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Climate of the Past Discussions

Interactive comment on "Does Antarctic glaciation cool the world?" *by* A. Goldner et al.

Anonymous Referee #1

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This paper assesses global and regional changes due to adding or removing a large Antarctic ice sheet (AIS), for Eocene vs. Modern conditions at various CO2 levels, using the NCAR CESM1.0 model. Much of the analysis and conclusions are based on single-number sensitivity metrics calculated from global mean or Antarctic-mean quantities. The paper looks both at changing albedo alone, and albedo+topography, due the presence or absence of an AIS.

One may question whether this sensitivity analysis is helpful to the problem of future climate change, because it involves other types of forcing. I think the paper does a good job of addressing this concern, and presents the results mainly as a caveat of using paleoclimatic data on past rapid changes as indicators of future climate sensitivity (in the abstract and conclusions), while clearly keeping track of ESS vs fast response. Another important caveat that emerges is that if the feedbacks involve clouds, analysis of past changes is likely to be model (GCM)-dependent. In my opinion the paper contains

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interesting new material that is definitely of sufficient significance for publication.

Specific Comments:

1. The style of much of the text is dense and detailed, and it takes unusual concentration and multiple readings to see the main results of the experiments. That is, it's hard to see the forest for the trees. I would say that the basic results (as opposed to the broader implications which are communicated quite well in the paper) are:

- Shortwave Cloud Forcing (SWCF) is the dominant feedback. In the Eocene, adding an AIS causes a reduction in low clouds (mainly 60S to 90S). In the Modern, adding an AIS causes the opposite, an increase in low clouds (mainly in tropics). Less low clouds causes warming, so the basic cooling effect of adding an AIS is largely canceled in the Eocene (net is < 1 K), and reinforced in the Modern. This is clearly seen in Fig. 4.

- Sea-ice albedo feedback is subsidiary, amplifying AIS cooling at both times, but weaker than SWCF especially for Eocene.

- At low CO2 levels, for Modern, the GCM produces (summer?) snow cover over much of non-glaciated Antarctica, so there is little albedo change when an ice sheet is imposed, less cooling than at high CO2. Also clearly seen in Fig. 4.

- (Some other secondary results: e.g., d(FSNS) and d(FSNT) are proportional).

Much of this is contained in the abstract and concluding section reasonably well. But in between, it is hard to pick out, split up by lengthy detailed discussions and background. If the above basic content can be communicated succinctly and stands out in the main body of the paper, then the paper will reach many more readers, as it deserves. Perhaps the intervening text can be streamlined and shortened, with simpler and clearer writing style, leaving out non-central discussion or moving some parts to Appendices.

2. Much of the study stems from the opposite responses of low cloud amounts in the Eocene vs. Modern. It is strange and interesting why this should be, at the same CO2 levels - the continent-ocean maps are not that different. There is a sentence addressing

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it with references (pg. 2660, line 9-10), and the basic SWCF maps are in Figs. 6b,7b. But there is no further questioning or analysis of WHY this should be - no discussion of cloud mechanisms and climate interactions that might be involved.

Perhaps this absence of questioning is acceptable, and may be common to other similar diagnostic papers under the umbrella of "beyond the scope". But I suggest at least attempting to discuss some physical cloud-related processes that could possibly be behind it.

3. The text on pg. 2661, lines 23-28 is hard to follow, concerning low cloud changes over Antarctica vs. other regions. I suggest adding a figure showing zonal means of low clouds vs. latitude, for modern and Eocene, with and without ice sheet.

4. In a few places, the fact that Modern global temperature is warmer than the Eocene at the same CO2 level is invoked to explain differences in behavior (involving snow cover on Antarctic land, pg, 2658, line 7; and "less sea ice", pg. 2659, line 14). But some of the Eocene cases are colder than some of the Modern, as shown in Fig. 4, so these arguments may not hold across the board. or instance, the Eocene at 560 ppm is colder than Modern at 1120 ppm. Does this invalidate the arguments?

Technical Points:

- Make clear, especially in figure captions, that "glaciated vs. unglaciated" generally implies "albedo + orographic" forcing as in Eq. (2).

- pg. 2651, lines 1-7: It would be interesting to briefly describe significant changes in the predicted Eocene aerosols from modern, if any. Could this be one cause of the different cloud responses (point 2 above)?

- Suggested changes: pg. 2653, line 5; and Fig. 2 caption: "based off of" to "based on". pg. 2654, line 4: "a couple different" to "two different".

Interactive comment on Clim. Past Discuss., 8, 2645, 2012.

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