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Climate of the Past Discussions

Interactive comment on "The effect of low ancient greenhouse climate temperature gradients on the ocean's overturning circulation" *by* W. P. Sijp and M. H. England

Anonymous Referee #1

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Review of manuscript cp-2015-147 "The effect of low ancient greenhouse climate temperature gradients on the ocean's overturning circulation" by W. P. Sijp and M. H. England

Sijp and England present an Earth system model study addressing the question by what an extend the strength of the global ocean meridional overturning circulation (MOC) would change when assuming a weaker Equator to Pole air temperature gradient in the framework of a paleo-climatological setting. More specific, the authors try to investigate the Cretaceous climate which is characterized by a strongly enhanced greenhouse forcing compared to today's conditions. They tackle the well known prob-

lem of an overestimated Equator to Pole temperature gradient observed in many Paleo-Greenhouse simulations by manually adapting the budget of the outgoing long-wave radiation.

Surprisingly, their numerical simulations do not reveal a pronounced response of the MOC towards a flattened meridional sea surface temperature (SST) gradient. Even a weakening of the sea surface wind stress by a factor of 0.5 does not substantially affect the MOC. This short and concise paper presents interesting results. Subject to minor revisions I recommend publication in CP.

I miss a short discussion of possible caveats arising from a certain choice of parameters (i.e. diapycnal diffusivities) or of model numerics (i. e. accuracy of underlying transport schemes) likely to affect the simulated MOC response. It makes a difference whether the models MOC is predominantly driven by winds or by diffusion. (see T. Kuhlbrodt, A. Griesel, M. Montoya, A. Levermann, M. Hofmann, and S. Rahmstorf (2007) Reviews of Geophysics 45, RG2001, doi:10.1029/2004RG000166.)

As the authors point out, it is known from former studies using present day boundary conditions that the MOC correlates linearly to deep (or mid-depth) ocean meridional density gradients (Rahmstorf, 1996; Griesel & Maqueda, 2006). In Figure 4 (d) and (f) the SST's and surface densities are shown. It would be nice to add two further panels showing the same quantities at depth at around 500 to 1000 meters.

Regarding figure 4 (a): Is the atmospheric albedo kept identical in all the three experiments?

I do not really understand the sentence in the abstract (page 4788, starting at line 10) "Ocean poleward heat transport is significantly reduced only in the Northern Hemisphere, as now the circulation operates across a reduced temperature gradient, suggesting the overturning circulation dominates heat transport in greenhouse climates." so: A significantly reduced ocean poleward heat suggests a dominance in overturning mediated heat transport ??? Please rephrase!

Page 4788 line 24: " . . . redistributes heat across the global, ..." Did you mean " . . . across the globe, . . . " ?

Page 4791 line 11: What is an "enhanced extratropical radiative balance" ?

Page 4810: Figure 6: What is the meaning of the three labels at the base of the figures (y – axis) ?

Interactive comment on Clim. Past Discuss., 11, 4787, 2015.