

## General comments

Huang et al. presented an interesting analysis of the global-scale effects of changes in ice sheet volume. It is useful to see the local, regional, and global changes in climate variables caused by reductions in the height of the east Antarctic Ice Sheet. The results were clearly and systematically presented. The methodological limitations of the model were nicely discussed and addressed.

However, it is unclear to me whether this is intended as an idealized study, or whether it seeks to replicate the effects of actual past and future changes in ice sheets. If the former, that should be made clear. If the latter, then there needs to be a much more robust discussion of the relevant past and/or future scenarios that are meant to be reproduced here. If these experiments are meant to investigate possible future changes in climate, then it would also be useful to see comparisons between the Pliocene control simulation and pre-industrial control, given that the Pliocene control simulation is run with PRISM4 boundary conditions that include significantly reduced ice sheet volume (specifically over West Antarctica and Greenland) as compared to the present-day. In general, it would be useful to see a more detailed discussion of how the sensitivity experiments presented here correspond to past/future scenarios that have been studied in the scientific literature.

Yes, our simulations are intended as idealized studies. As HadCM3 is a ‘rigid lid’ model, the water contained in Antarctica did not get redistributed over the ocean when we reduced the EAIS height, which means the sea-level is essentially fixed. Therefore, the effect of changes in the surface albedo, sea level, and continental margins, which would undoubtedly occur with such orographic variations, have not been explicitly taken into account in our simulations (see section 4.3 Modelling methodological limitations; lines 251-258). We add some words to make the expression clear (line 65).

## Specific comments

- 1) Paragraph starting on line 50: You discuss using the mid-Pliocene warm period as an analog for end-of-century climate. The time-scales for changes in different

parts of the Earth system differ; as you discuss, although present-day CO<sub>2</sub> concentrations are similar to the Pliocene, it will take time for Earth's global mean temperature to rise to Pliocene levels. It will also take time for vegetation to adjust to the Pliocene climate, and—importantly—for ice sheet loss comparable to Pliocene conditions to occur. I think this section needs to include some discussion of the existing scientific understanding of future changes in the volume of the East Antarctic Ice sheet, including the possible time-scales of ice sheet loss. How far into the future might we expect to see a mid-Pliocene-like East Antarctic Ice sheet volume?

Done (lines 63-64). Thanks for the suggestion.

- 2) Line 105, “our experiments focus on changing the East Antarctic Ice Sheet height”: this makes it sound like you are changing the East Antarctic Ice Sheet height against its modern or pre-industrial value, but you are changing the East Antarctic Ice Sheet height against its reconstructed Pliocene value.

Thanks. We have revised the sentence to make it clear (see line 109).

- 3) Paragraph starting at line 108: I'd like to see more justification for this experimental design. Are the 0%EAIS, 25%EAIS, 50%EAIS, and 75%EAIS experiments intended to represent analogs for possible future scenarios, and if so under what conditions and over what time-scales could these scenarios arise?

These sensitivity experiments are hypothetical scenarios. We add more justification for the experimental design (lines 122-127).

- 4) Line 112: Are changes in the ice sheet dynamically resolved in the model, or are you manipulating the height of the ice sheet for each sensitivity simulation? This is unclear here.

In our study, we manipulate the height of the ice sheet for each sensitivity simulation. We have improved the sentence to make it clear (lines 114-116).

- 5) Lines 112-118: Does the mid-Pliocene control experiment already have reduced EAIS volume, as specified in the PRISM4 boundary conditions? If so, it would be helpful to describe in more detail the differences between PRISM4 EAIS configuration and its present-day volume/extent.

In the mid-Pliocene control experiment, the EAIS volume was as specified in the PRISM4 boundary conditions (lines 128-130). The differences in EAIS volume between the mid-Pliocene and present-day have been added (lines 130-132). Thanks for the suggestion.

- 6) Lines 188-191: The winds bringing moisture over the continent are different from the katabatic winds mentioned; it would be helpful to be more explicit here about the causal relationships between weakened katabatic flow and elevated moisture transport.

