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Climate of the Past Discussions

Interactive comment on "Modelling ice sheet evolution and atmospheric CO_2 during the Late Pliocene" *by* Constantijn J. Berends et al.

Anonymous Referee #1

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The late Pliocene has been a focus for the paleoclimate data and modeling studies as its averaged warmer-than-present climate condition as well as the intensification of NH ice sheet occurred during this period. This paper presents the ice sheet and pCO2 evolution during the late Pliocene with the inverse modeling method and the asynchronous climate-ice sheet model approach. By combining validated modeling methods and Pliocene-based GCM climate matrix, the authors further constraint the pCO2 and sea level variations in particular for the MIS M2 and the late Pliocene warm interval. This work contributes importantly to the understanding of the climate variability and evolution for the late Pliocene in terms of transient modeling study. However, the current work is still not qualified for the final publication, I would recommend its publication after the following comments are considered.

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Discussion paper

General comments:

1. The introduction is too short to draw an overall background of this study. For example, concerning the late Pliocene warm period, the authors only list the related references without introducing the related results briefly. Much attention is paid on the MIS M2 and no introduction for the glacial interval after 3.0 Ma. However, the title of this paper indicates the objective of this study is to draw the ice sheet and pCO2 evolution over the late Pliocene and their transient simulation is also carried out from 3.65Ma to 2.75 Ma. Thus, the introduction needs to be modified or the title needs to be changed.

2. The authors validate the inverse method by applying it to investigate the last glacial cycle. In their results, the inversed pCO2 and modelled Benthic delta O18 show good agreement with the data. The modelled benthic delta O18 are largely improved comparing to their previous study (Berends et al., 2018), this is reasonable since the extra matrix provides more suitable climate states for the last glacial cycle. However, this extra climate matrix is not suitable for the late Pliocene. Unlike the PI, the pCO2 records during these warm periods are mostly higher than 300ppmv. In this climate matrix, there is only one warm state (PlioMIP,405ppmv) and it is far from the relative cold climate states, this will add more uncertainties to the warm period simulation for sure. To better understand the late Pliocene warm interval, at least, a medium warm-pCO2 (between 405 and 280 ppmv) and a strong-than-PI insolation climate matrix need to be included.

3. Please explain more details about the equation (2). What is the theoretical relation between (1) and (2) ? Why can this relation be also established during the late Pliocene without glacial-interglacial cycle?

Specific comments:

1. Line numbers are not continuous, it is not easy to comment.

2. Page 1 line 9: “such a climate state existed for a significant duration of time”, please

specify how this climate state is.

3. In Figure 1: There are a lot of pCO2 data across this period, here the authors only show one inverse data which may mislead readers.

4. Page 2 line 9: “Over a period of about 20,000 years”. Why is 20 kyrs, please provide the specific date for MIS M2.

5. Page 6 line 3: 200 ppmv, not 220 ppmv ?

6. Please describe the information for each labeled plot. Figure 9 is not labeled with the alphabet.

7. For the model parameters, the authors choose to vary the standard parameters by increasing or decreasing 10 %, does this value represent the range of parameter uncertainty ?

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