Atmos. Chem. Phys. Discuss., 9, C9167–C9169, 2010
www.atmos-chem-phys-discuss.net/9/C9167/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "A review of the theoretical basis for bulk mass flux convective parameterization" *by* R. S. Plant

Anonymous Referee #2

Received and published: 3 January 2010

This paper fills an important niche in the literature on convective parameterization by establishing the relationships between bulk and spectral approaches. The treatment is definitive, and, though largely formal, as noted by anonymous reviewer 1, beneficially so. It delineates clearly the extent to which a bulk parameterization can be derived from a spectral representation and the important limitations which arise in doing so. The paper quite appropriately notes that the most serious issues arise with regard to microphysics and condensate detrainment.

The paper provides an insightful and original discussion about issues related to time

scales in convective ensembles, emphasizing the scales associated with changes in the partitioning of mass flux among ensemble members in spectral approaches and its implications when these fluxes are aggregated in bulk parameterizations.

From my perspective, this paper would be recommended reading for scientists entering the design stage for a cumulus parameterization with a specific intended application. It will also serve an important pedagogical role for those studying convective parameterization. Given the importance in climate and climate change of interactions between convective and stratiform clouds, along with interactions between aerosols and convective clouds, the points made in this paper about detrainment and microphysics in bulk parameterizations have serious implications.

One point not made in what is otherwise a fairly comprehensive treatment involves vertical velocities in deep convection. Although the paper's main emphasis is convective mass fluxes, it's worth noting that bringing microphysics, aerosol activation of liquid droplets, and ice nucleation into convective parameterizations will require parameterizing vertical velocities, since these are key, highly nonlinear drivers of these processes. A spectral parameterization is a natural method for introducing vertical velocities and allowing nonlinear dependencies. Bulk methods are problematic, as can be seen following the formalism in this paper. The averaging of vertical velocities into a bulk value will preclude treating processes depending non-linearly on them.

Anonymous reviewer 1 suggests some figures. A schematic suggesting the consequences of the "Yanai ansatz" on detrained condensate would be a useful figure.

The author may wish to slightly re-craft lines 7-10 (p. 24947) the Introduction. Although convective plumes dominate *upward* transport, in mass-flux parameterizations, subsidence, which partially compensates this upward transport, also plays an important role.

Given the care in expression throughout this paper, a slight suggested re-wording for lines 15-16 on p. 24962 would be “rescaling can be thought of as selecting a privileged member."

Regarding Eq. (52) and the subsequent discussion, the author may wish to consider whether a subtle distinction should be maintained between the definitions of bulk work function and dilute CAPE. Note that the definition of A_B includes a dependence on $M(z, \lambda)$, as does the general definition of cloud work function in (48). Dilute CAPE could be defined without that dependence, *i.e.,* as the buoyancy per unit mass without consideration of the mass change in the plume with height, but, of course, using values of $s_{vc}(\lambda)$ modified by dilution.

In the references, line 10, p. 24978 (and line 26, p. 24972) “Donner, L.J., Seman, C.J., and Hemler, R.S." should be "Donner, L.J."

A minor point regarding the appendix: Although rare, it is not impossible that q could increase with height (especially in a numerical model), violating the assumption of its monotonic decrease (line 8, p. 24977) and the assertion (line 5, p. 24976) that the cloud base for *any* entraining plume lies above that for a non-entraining plume.