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Interactive Comment

Interactive comment on “Deep-convective vertical transport: what is mass flux?” *by* J.-I. Yano

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

Yano (2009) makes use of the framework developed by Riehl and Malkus (1958) to present his perspective on convective mass fluxes, and on their use in the parameterized transport of tracers in 3D atmospheric models. The discussion in particular builds on our recent analysis of the viability of sensitivity studies examining the role of deep convective transport in atmospheric chemistry (Lawrence and Salzmann, 2008). It is nice to see this detailed historical perspective.

However, we would like to point out that we disagree with the primary conclusion of the manuscript, that "the best way to turn off the convective transport of chemical species is to set the vertical profile of the chemical species within convective components (both updrafts and downdrafts) equal to that of the environment." As the author points out, this is equivalent to simply turning off the convective transport of one or more tracers, which we have tried to make very clear is definitely not the best way to turn off the convective transport of chemical species. The author uses a very different reasoning for suggesting this approach than the reasoning used in previous studies, but regardless of how it is arrived at, we still think that this approach is flawed in being used to determine the net effect of convective transport on selected atmospheric tracers (or generally on atmospheric chemistry).

In global chemistry-transport models (CTMs) and chemistry-GCMs (CGCMs), the deep convection parameterizations assume that updrafts in any model column are exactly balanced by the sum of downdrafts and local subsidence, and thus do not account for the net upward transport of air mass through deep convective clouds. Instead, net air mass transport is exclusively simulated by the "large scale" mean winds. In Lawrence and Salzmann (2008), we show that there is significant overlap between "convective" and "large scale mean" fluxes. Therefore, a significant part of the tracer transport that is simulated using the mean vertical velocities in the advection routine is actually due to deep convective clouds, i.e., the large scale vertical velocity used in current models represents a mean over cloudy and cloud free areas. With this in mind, one can see that simulations in which the deep convective transport is turned off nevertheless still contain vertical transport by a component of the total global deep convection, though this transport is then occurring in the advection routines, rather than in the deep convection routines, where it belongs. Since the approach proposed in Yano (2009) is numerically equivalent to this (despite being philosophically different), and would give identical results in model simulations, we cannot agree that it is the best approach to turn off deep convective transport.

Yano (2009) also suggests in Sect. 4.1 that what we call "mass balancing mesoscale subsidence" or "convective subsidence" can alternatively be termed the "residual environmental subsidence", "because it measures a part of environmental subsidence not counted by the grid box averaged vertical motion w-bar." We would like to make clear (as acknowledged by the author later in the same section) that while subsidence in the vicinity of storms can exist, much of the mass balancing subsidence in large scale models is artifical: it does not really measure anything physical - it is simply a numerical construct to balance the difference between the updraft and downdraft convective mass fluxes in any given model column. Furthermore, we disagree that this mass balancing (or "residual") subsidence "should in fact be considered as part of the total environmental descent", rather a main point of Lawrence and Salzmann (2008) is that turning off this artificial descent results in the large scale advection taking over some of the transport that in reality takes place inside deep convective clouds (and which would otherwise be numerically offset by this artificial subsidence).

Finally, we would like to reiterate our argument that it is not viable to only turn off the convective updraft and downdraft mass fluxes, and leave the mass balancing subsidence turned on in order to balance the deep convective transport which is present in the large scale advection, since this would result in a severe non-monotonicity, which is, with good reason, one of the "taboos" in atmospheric tracer modelling (for good discussions on essential requirements for viable tracer transport simulations, see Rasch and Williamson, 1990, or Jöckel et al., 2001).

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