

Clim. Past Discuss., referee comment RC2
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Comment on cp-2022-30

Michiel Baatsen (Referee)

Referee comment on "How changing the height of the Antarctic ice sheet affects global climate: a mid-Pliocene case study" by Xiaofang Huang et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2022-30-RC2>, 2022

The authors present a model study on the impact of a reduced East Antarctic Ice Sheet in context of the mid-Pliocene Warm Period, using the HadCM3 model which took part in the PlioMIP2. They present the results of a number of sensitivity studies in which the height of the EAIS is gradually reduced. This study is relevant and the results are interesting, but I am missing a thorough scientific basis beneath many of the results presented. The study is also missing a good discussion regarding how these results can be interpreted in light of the present/future climate, as they are based on Pliocene simulations. The latter were shown several times to be highly dependent on the mid-Pliocene boundary conditions, stressing on the importance of a good assessment of the state-dependency of the system. I believe a considerable improvement can be made in order to better explain the results and provide more context on how they can be interpreted in light of present-day climate.

General comments:

- Terminology regarding EAIS is a bit confusing; '0% EAIS' for the largest anomaly is not very intuitive. Consider adjusting to e.g. -25/-50/-75/-100%, and 0% or 'original' for the default configuration.
- Does the inclusion of dynamic vegetation have any significant impact compared to the original configuration?
- Overall, figures of different experiments are rather repetitive. It could be more informative to show e.g. anomalies normalised by the 0% EAIS anomaly, to check whether the other experiments result mostly in a linear response of the strongest signal.
- The paper is quite descriptive, I am missing a more mechanical insight into the responses shown. Many of the claims or explanations are not supported by what figures show, or not shown at all, making it hard to follow the discussion of the results.
- Subsections 4.1 and 4.2 seem to be mostly results and should therefore at least partly move to section 3?
- Structure can be improved; many of the analyses implemented are presented 'on the

go', rather than in the methods section up front along with their motivation. This would make the overall storyline clearer.

Specific remarks:

- L19: surely there are studies? e.g. work of DeConto et al, Gasson et al.
- L25: temperature changes as a result of pressure changes: how are these linked?
- L136: 5C/km is much lower compared to free tropospheric lapse rate (usually $\sim 7\text{K/km}$, often $\sim 8\text{C/km}$ over ice sheets), is there an explanation for this?
- L167: Some decrease in precipitation can indeed be expected at lower temperatures, but can you also estimate how much? Does that explain the changes seen? Apart from the global precipitation reduction outside of Antarctica, I hardly see any correlation between the temperature and precipitation anomaly patterns, so clearly other processes are at play to explain the regional responses.
- L175: The precipitation response seems to occur mostly in the South Pacific ITCZ and SPCZ, can you explain why?
- L188: It would be very helpful here to make a simple budget analysis of the zonally averaged southward moisture transport at different atmospheric levels. The strongest precipitation responses extend quite far over the ocean, suggesting that reduced baroclinicity may play an important role as well.
- L198: again, it would be nice to know whether the responses of the different experiments are linearly related to the EAIS reduction factor and if not how they can be explained.
- L220: I doubt whether this seemingly very simple reasoning explains what is going on; besides the global pattern the temperature and pressure responses do not seem to be that well correlated either. What about circulation changes, heat transports, radiative effects?
- If it is purely the effect of pressure, you should use the ideal gas law and estimate the temperature response from the pressure response and compare it to the actual temperature change found.
- L234: Your abstract suggests that such studies do not yet exist?
- L238: Can you support this statement?
- L260: This EBM approach was also used for the Eocene by Lunt et al 2021 and for the Pliocene by Baatsen et al 2022.
- L262: The heat transport component indeed seems to be quite important over Antarctica. I do not follow how a cooler Southern Ocean is linked to higher Antarctic temperatures here? Also, it would be very useful to separate the temperature gradient and circulation components of the meridional heat transport.
- L281: I do not find this number anywhere in the results, how was it determined? Same for the 5% precipitation increase per degree C.
- L286: Yet, you show that the heat transport is more important in the EBM analysis?
- L287: This seems to be more of a motivation, rather than a conclusion from the results.

Figures:

- Missing a figure showing the heights and/or height anomalies applied in the

experiments.

- Figure 2: it would be helpful to remove the idealised lapse rate effect due to elevation changes, to distinguish with other dynamical/feedback effects.
- Figure 3: SST responses are almost identical to SAT responses, so I'm not sure what this figure adds besides using a more practical colour scale. Maybe showing the full-depth or upper x meter average temperature response would reveal some more fundamental circulation-related impacts. In fact, I am missing any ocean circulation responses in the figures shown.
- Figure 4: again this figure is rather repetitive between the experiments. While this is useful to know, it does not give any explanation of the patterns seen. Are these the direct result of elevation changes, or rather e.g. the related temperature/circulation changes? What are the seasonal responses?
- Figure 5: precipitation anomaly plots are always challenging to interpret, as there is already substantial variability in the reference, without which it is tough to see what is relevant.
- Figure 6: This is a very useful figure, but hard to read. Why show the entire Southern Hemisphere, rather than e.g. 30S-90S? The projection used seems to be cylindrical, which contracts Antarctica at the expense of lower latitudes. Using a polar stereographic projection seems to be a more logical and practical choice here. Interpreting anomaly quiver plots is pretty challenging. I think it would help to add colour shading showing whether the anomaly induces a weakening (e.g. blue) or strengthening (e.g.) red of the flow in the MPcontrol.
- Figure 8: global sea level is adjusted by lowering the land by 60m, but coastlines seem unaffected? This figure also shows that besides the EAIS, temperature and pressure anomaly patterns do not correlate well.
- Figure 9; it is hard to see what is going on besides Antarctica and for the largest terms. Consider changing the scaling or separating some of the components. The different components do not show actual warming/cooling, but their estimated (linear) temperature contribution from the EBM.

Typos/small errors:

- L134: increases?
- L194: MPcontrol
- L195: the Antarctic continent?
- L209: explained by lapse rate: something is missing here
- L268: height sheet
- L284: decrease