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Geoscientific Model Development Discussions

Interactive comment on "Parameterizing deep convection using the assumed probability density function method" *by* R. L. Storer et al.

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Thank you for your well thought out and useful comments. We have addressed the comments in a revised manuscript by adding a section and figure on convective dynamics, as well as an appendix with the model equations, which we believe have improved the manuscript. Below are the original reviewer comments in italics with our responses following in plain text.

This is a valuable paper that extended the pdf-based CLUBB to deep convections. It showed SCM simulation results and comparison with LES results for three cases of deep convection and two cases of shallow clouds. The paper is a valuable contribu-

tion to document a potentially viable scheme of deep convection and its performance in SCM setting. I therefore recommend acceptance of the paper subject to the following improvements. Major comments: In extending the CLUBB to deep convection, the paper emphasized cloud and precipitation microphysical process. The paper did not discuss the viability of CLUBB to describe the dynamics of deep convection and how their extension would impact the dynamics of deep convection, i.e., the profiles of vertical velocity and its properties in deep convective clouds. Ultimately, one needs to have credible dynamics to trust the microphysics. The authors should also try to discuss why CLUBB works for the dynamics of deep convection since it was initially designed for shallow convection and turbulence, and show results that it works.

You have raised an important point. We have added a section about dynamics, including a plot with several relevant variables. CLUBB does a reasonable job of reproducing most of the dynamic variables, though some work still needs to be done on improving the coupling between microphysics and dynamics.

The text in the added section is as follows:

"Deep convection can have important effects on large scale dynamics through various feedbacks with microphysics (e.g. Liu et al., 1997; Tompkins, 2001; Khairoutdinov and Randall, 2006). As such, it is useful to examine the performance of CLUBB-SILHS with regard to dynamical fields such as vertical velocity. Figure 10 demonstrates some dynamic fields, the variance of vertical velocity and the turbulent flux of liquid water potential temperature and total water mixing ratio, in all three deep convective simulations. CLUBB-SILHS does a reasonable job of representing the variance of vertical velocity in all three cases. The turbulent flux of total water is quite similar in CLUBB-SILHS and SAM, though in ARM97 is a bit low. The turbulent flux of liquid water potential temperature is too low, particularly in TWP-ICE and ARM97. These cases are the most convectively active, so it is not surprising that the SCM would have the hardest time representing their dynamics. It is worth considering ways to improve the dynamics in future work, particularly by improving the coupling between

microphysics and dynamics. Adding complexity to the formulation described in Section 2.2.2 may be one way to accomplish this; however at current CLUBB-SILHS does a reasonable job in simulating the subgrid scale dynamic variability."

Some key basic controlling equations of the moments should be included so that the readers can see where the modifications are made and why only these are chosen but not others.

This is a good point. We have added an appendix with the basic prognostic equations for reference for the reader.

The sensitivities of the results to time step and vertical resolution make the scheme unsuitable for practical use. Some discussions will be useful on what should be done.

It was expected that the simulations would be sensitive to temporal and spatial resolution, however CAM is sensitive to these parameters as well. CLUBB-SILHS is being tested within CAM5 in order to see what biases might be introduced. The current simulations have not been tested or tuned at all for use within a GCM host model, and so more work will need to be done to determine how suitable the SCM is.

Minor comments: Page 3812, line 15, ?correlated?, do you mean ?collocated??

Yes, that is a more appropriate word, thank you.

For the second assumption on page 3812, why do you need to make this assumption?

Thank you for catching this. This assumption was made in an earlier version of the code, but has since been remedied.

Interactive comment on Geosci. Model Dev. Discuss., 7, 3803, 2014.

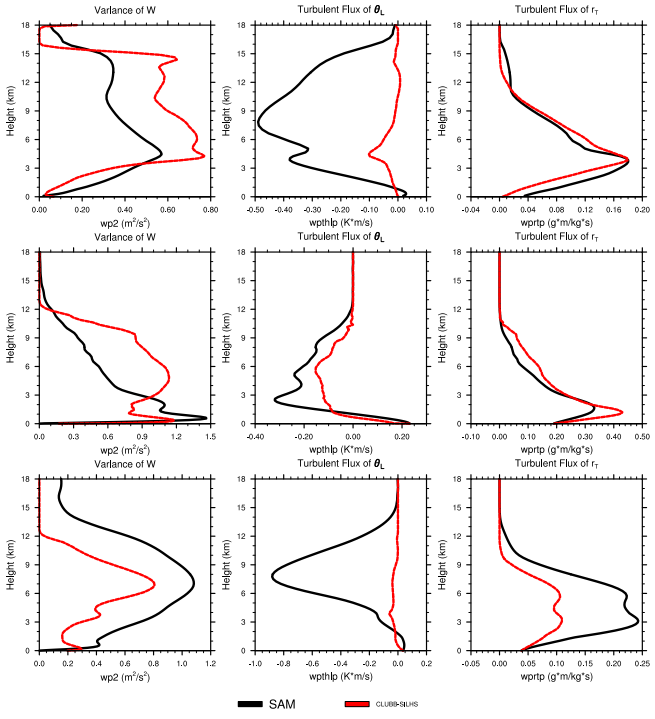

Fig. 1. Variance of vertical velocity, turbulent flux of liquid water potential temperature, and turbulent flux of total water mixing ratio for the 3 cases