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Interactive comment on "Modeling the transport of very short-lived substances into the tropical upper troposphere and lower stratosphere" *by* J. Aschmann et al.

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(This comment is on behalf of Marc Salzmann and Mark Lawrence; the ACPD interface only allows one author in the document header.)

Aschmann et al. (2009) have developed a novel approach to parameterizing deep convective transport in isentropic coordinate models. With this approach they "explicitly model the large-scale subsidence in the tropics with deep convection taking place in fast and isolated updraft events." While the total mean vertical velocity (i.e., the average of cloudy and cloud-free regions) is positive upwards (ascent) in many tropical regions of frequent deep convection such as the equatorial Pacific warm pool, there is

some disagreement regarding the surroundings of moist convection, for example the areas between mesoscale convective systems (MCS). On the one hand, the concept of "mass balancing" mesoscale subsidence (e.g. between MCSs) has been widely echoed in the literature. On the other hand, several studies have emphasized that in regions of large scale ascent, such as the Intertropical Convergence Zone, subsidence does not necessarily have to take place between clouds based on mass balance considerations (e.g., Mapes, 1993; Salzmann et al., 2004; Lawrence and Salzmann, 2008).

Deep convection interacts with the surrounding atmosphere in several ways, some of which do not favor subsidence between clouds. In particular, convective anvils absorb long-wave radiation, significantly reducing radiative cooling. Furthermore, a study by Mapes (1993) suggests that heating associated with MCS could lead to upward displacement at low levels in a mesoscale region surrounding the heating through inviscid gravity wave dynamics (outside the immediate outflow). Inside convergence zones, where averaging over deep convective updrafts, weaker mesoscale downdrafts, and cloud free areas between updrafts yields a net ascent, deep convection occurs as an important part of the underlying circulation. It is, nevertheless, often convenient to separate between large scale motion and deep convection. Then, the adiabatic cooling associated with large scale vertical ascent inside convergence zones should be more than balanced by convective heating. For example, Tian et al. (2001) found that during a four month period convective heating (including condensation heating) was on average roughly three times as large as radiative cooling in an area located in the south Pacific Warm pool, with the difference being approximately balanced by cooling associated with large scale dynamics (i.e. regional radiative-convective-dynamical equilibrium). Interestingly, it is often stated that deep convection forces air to descend (e.g. Yanai and Johnson, 1993). Especially in parameterizations of deep convection, mass balancing subsidence is usually required to take place in the same vertical grid column as the deep convection in order to make the parameterization mass conserving. The associated apparent subsidence and heating can then, however, be partially

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balanced by large scale mean ascent and cooling, e.g. in the rising branch of the Hadley or Walker cell. In this case, the "mesoscale mass balancing subsidence" diagnosed by a convective parameterization occurs in part as an artifact of the operator splitting (Lawrence and Salzmann, 2008).

Aschmann et al. explicitly take into account radiative cooling for diagnosing large scale vertical velocity. In addition, they implicitly take into into account convective heating inside updrafts when they compute deep convective mass fluxes based on ERA-Interim analysis and apply them to calculate deep convective transport. The heating of environmental air (apparent heat source) associated with mass balancing subsidence around deep convection, which is usually parameterized in dynamical models, and can be balanced by radiative cooling and cooling due to large scale ascent is apparently not taken into account by Aschmann et al. While the approach by Aschmann et al. seems reasonable, it would certainly be interesting if they could briefly discuss their treatment of the various components of cooling and heating and their anticipated contributions to the results, especially in the light of a comparison to using height- or pressure coordinate Eulerian models, which constitute the more "traditional" approach to simulating the entire troposphere.

Finally, Kuang and Bretherton (2004) have demonstrated that deep convection can significantly affect the thermal structure of the Tropical Tropopause Layer, which has not been taken into account in the Aschmann et al. approach, but might be interesting to consider in the future.

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