model reach quasi-equilibrium? Please clarify this in the manuscript.

In Fig. 4: How the temperature anomaly over sub-shelf region is calculated? Is WAIS also removed in the control run? Actually, the RCM used cannot simulate oceanic temperature below ice shelves that is required in PISM.

In Fig. 5: How many experiments are carried out? Nine? If so, as the number of experiment is not large enough, the results from each experiment can be plotted as a dot rather than dashed lines in Fig. 5, which may cause misunderstanding. Besides, the work of Yan et al. (2016, JGR) can be added here.

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