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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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We thank Marc Salzmann and Mark Lawrence for their thoughts about convective transport and their comments on our manuscript. Their central points are given here in *italics*.

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.

It is true that we do not force mass balancing subsidence within a model column. Rather we assume that the subsidence around deep convection is constrained by the clear sky radiative heating rates. Although clouds (in particular anvil cirrus) may also affect the large scale radiative heating rates away from convective updrafts, we use clear sky radiative heating rates here to avoid problems with counting part of the upward mass flux within convection twice. It may be worth emphasizing again that our convective updrafts (or more specifically the convective detrainment rates) are taken from the ERA-Interim analyses. I.e., our convective transport is only as good as the representation within ERA-Interim is. It has been shown in a number of studies before that the large-scale transport in the stratosphere is better represented in models constrained by radiative heating rates than in models using vertical velocities in a "traditional" approach. It is less clear whether this is also true for the large scale transport in the troposphere. Our first comparison with ozone, relative humidity and halogenated VSLS gives some confidence that our approach results at least in a reasonable tracer transport in the upper troposphere. However, for the investigation of transport of VSLS into the stratosphere this does not appear to be critical: in order to reach the stratosphere, air has to be lifted by deep convection above the level of zero radiative heating. It is hard to imagine any other process that will be effective to transport VSLS into the tropical tropopause region.

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.

Fueglistaler et al. (2009) have shown the diabatic heat budget of the Tropical Tropopause Layer in the ERA-Interim reanalyses. They find that in addition to the radiative heating ERA-Interim contains a "residual" diabatic cooling in the lowermost stratosphere over the Maritime Continent, due to the model's turbulent mixing parameterization. It remains to be shown whether this is real or a model artefact and whether or not this is due to the same mechanism as in the idealized cloud resolving model calculations of Kuang and Bretherton (2004). This additional diabatic cooling is not taken into account in our calculation of the large scale vertical velocity. We will include a note in our manuscript. It would indeed be interesting for a future study to investigate how this convective cooling as well as cloud radiative effects affect the diagnosed stratospheric upwelling and how this compares to the upwelling in more "traditional" Eulerian models formulated in pressure coordinates.

References

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