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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Thermodynamics of climate change: generalized sensitivities" *by* V. Lucarini et al.

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We wish to thank the referee for the interesting comments. We believe they have helped us to improve the overall scientific content of the paper.

This paper is a very interesting effort to develop measures of climate model fidelity to data that characterize the efficiency with which the climate system converts potential energy to kinetic energy, or equivalently. A single climate model (PRISIM) is analyzed, and it is found that as with temperature, the measures of climate system efficiency vary nearly linearly with the log of CO2 concentration, when the model is allowed to fully equilibrate. The authors do not explicitly address how these measures of climate model fidelity are to be compared with the same measures applied to the earth, which is not in equilibrium- it would be good to see some discussion of how well these mea-

sures averaged over, say, thirty years in a simulation with monotonically increasing CO2 correlate to measures made at equilibrium with the same mean CO2 level. Agreement would make the measures much more promising as tests of climate model fidelity.

We do appreciate the problem of time-dependent changes in CO2 concentrations. Nevertheless, as a first step in that direction, we wanted to tackle the simpler case of stationary simulations. We refer to this in the conclusions.

There are few areas where the paper could be improved: It be very helpful to have a figure showing where the Θ+ and Θ- regions are located in the atmosphere, to give the reader some intuition about the nature of the warm and cold pools discussed in the introduction.

We thank the reviewer for this comment. This has been worked out in detail in Figs. 3 and 4 and has, in our opinion, greatly improved the physical insight of the paper. We show that the areas where on the average positive and negative heat balances are found are well distinct and the way they change in altered climate conditions explain rather well the observed changes in the global thermodynamical properties of the system.

It may be that the authors are planning an additional paper with more climate sensitivity indices, but this paper would definitely be improved by the addition of a few additional measures. The most obvious would be: the sensitivity of Hadley Cell overturning, the sensitivity of convective precipitation and large scale precipitation.

We totally agree that it is important to treat these sensitivities, but they are out of the scope of this, preliminary, paper, where we want to study properties directly related to the global scale thermodynamics of the system.

I assume there is some fixed meridional ocean heat flux applied within the slab ocean. I would be very good to investigate the sensitivity of a few of the climate sensitivity measures to the strength of this heat flux.

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10, C2396–C2398, 2010

The heat flux is set to zero, as already specified in the earlier version (see now at page 6) of the manuscript. This matter is surely worth addressing, but beyond the scope of the present paper. In particular, it would be really relevant to use a model with a dynamic ocean.

Finally, I concur with the recommendation of the first reviewer that the prediction of reduced surface wind speeds winds be confirmed. Reduced dissipation could also, after all, result from a redistribution of winds from high roughness areas to low roughness areas, and a reduction in total dissipation certainly doesn't imply that dissipation is reduced in over most areas.

This has been taken care, and geographical features have been evidenced. The largest changes occur in the mid-latitudes in the SH. The wind stress is greatly reduced in the 1000 ppm with respect to the 100 ppm simulation, whereas changes between the 1000 and the 350 ppm suggest that ACC is reinforced (so that wind stress locally increases), but overall a decrease is realized. See Figs 3, 4, 6 and related comments in the new manuscript

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/10/C2396/2010/acpd-10-C2396-2010-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 3699, 2010.