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Interactive comment on “A unified parameterization of clouds and turbulence using CLUBB and subcolumns in the Community Atmosphere Model” *by* K. Thayer-Calder et al.

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1. Introduction: Needs for overcoming the current custom of using separate equation set for each parameterization: It would be helpful to refer to some of the previous proposals and efforts here. Yano et al. (2005) emphasize an importance of developing a suite of subgrid–scale parameterizations starting from a single set of equation system. More specifically, they propose a mode decomposition as such a general principle enabling a consistent development of subgrid–scale parameterizations (see also Yano et al. 2014).

The revised manuscript discusses Yano et al. (2005) and its relationship to CLUBB-SILHS.

A series of work by Moncrieff and colleagues (Moncrieff and Green 1972; Moncrieff and Miller 1976; Moncrieff 1978, 1981 1992; Thorpe et al. 1982; Moncrieff and So 1989) may be considered a more solid effort for developing a parameterization specifically for mesoscale convection organization from a first principle of the vorticity conservation.

Some researchers believe that parameterizing mesoscale organization in a non-regime-specific way will prove to be challenging. Mesoscale organization depends partly on momentum transport, and, for instance, Arakawa et al. (2004) write “even the direction of the [momentum] transport depends on the degree and geometry of the cloud organization. The problem then becomes that of predicting regimes of cloud organization and their transitions.”

CLUBB does not attempt to parameterize subgrid-scale mesoscale organization. Instead, CLUBB focuses on the distribution of velocity components, thermodynamic scalars, and hydrometeors. For this reason, CLUBB addresses a different problem than does the series of papers by Dr. Moncrieff and his collaborators.

The revised manuscript states: “CLUBB parameterizes momentum fluxes using down-gradient diffusion, but CLUBB does not explicitly parameterize subgrid-scale mesoscale convective organization (e.g., Moncrieff, 1992; Donner, 1993; Moncrieff and Liu, 2006).”

So long as I understand, the present series of studies makes an equivalent effort by invoking the subgrid-scale distribution of variables (probability density function, PDF) as a general guiding principle. This point could be better emphasized in the manuscript.

The manuscript now adds a new section that compares and contrasts Yano et al. (2005) and CLUBB-SILHS.

2. Introduction: Importance of subgrid coupling between clouds and microphysics:

Here, Hohenegger and Bretherton (2011) would probably not be the best reference to make this point. Though they indeed invoke the precipitation rate as an input variable for defining the entrainment–detrainment rate, this is more as a crude measure of the cold pool strength in the boundary layer not directly available in the given convection parameterization. Importance of coupling between convection and mircophysics is better discussed, for example, by Emanuel (1991) and Donner (1993) in their parameterization studies.

The revised manuscript cites Emanuel (1991) and Donner (1993). It continues to cite Hohenegger and Bretherton (2011), because that paper specifically notes that precipitation is a key difference between shallow and deep convection. The new manuscript writes:

"Hohenegger and Bretherton (2011) state that "the main difference between shallow and deep convection is precipitation (both rain and snow) and its effects." If true, this hints that a PDF parameterization that can accurately parameterize shallow convection can, in conjunction with a suitable coupling to the microphysics, also parameterize deep convection."

3. Methodology: The presentation of the methodology is rather terse, and it can be expanded. I would like to see a better–presented overview of the methodology.

CLUBB and SILHS have been thoroughly described in a number of prior papers, but those description papers weren't singled out as such in the submitted manuscript. To correct this shortcoming, the manuscript now writes that:

"CLUBB's methodology is overviewed in Golaz et al. (2002), and an up-to-date listing of CLUBB's equations is contained in Storer et al. (2015)."

"SILHS' methodology is described in Larson et al. (2005) and Larson and Schanen (2013)."

The new manuscript also contains a figure showing a flow-chart-style overview of the

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SILHS methodology in Figure 1.

So long as I understood there is an interplay of calculations within the PDF and physical spaces. What processes are evaluated in the PDF and physical spaces, respectively?

The overarching approach of CLUBB-SILHS is the standard one for cloud parameterizations: the parameterization does calculations on the subgrid scale (in CLUBB-SILHS, this involves integrating over a subgrid PDF), and then ultimately outputs grid-mean tendencies to the host model.

The original and revised manuscripts state that: “One set of microphysical tendencies is calculated per each subcolumn. The tendencies are then averaged in order to produce a grid-mean tendency. The grid-mean tendencies are then fed into the host model’s grid-mean equations for microphysical species, temperature, and moisture.”

A flow chart for calculation steps could be helpful for getting an overall picture clearer, too.

A schematic (Fig. 1) has been added to the manuscript.

Also, a flow chart is contained in Fig. 3 of Golaz et al. (2002).

It would also be helpful to know how convection (i.e., Zhang and McFarlane scheme) is coupled with CLUBB.

Table 1 in the original manuscript showed that deep convection is parameterized not with Zhang-McFarlane but rather with CLUBB-SILHS. However, to clarify further, the introduction now includes the sentences “Here, we evaluate a new configuration of the CAM climate model that we call “CAM-CLUBB-SILHS." It shuts off the Zhang and McFarlane (1995) parameterization of deep convection and instead uses CLUBB to parameterize deep cumulus, shallow cumulus, stratiform liquid clouds, and stratiform ice clouds.”

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