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Geoscientific Model Development Discussions

Interactive comment on "Radiative-Convective Equilibrium Model Intercomparison Project" *by* Allison A. Wing et al.

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General Comments:

An intercomparison of models in RCE is an excellent idea. This paper provides a good framework to help organize the project and build on the current momentum that the topic of RCE has. The paper is well written.

The current level of organization for this project is impressive and will hopefully lead to many participating models. The availability of diagnostic codes is also a major benefit.

I think the third theme on robustness is one of the most critical. It gets a bit lost in the discussion about aggregation and sensitivity to warming. When the literature on RCE is surveyed, the apparent diversity of results is often the primary first impres-

sion. For example, not all RCE models aggregate. The WRF model in RCE mode (for a particular configuration) does not aggregate while SAM does (see last chapter of dissertation by Wenyu Zhou). The DAM model does not spontaneously aggregate (Jeevanjee and Romps, 2013). The broad range of results displayed in Held, Zhao, and Wyman, 2007 illustrates the difficulty of establishing a 'ground-truth' or baseline for RCE experiments. Some RCE models generate a 'QBO-like' oscillation, and some have an issue with dominant and persistent upper-level clouds. Another example of large variations in RCE results is shown in Silvers et al. 2016 where the ICON model exhibits large differences in the climate sensitivity for differing domain sizes despite similar subsidence fractions. There are consistent and robust results from RCE models, and I think much can be learned from them, establishing the bounds within which RCE is consistent among models and without which RCE varies across configurations would be one of the most significant/useful scientific outcomes of RCEMIP. The authors are clearly aware of this general point (lines 16-18 of page 2), but it could be clearer in the text, and emphasizing the importance of this component could make the project more appealing to some potential participants.

It will be very useful to the community to determine the response of clouds to warming, but this will have to be interpreted through the lens of RCE and the applicability to observations will be dependent on our ability to establish a consistent picture of the RCE results. This is why I think the current first theme, clouds and climate sensitivity, is secondary to the robustness theme.

It is not essential, but I think it would be useful to be more precise about a second set of non-required (Tier 2) experiments. This could be written in such a way that modeling centers wishing to participate with minimal effort are not thus discouraged from participating, but that more ambitious modeling centers or individuals could clearly push farther into the project in a coordinated way. My suggestions for further experiments would be:

1. Rotating RCE 2. GCMs in RCE mode with convective parameterization turned off

3. RCE with cloud RCE off (COOKIE type experiments) 4. Kessler physics across the hierarchy of models

This doesn't necessarily need to be incorporated in the paper: Presenting the hierarchy of model types as having 3 tiers misses a critical tier of a GCM with simplified microphysics. If we are discussing tiers and hierarchies why not state five model types for RCE: LES-RCE (sub km) CRM-RCE (1-5km), DoublyPeriodic_CourseRes-RCE(simple physics), DoublyPeriodic_CourseRes-RCE(full physics), and a global GCM-RCE(full physics).

Figures:

Overall the figures are clear, well formatted, and useful. However, the current set of figures isolates the different models rather than capitalizing on the intercomparison.

It would illustrative of the motivation for RCEMIP to have a figure illustrating the same quantity across the hierarchy of model configurations. For example, it would be nice to see something like a plot of vertical mean cloud fraction from SAM, NICAM, and CAM; a panel plot showing OLR (or water vapor path) from these three model configurations; or a panel plot showing the subsidence fraction as a function of time for the three model types.

Figure 9: It isn't a big deal, but why weren't the RCEMIP protocol parameters used for this figure?

Figures 12-14: I am assuming that these figures are showing data from the same 3 CAM simulations. Am I right? If so, this is not explicitly mentioned in the captions, and should be.

Specific Comments:

Page 2:

Lines 16-18: This seems to say that the reason it is still unclear if the observed at-

mosphere aggregates is because details of aggregation in models are dependent on model formulation. But in my opinion the lack of clarity on aggregation in observations and its relevance to climate change is mostly due to the difficulty of connecting an RCE model to cases with strong dynamics and horizontal gradients of forcing.

Line 27: I agree that it will be useful to extend the range of models used to simulate RCE, but single-column models have already been used to study, or in coordination with, RCE. So single-column models don't extend the range that already exists, nor will the proposed experiments here. What RCEMIP will do in this regard is to help fill-out the ensemble space of a baseline set of model configurations. This is important to evaluate the generality ('robustness') of the previous work on RCE, and will help to identify or map out what types of RCE models are still needed in the hierarchy to better our understanding.

Line 30: Citing Silvers et al. here is questionable, as we did not make the comparison suggested, rather out intention was to motivate the comparison. All of our domain sizes had the same grid-spacing. Page 2, line 2 would be more appropriate. Also page 4, line 32 (on comparing the spread of climate sensitivity) would work, but is not necessary.

Page 3

Concerning the themes outlined, themes 2 and 3 seem quite broad and as a result a bit vague. Perhaps broadness is the aim?

Page 4

Lines 2-4: This sentence seems to be overly emphasizing what RCE would tell us about clouds in the observed atmospheric system. The connection between the climate sensitivity of RCE simulations and the fundamental characteristics of modeled clouds is almost clear, but what are the fundamental characteristics of modeled clouds, perhaps you could say the climate sensitivity is one of those characteristics but not all encompassing? My interpretation is that the RCE convection is a key baseline that will

help us understand the role of modeled convection in determining the climate sensitivity.

It would be useful to ask for the ice-fall speed, and the fraction of convective precipitation from models to be saved. These would be helpful to categorize or interpret seemingly different results (as discussed in Held, Zhao, and Wyman, 2007).

Technical Corrections:

Page 3

There should be a “to” on line 9 between “guide” and “those who”

Page 5

Line 14: Perhaps delete this comment? ‘mimicking’ sounds like you are playing tricks here, or like you are not really representing the state described. I think something like, ‘representing’ would be more accurate. You are representing the described state. Shortcomings in the representation come from RCE, or the model itself, not from the boundary conditions.

Line 24: ‘conditions’ should be singular.

Page 10:

Line 28: “from” should be “for”, “with”, or “in”.

Line 33: There is an extra “to” in the last line.

Should more be said about necessary adjustments when altering the radius of earth? Maybe just citing more of Kevin Reed’s work would be an easy way to give people a clue about the details without adding too much technical material to the paper.

Page 13:

Line 2: Should “aggregation” be added here to indicate what was compared? As written, it is a bit unclear and the sentence should be reworded a bit for those who

have not read Cronin and Wing.

Page 14:

Line 17: ‘Figure’ should be plural.

Page 15:

Should we really be calling a GCM with 14 km horizontal grid-spacing a cloud resolving simulation (GCRM)?

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