Done (lines 199-203). Thanks for the suggestion.

- 7) Lines 203-205: This is too vague.

Thanks for this comment. As our sensitivity experiments are hypothetical scenarios, it's hard to be more specific there based on the preliminary results.

- 8) Line 208: In section 4.4, you present a nice analysis of the energy balance, and find that “heat transport by winds from the Southern Ocean to Antarctica is the primary factor influencing the temperature changes over Antarctica.” Line 208 makes it sound like the atmospheric temperature lapse rate is the primary factor for warming over East Antarctica, which seems to contradict your findings in section 4.4.

Based on the analysis of the energy balance (Figure 9), we found that the primary factor is actually heat transport. However, the topography (which represents the lapse rate) is also important (turquoise line in Figure 9). We did not say that the atmospheric temperature lapse rate is the ‘primary’ factor on line 208. We are sorry

for the misleading sentence, which have been rewritten (lines 223-225). Moreover, we add some words to make the expression more clear (line 290).

- 9) Line 230: was EAIS height reduced below the PRISM4 reconstructed height during the mid-Pliocene warm period? PRISM4 focused on a specific interglacial period, so the height of ice sheets would have fluctuated during the mid-Pliocene. But is there evidence to suggest that the EAIS would have disappeared completely? Or are these hypothetical scenarios? Again, the justification for the experimental design needs to be more clear.

This is the same question posed in specific comment 3. See the responses above.

- 10) Line 245: would this have effects on ocean gateways such as the Bering Strait, and what impact might this have on ocean dynamics? Would these effects be significant?

Yes, that is correct. Reducing the height of the land could open up some gateways that are closed in our experiments. However, this experiment was designed to remove the unrealistic surface air pressure anomaly over the land (Figure 8a), and see how this affected the surface air temperature anomalies. Therefore, we add some sentences to make the experiment design more clear (lines 261-265)

- 11) Section 4.4: Please add more detail about how you conducted this energy balance analysis.

Done (lines 282-283).

- 12) Line 273: Which of these sensitivity experiments are applicable to which future and/or past climate scenarios? Please be more specific here.

Thank you for the suggestion. Our sensitivity experiments are hypothetical scenarios. It's hard to specify which future and/or past climate scenarios based on the preliminary results. To avoid misunderstanding, we rewrite the sentences (lines 295-297)

- 13) Line 278: similar to previous comments—is there evidence for these changes in EAIS height actually occurring during the mid-Pliocene warm period? Or are these hypothetical scenarios?

These are hypothetical scenarios. This is the same question posed in specific comment 3. See the responses above.

### Technical corrections

- 1) Line 59: would make more sense to write: “due to the large thermal inertia of the oceans, the global mean temperature is not projected to reach the level of the Pliocene until the 2040s.”

Done (line 60). Thanks for the suggestion.

- 2) Line 85: this is the spatial resolution of, not over, the ocean—correct?

Done (line 88).

- 3) Line 194: Typo, MPControl to MPControl

Many thanks. We are sorry for this mistake and have revised it (line 209).

- 4) Line 209: could change to “which can be explained by the lapse rate”

We have rewritten this sentence (lines 223-225).

- 5) Line 219: rewrite as “leading to higher air pressure over Antarctica and lower air pressure over extra-Antarctic regions.”

Done (line 235).

- 6) Line 220: perhaps it would make more sense to replace “translate to” by “correspond with.”

Done (lines 236-237). Thanks for the suggestion.

- 7) Line 232: “costal” to “coastal”

Done (line 248).

- 8) Line 269: there is no Section 4.4.4

Many thanks. We are sorry for this mistake and have revised it (line 290).

- 9) Line 284-285: should be “the surface air temperature and the sea surface temperature both decrease.... The surface air pressure increases over East Antarctica, while decreasing elsewhere”

Done (line 307). Thanks for the suggestion.

- 10) Line 286: awkward sentence. Could rewrite as: “Energy balance analyses show that the temperature changes over Antarctica are mainly caused by topographic changes in the EAIS.”

Done (lines 308-311). Thanks for the suggestion.