Reply to referee #2

CLIMBER-2 includes a shallow-ice approximation ice sheet model over the Northern Hemisphere, which allows the ice sheets in presumably Greenland, North America and North Eurasia to respond interactively with the climate. Antarctica is prescribed based on the PRISM3 Antarctic ice sheet reconstruction. Could the authors state the reason why Antarctica is not simulated in the same way as the Northern Hemisphere ice sheets? Also, I think it would be useful for the authors to comment on the potential implications of the lack of interactive coupling over Antarctica.

The ice-sheet model Sicopolis, used in CLIMBER-2, is applied only to the Northern Hemisphere (NH) because it does not include ice shelf model that is crucial for simulation of the Antarctic ice sheet. Although this is a limitation of our modeling approach, it is obvious that variations of the Antarctic ice sheet on the orbital time scales had a rather localized effect on climate. The main aim of our study is to quantify the range of variability in temperature and vegetation caused by orbital forcing and assess the importance of vegetation-climate feedback. The most relevant processes contributing to the response of climate to orbital forcing are taking place in the NH, because of the larger land area where ice sheets can expand and vegetation can change.

1711-2: The authors use the astronomical solution of Berger and Loutre (1992) to compute the orbital forcing throughout the mid-Pliocene. However, as many of the proxy records are tuned to the more recent astronomical solutions of Laskar (e.g. Laskar et al., 2004; 2010), it would be useful for the authors to detail if these astronomical solutions differ significantly.

Insolation computed using Berger and Loutre (1992) and Laskar et al., 2004 differ mostly in timing of maxima and minima (ca. 10,000 years shift) but very little in absolute values (see attached figure). Since for our study only absolute values are important, the difference between the two sets of orbital parameters has negligible effect. However, to be consistent with calibrated proxy data we will redo the transient runs using the orbital solutions of Laskar et al. (2004).

1712-10: Although the authors use the term synergy in the context of factorisation with a reference to Lunt et al (2012) and describe this mathematically in Appendix B, I think it would be useful for the reader to know what is implied by synergy. It is unclear how this term should be interpreted, for example when looking at Figs 1b and 2b, and therefore I think a more detailed description is required.

We will add a sentence where we describe the interpretation of the synergy term in simple words. It is simply the portion of the total signal that can not be explained by the linear superposition of the contributions from single factors. The fact that the synergy is very small in our simulations implies that the response is quasi-linear.

1715-10: The authors write that "The magnitude of NH ice sheet volume variations corresponds to approximately 15 m sea level equivalent....." As this is the first mid-Pliocene climate simulation that is likely to capture or at least move towards simulating the 'glacial' or colder states within the PRISM time slab, it would be very interesting to know the locations of ice growth in the model. Due to the resolution of the model, is the 15 m SLE of ice made up solely of ice on Greenland? Or is there ice growth at certain

times in North America and Eurasia? It would be useful for the authors to go into more detail on this.

The ice sheet model is run at a reasonable high resolution of 0.75x1.5°. 15 m SLE variations result from variations both in the Greenland Ice Sheet and an expansion of ice caps over North America and northern Europe simulated during the coldest orbital intervals. We will discuss the ice sheet variations in more detail in a forthcoming paper where we will use a much higher resolution for the Greenland Ice Sheet.

1716-9: "...the summer SST increase in the NH estimated from proxy data falls well into the wide range of SSTs modelled throughout the MPWP." Although I agree with this statement generally, the blue line on Figure 5 is actually outside the modelled range northwards of 80N. I suggest rephrasing this statement accordingly

This sentence will be corrected according to the referee's suggestion.