Atmospheric
Chemistry
and Physics
Discussions

Interactive comment on "The influence of internal variability on Earth's energy balance framework and implications for estimating climate sensitivity" *by* Andrew E. Dessler et al.

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Comment: It seems to me the key underlying assumption in the paper is that the specific model used (MPI-ESM1.1) has internal variability which is an accurate representation of the Earth's internal variability. I don't think the authors have shown this is true. That is, if the model's surface temperature is considerably more variable than Earth's actual surface temperature history, that would suggest less correlation in the model between a change in surface temperature and a change in loss of heat to space than is correct.

Response: Ours is a methodological study that asks the question: does the method

used to obtain ECS from a single realization of the historical record warming work in a perfect model experiment? We find the answer is that there is considerable uncertainty associated with single realization estimates, as show in Fig. 2. This is the result of internal variability in the model. While it is difficult to rigorously validate internal variability in models in general, much work on this has been done (see, e.g., Sect. 9.5 of the IPCC Fifth Assessment Report, Working Group 1) and the models' variability seems reasonable. For this specific model, there was also an evaluation done for variability in the global radiation budget (Hedemann et al. 2017, Fig. S7). That said, we stress that none of this matters for the purpose of this perfect-model study.

Comment: The spaghetti graph in the paper, which overlays 100 model runs (100 runs!?!) and compares to the GISS history, obscures how much internal variability there is in the individual runs.

Response: There seems to be some confusion about what we mean when we talk about "internal variability". Internal variability in this paper refers to variability in the pattern of surface warming, not variability in the global average warning. In other words, given an amount of global warming, internal variability is a measure of the different ways the warming can be distributed around the globe, which in turn affects the planetary radiation balance. This is what interferes with estimates of ECS from the historical record.

Comment: I find the arguments about modeled temperature changes at 500 mb unconvincing. That is not how EB estimates of ECS have been done, and in any case, it seems irrelevant to the paper's central claim that Earth's surface temperature has too much internal variability to generate a useful estimate of climate sensitivity.

Response: Our discussion of 500-hPa temperature is presented as a different and in many ways superior description of the energy balance of the planet. It has little bearing on the argument that using surface temperature produces an imprecise estimate of ECS.

Comment: I have never looked specifically at individual runs of this model, but I have looked at individual runs from several other models, and many consistently display much more short term variability than the instrumental temperature history shows. This did not surprise me at all, since models which are too sensitive to forcing are likely going to display higher short term variability. The paper could be improved by comparing the GISS and Hadley temperature histories to a dozen or two randomly selected individual model runs, on 4 or 6 graphs, so that any differences variability could be visually compared. We should expect to see at least some runs where model variability is comparable to or less than measured variability. If all model runs are more variable than the historical record, I think that cases serious doubt on the accuracy of the key underlying assumption. The paper could be improved much more by calculating the variability in surface temperature for each modeled run as the total range in temperature anomaly over a few different time windows; eg. total temperature range over 5 year, 10 year, and 20 year rolling boxcar periods, and comparing to the same range values from the temperature history. If the model is a reasonable representation of Earth's internal variability, then the variability for the temperature history will fall well within the distribution of variability for the individual model runs.

Response: This emphasis on global average variability is not what we mean when we talk about internal variability. See comment above.

Hedemann, C. et al. The subtle origins of surface-warming hiatuses. Nature Climate Change, doi:10.1038/nclimate3274, 2017.