

Interactive comment on “A conceptual model of oceanic heat transport in the Snowball Earth scenario” by D. Comeau et al.

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We would like to thank Reviewer #2 for the helpful and insightful comments on the manuscript.

Major Comments 1. We certainly agree that atmospheric heat transport is crucial to the global climate system and energy budget. Our modeling approach was to incorporate the atmosphere as a forcing, rather than a coupled aspect of the model. The air-sea heat flux component is an important aspect of heat transport, but at coarse spatio-temporal scales it is important to understand the basic state of outcomes before adding these fluxes with their very strong dependence on local/resolved dynamics. We believe we are not asserting that the model is not transporting all of the planet's heat through the ocean, as is stated by the reviewer. The atmosphere is a forcing in our model

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through ϵ - heat transport within the atmosphere is not modeled, but is all wrapped up in ϵ - perhaps having different ϵ s for each box (or even a pole-to-equator profile) could mock up varying atmospheric forcing by latitude, at the cost of introducing another parameter. The atmosphere may well transport six times as much heat - our approach is that the net effect of the atmosphere (including heat transport within the atmosphere) on the ocean / ice coupled system is through the radiative balance via ϵ . The Trenberth and Caron reference is a useful one, particularly Figure 5 for reference ocean heat transport values.

2. We thank the reviewer for pointing this out. This has been corrected in the code, and does not qualitatively change results. All corresponding equations have been modified, and the experiment results from the corrected code will be in the revised manuscript.

4. This is a valid point, and new figures for the global glaciation experiment at true equilibrium will be revised. The climate state in Figure 3 is changing much slower than its transition towards this state, though clearly not at equilibrium with net ice accumulation everywhere. Running the model further results in net melting in the tropics.

4. We were aiming for the simplest model that would capture ocean heat transport in Snowball Earth scenario. We certainly agree that precipitation minus evaporation is missing from the model and would affect the results, though we would expect the main results of our study regarding ice/ocean interaction through heat transfer and its affect on the global climate state to stand.

Minor comments In general we agree with the minor comments and will revise accordingly. We are not aware of observations of modern ice shelves that would assist in estimating ϵ , though this would certainly be extremely useful data to have.

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