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Interactive comment on "Abrupt transitions in an atmospheric single-column model with weak temperature gradient approximation" *by* Benjamin A. Stephens and Charles S. Jackson

Anonymous Referee #1

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The authors study abrupt transitions with gradual increase in sea surface temperature in an idealized tropical atmosphere. The approach the authors take is the single-column modeling that incorporates the weak temperature gradient (WTG) approximation. Their numerical experiment with different SST show that abrupt transition can arise from the interplay between local deep convection and the large-scale adjustments parameterized via WTG. The authors further suggested the abrupt transition is related to evaporative cooling.

The study concerns dynamics of tropics; and it fall in the scopes of WCD. The writing is mostly clear, but needs some improvement in clarity. The language is sometimes too

informal, which needs to improve. My main concern is that the RCE experiment seem to have a closed water budget, and the WTG experiment without any SST anomalies deviate too far away from the RCE run. My comments are listed below. I recommend major revision.

Major comments:

1. The RCE experiment (Table 1) has total precipitation 1.72 mm/day (1.26+0.46), and evaporation is ∼3.42 mm/day (99.3W/m2). The two should equal to each other in RCE. But they are quite off in this RCE experiment (Table 1). Besides the water balance, there is also heat balance over the column in RCE, i.e., HFX+LH=Radiation cooling. The results indicate that the sampling period is not in RCE, and the numerical error is too large to be explained by sampling uncertainty. I suggest checking the results carefully to see if the experiments truly reach a statistical equilibrium.

2. The WTG experiment without any SST anomalies (Table 1, Fig. 1) has rain more than 200 mm/day, which is 10 times of rain in RCE. This is too large, and it's unlikely this is physical. Without any external perturbations, the WTG experiments should have rain about the same amount of rain as RCE in principle (e.g., Daleu et al. 2014). It might be that the target temperature profile is not representative, causing excessive rain in this experiment.

3. The design of the numerical experiments are sometimes quite confusing. For example, E1 and E2 (Section 3.2) are solution obtained during the warming and cooling phases. But it's never clear when the warming or cooling phases start or end, and what are the SST values in those phases. Section 3.3 discuss hysteresis and multiple equilibria, which should depend on initial conditions (dry or wet initial conditions in previous studies). But it's not clear what are the initial conditions for this experiments.

4. Section 3.3. The authors discuss abrupt transitions and quasi-stationary states. These seem to be very much dependent on the numerical configurations (e.g., whether to predict/diagnose fractional cloudy amounts). I suggest a few more ensemble runs to

ensure these abrupt transitions are robust.

Specific comments:

L4: delete “of scale”

L10-11: “re-stabilizing the lower-column evaporative cooling” does not make sense

L45-46: SCMs do have large-scale dynamics. They are in the form of prescribed large-scale forcing. What the SCMs lacks of is the interaction between the local processes in SCMs and large-scale dynamics.

L84: provide references for these CAM schemes.

L85-86: Give the reference or the URL link to the webpage.

L87: be specific how you set the model to yield fractional cloud amounts

L89-90: this discussion of cloudy points or not does not appear to be relevant to the SCM simulations, because the column is partially cloudy all the time.

L95: set latitude to 0 does not eliminate seasonal cycles in radiation. Do you still have seasonal cycles in radiation? If yes, the runs cannot really reach statistical equilibrium.

L100: this is single column experiment – only 1 grid point. Why do you need specify horizontal grid spacing?

Figures 3, 4 : f_ls is not usual state variable representing statistical equilibrium. Please also show rain or other state variables.

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