Reviewer Comment-blue shade

Short comment response to reviewer:
We thank the reviewer for the detailed and insightful comments on our manuscript. The reviewer brings up valid points for improving the description for how we define forcing and the experimental design of the study. Below we respond briefly to some of the general comments outlined by the reviewer and once the open discussion is closed we will upload a full response to all reviewer comments.

Discussion of major points:
Reviewer major point 1) In several places (see below for some examples), reference is made to 'radiative forcing' in a loose sense, where in fact this phrase has a clearly defined meaning which is different to that sometimes employed here. Radiative forcing is the change in TOA radiative fluxes BEFORE feedbacks such as sea ice and clouds and snow have responded. So, to say that e.g. "cloud shortwave feedbacks will determine the change in radiative forcing" appears misleading. If you mean that the background cloud distribution will determine the radiative forcing of removal of the ice sheet, then please make this clearer.

Response: We thank the reviewer for highlighting this issue. In the revised draft we will define the forcing of the Antarctic Ice Sheet (AIS) as the "effective forcing" because our forcing is calculated after the fast feedbacks like snow, sea-ice, and water vapor have operated. The authors will be clear about their definition for "effective forcing" in the revised manuscript.

Our interpretation of effective forcing includes fast feedbacks into the definition because calculating the effective forcing due adding and removing the AIS is complicated by the fact that the Eocene has thick, low cloud deck over Antarctica and introducing this change will have a different effective forcing on climate than the same changes made in Modern where Antarctica is a relatively cloud free region. Results from the study suggest that the underlying mean cloud distribution will determine the effective radiative forcing of adding and removing the AIS in these time periods.

In the discussion paper we calculated the "effective forcing" three different ways, FSNT (top of atmosphere), FSNS (at the surface), and clearsky net shortwave flux at the surface (FSNSC) with the latter being the closest to the standard calculation for "radiative forcing", but we note that all calculations do include the fast feedbacks.

Reviewer major point 2) I strongly feel that some additional simulations would hugely benefit this paper. At the moment the prescribed changes to the Antarctic ice sheet are different for the Eocene and modern simulations, i.e. the 'no-ice' and 'full-ice' configurations are both different for the Eocene vs. modern. At present it is therefore impossible to rule out that the different response in the Eocene compared with the modern is just due to a complicated response to Antarctic ice sheet configuration, as opposed to paleogeography and ocean gateway configuration remote from Antarctica. I would like to see additional simulations where the

MODERN Antarctic ice sheet is put into the Eocene simulation, and vice versa (e.g. a change is made to the land sea mask rather than just the surface properties. I feel this would remove a lot of ambiguity as to the actual reasons for the changes observed. Because these are slab simulations, I don't expect these would take very long to run. Furthermore, it should be clarified how else the modern/Eocene differ, for instance in the prescribed aerosol loading, and to discuss if this could also be playing a role.

Response: The reviewer brings up a valid critique about the experiment design. The authors spent significant time setting up the boundary conditions for this modelling study and changing the landmask is a non-trivial task within the CESM1.0 framework. Altering the landmask for either time period would require redeveloping the interpolation coupler files for the Modern/Eocene grids and redoing all the boundary conditions including the workflow described below.

Steps for regenerating boundary conditions files:

1) Developing a new set of coupler mapping files to interpolate land/atmosphere grids to ocean grids for Eocene and Modern.
2) Interpolating the vegetation schemes to fit the new landmask.
3) Deciding how to interpolate the existing Modern and Eocene ocean heat fluxes to fit the new landmask.
4) Making new input files for the ocean grid and land grid to be compatible within the new landmask around Antarctica.
5) Rerunning the offline aerosol runs because they are dependent on the topography and landmask.
6) Developing new datasets for atmospheric topography and land runoff.

