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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 #2

Received and published: 29 October 2012

This paper aims to explore the impact of the Antarctic ice sheet on the Earth System, under both modern and Eocene background conditions, and at a range of CO2 levels. The work has implications for our understanding of the Eocene-Oligocene transition, but the authors rightly highlight that this is primarily a sensitivity study, and is not intended to faithfully model conditions before and/or after the EO. The paper is of great interest, and is generally well written. I do however feel that the experimental design could be improved in order to better understand the results.

N.B. that I completed this review prior to reading the other review and associated comments, so this review is completely independent.

General comments:

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

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is different to that sometimes employed here. Radiative forcing is the change in TOA radiative fluxes BEFORE feedbacks such as seaice 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.

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 plaeogeography and ocean gateway configuration remote from Antarcitca. 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.

I also feel that there are significant problems with using a LOCAL forcing and a local temperature response to define a sensitivity (S[Antarctica]). Given the problems estimating the forcing itself, and the likely dependence on definition of the area considered, and that a local forcing can have significant non-local effects, I am not sure what is really learnt by this calculation, which is not central to the paper. Furthermore, the assumption of local forcing/response ignores possible transport effects.

Specific comments:

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Please add a sentence in the abstract to say that because the important mechanisms are cloud related, the results are likely to be model dependent, and should be verified by other models.

P2648, line 13. Given that both the forcing of the EOT and the global mean temperature response have large error bars, it is dangerous to make any conclusions about climate sensitivity. Here you cite the modal value of 1.5 K(W/m2)-1, but this itself has such large error bars as to be almost meaningless. Please don't make the same mistake as Asten, Climate of the Past Discussions, http://www.clim-past-discuss.net/8/4923/2012/cpd-8-4923-2012-discussion.html. Also pg 2669, line 15-16.

P2648, line 18. Here also, 'surprisingly' is a bit misleading. Through a non-linear change of state, of course the sensitivity will appear high. It is not 'surprising' that a single step over the edge of a cliff results in a painfall fall!

P2649, line 8 – it is not obvious to me that radiative forcing associated with removing an ice sheet is necessarily any more problematic than determining CO2 forcing. Long-wave forcing will also be partly dependent on the background state, due to different topographies.

P2651, line 1 – some more details of the model setup would be appreciated – the aerosol section is a bit vague – "like" sea-salt, dust etc. – is this list exhaustive or not? And how are they different in the different CO2 simulations – maybe these are actually also controlling the varying response to the ice sheet? Does your diagnostic framework allow you to tell the difference between surface, aerosol, and cloud albedo feedbacks, or just between surface+aerosol and cloud, or surface and aerosol+cloud?

Some experimental design details are missing, such as how long the simulations were run for, and how the slab ocean fluxes were calculated, and of they are the same in each simulation, or are calibrated for each CO2 level?

Figure 1 is good, but it would be worth devising a simple nomenclature for naming

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the simulations, e.g. using single-character subscripts/superscripts for CO2, Antarctic topography, and Antarctic albedo. The nomenclature of Deltas (e.g. p2654, line 2) could be greatly improved by indicating what CO2 levels the transition is between. At present the nomenclature is very clumsy for Eqns. 1-3, and not at all intuitive.

P2652, line 26 – snow is not the only important fast feedback here – the feedbacks manifest themselves as an albedo change mediated by snow, but e.g. seaice, clouds, water vapour etc. are all contributing to the overall warming/cooling which ultimately modifies the snow.

P2655, line 8 – after how long into the simulation are the radiative fluxes calculated?

Are the simulations in radiative equilibrium at the TOA? The whole diagnostic framework centers on the radiative fluxes, but how in-balance are these globally? And does it matter if they are not? As they as slab runs I wouldn't be surprised if there as a significant radiative inbalance, which was also very different in different simulations. . ..does this matter?

P2663, section 3.2.2. It would be instructive to also apply the diagnostic framework of Heinemann et al – is your analysis consistent with his?

P2664, line 25/26 – please add some discussion here about WHY the seaice feedbacks are stronger in the modern, even at the same CO2 level as modern.

P2666, line 2 – NB that clouds are likely to be highly model-dependent.

P2668, line 8 – please elaborate on the "correlations between surface and cloud albedos".

P2669, line 1-6 – "produces a good match" – please give vales from you models and from the proxies so we can know what you mean by "good".

P2770, line 1 – I don't agree that neglecting orbital variations is a 'weakness' of this study. This paper discusses a sensitivity study, for which orbital variations are irrele-

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vant. If you were trying to reproduce proxy data for the transient change across the EO, then neglecting orbit would be a weakness, but not for this paper.

P2670 line 10, even better than using a newer version of CAM, use a completely different model!

P2671, line 1 – I wouldn't believe any comparison with proxies, especially of climate sensitivity where both the forcing and the global mean response are not calculable from the proxies.

P2671 – caveat needed (also in abstract) that the whole study assumes that ocean circulation changes are irrelevant.

Typos/technical comments:

Abstract: Line 4-6. This sentence is unclear. Maybe say "depending on the background atmospheric CO2 concentration" rather than "when CO2 is dropped from 2240 to 560ppmv".

Line 7: "which is defined" -> "which we define"

Line 8: "radiative forcing" – see general comments.

Line 13: "partially due"... at the moment this is somewhat conjecture - the additional simulations I am proposing will allow this to be properly tested.

Line 22-23: "model results show that"-> "model results suggest that".

Line 25: give the date (Ma) of the EOT.

Final sentence of the abstract is a bit garbled (e.g. I am not sure what is meant by "into the future").

P2647, line 4 – give date of EOT.

The style is somewhat "chatty" in places, e.g. "significant temptation", "messy" p2647; "plague", p2648; "couple", 2654.

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P2648, line 9 – “state dependent” -> “dependent on background state”.

P2648, line 25 – see my general comments about ‘radiative forcing’.

P2648, line 29 – “systems’ fast feedbacks”.

P2649, line 11 – “Modern” -> “modern”

P2652, line 13 – remove ‘albedo’ here – the plots are just of topography.

P2654, line 4 – “couple OF” different approaches.

P2654, line 17 – even fast feedbacks don’t act “immediately”!

P2655, line 5 – “global calculation” of what?

P2656, line 4 – define clearsky.

P2657, line 10 – Delta T is relative to what in this case?

P2657, line 22 – be more precise than “little” – how little?

P2657, line 23 – be more precise than “smaller” – how much smaller?

P2658, line 1 – “increased snowfall” relative to what?

P2658, line 6 – Antarctic -> Antarctica.

P2658, line 24 – add “however”.

P2658, line 29 – diminishes with respect to what?

P2660, line 16 – in the SH, except over Antarctica itself which of course cools!

P2661, line 14 – warm the glaciated Eocene simulation IN THE SOUTHERN OCEAN.

P2664, line 12 – should these forcing be –ve?

P2666, line 24 – define non-ghg forcing – e.g. dos this include vegetation, ch4, n2o changes, or just ice sheet forcing?

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P2667, line 3 – units of sensitivity usually K per W/m2, [as it's =1, the value won't change!]

P2667, line 12 – see my general comments on radiative forcing.

P2670, line 11 – oceans -> ocean's or oceans'

P2671, line8 – not sure what is meant by "robust within CESM1.0". .

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