With this being said the authors are working on developing new topography in Antarctica using the ANTSCAPE Antarctic paleotopography (Wilson et al., 2011), which would allow for the landmasks to be about the same size between Modern and Eocene. The generation of this new boundary condition for the Eocene has taken time and is ongoing.

The simulations suggested by the reviewer are important, but would be a complete rework of boundary conditions and rerunning of all experiments. The main results presented in the study are not dependent on Antarctic landmask size. We have done additional simulations for the Miocene (~15 mya) with a new Antarctic landmask as large as modern day, where we add and remove the AIS, and the temperature response ($\Delta T = -0.39$ K) (Figure 1) falls on a continuum between the Eocene and Modern simulations where we add and remove the AIS (Figure 6a and 7a current discussion paper). The main results we want to convey within the present study and in future results is that AIS effective forcing will change between different time periods (Eocene, Miocene, and Modern) because of the background climate state and cloud parameterizations within the model configurations.

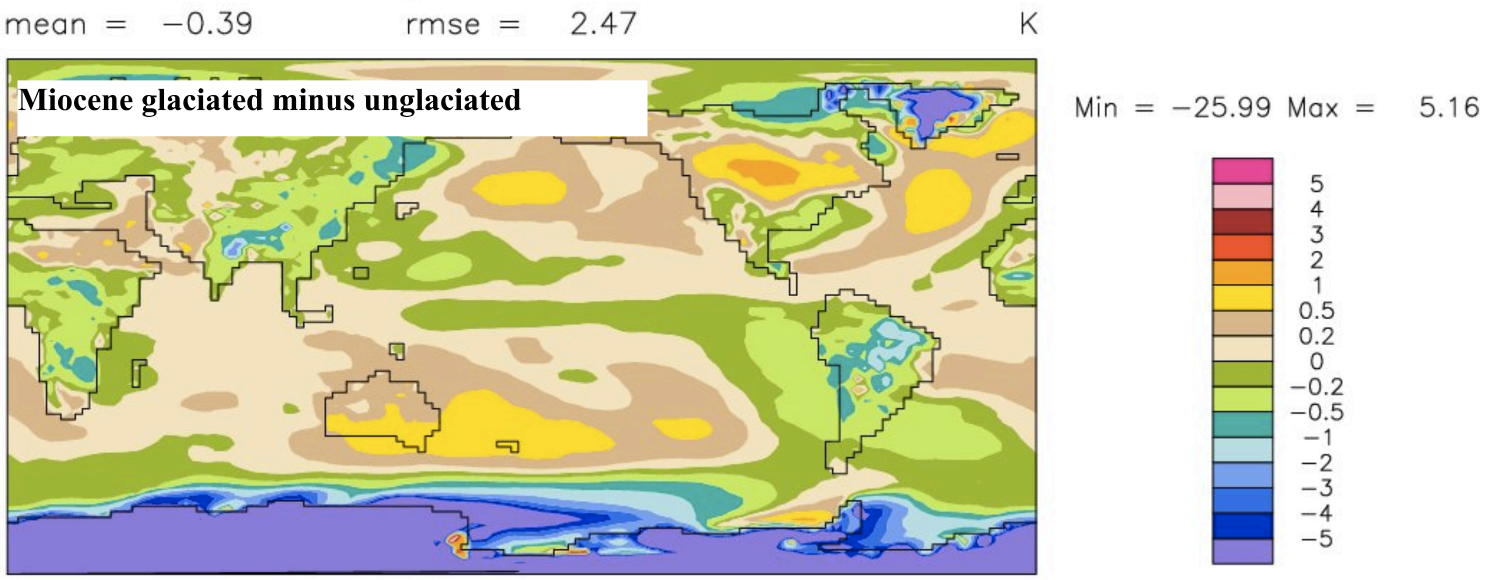

Figure 1. Annually averaged anomalies for surface temperature (K) for a glaciated (alpha+oro) minus unglaciated Miocene simulation. Both simulations are run at 560 ppm CO_2.