Atmos. Chem. Phys. Discuss., 6, S6784–S6787, 2007
www.atmos-chem-phys-discuss.net/6/S6784/2007/

Atmospheric
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Discussions

Interactive comment on "The role of the retention coefficient for the scavenging and redistribution of highly soluble trace gases by deep convective cloud systems: model sensitivity studies" *by* M. Salzmann et al.

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Received and published: 14 February 2007

We appreciate the review by this referee and the helpful comments and questions.

Abstract
The following sentence regarding the role of the dynamics and microphysics in the inflow region was included into the abstract:
"The large difference between LSF and bubble runs is attributed to differences in dynamics and microphysics in the inflow regions of the storms."

2. Model description

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Equations 4–7 were omitted. Eq. 3 was retained because a similar equation without the ventilation coefficient has often been used in model studies regarding trace gas scavenging. Without the ventilation coefficient Eq. 3 is strictly speaking only valid for drops at rest. Sensitivity studies (not included in the paper) indicated that omitting the ventilation coefficient does not change the main conclusions of this paper. Omitting the ventilation coefficient does, however, decrease the scavenging by rain drops significantly and leads to somewhat higher simulated mixing ratios of the highly soluble tracers in the lower troposphere (see Salzmann, 2005).

3. Model setup and Meteorological overview
The paragraph “The Henry’s law coefficients ...” was moved to the “Model description”.

3.2., Figure 3 of the original manuscript
For studies using LSF, different models often show similar biases in T and q (e.g. lower tropospheric bias in T and q for ARM in Xu et al., 2002). The influence of the representation of turbulence on these biases is in general not very well understood. Boundary layer turbulence is probably particularly important for the onset of deep convection. Using the same constant eddy diffusion coefficients for the ARM A LSF run as were used for the STERAO run, did not change the results significantly (there is a remark on this in Sect. 3.3 of the original manuscript). However, future studies on the relationship between the representation of turbulence and simulated tracer transport in CRMs would be very useful.

4. Transport of highly soluble tracers
The boundary layer mixing ratio of “T1 insoluble” in Fig. 4c (original manuscript) shows a very small decrease for the ARM A BUB case. For this case only a small part of the domain is shown and it is possible that transport across the lateral boundaries of this part of the domain plays a role in replenishing the tracer. It should, however, also be noted that only a relatively small amount of “T1 insoluble” actually resides in the upper troposphere. T2 has, unlike T1, a non-zero background above the boundary layer, so that for T2 the decrease due to the downward transport of tracer-poor air from

above the boundary layer is smaller. The difference between the upper tropospheric mixing ratios of “T1 released” and “T1 retained” in the bubble runs (Figs. 4c and d of the original manuscript) indicates that the upwards transport of “T1 released” takes place mainly inside cloud droplets (see also Figs. 6g and h of the original manuscript). Cloud droplets are more efficient in taking up soluble trace gases than larger rain drops because the uptake by rain drops is strongly limited by the gas phase diffusion (τ_{Dg}). Because of this diffusion limitation, it is also possible that a highly soluble tracer can escape scavenging when rain falls through rapid updrafts. Furthermore, in the bubble cases, rain is mainly formed above the lowest kilometer of the troposphere (see Fig. 12 of the revised manuscript and discussion in Sect. 5 of the revised manuscript).

6. Additional sensitivity runs and discussion
Mid-tropospheric entrainment plays a role in the TOGA COARE case, but is less efficient than entrainment from the boundary layer (see Salzmann et al., 2004). This does, however, not mean that a boundary layer tracer is transported by a "convective ladder" as was postulated by Mari et. al. (2000).

Suggested References: The suggested references were added in Sect. 6 in an extended discussion of the H_2O_2 retention coefficient:

“The retention coefficient for H_2O_2 is likely to depend on the details of the freezing process (Stuart and Jacobson, 2003; Stuart and Jacobson, 2004). Strong acids such as HNO_3, on the other hand, are expected to be well retained independent of freezing conditions (e. g. Voisin et al., 2000; Stuart and Jacobson, 2003). In an early laboratory study Iribarne and Psyhnov (1990) found that H_2O_2 was also completely retained in the ice phase after cloud droplet freezing. Snider et al. (1992) and Snider and Huang (1998), on the other hand, found that H_2O_2 is largely released to the gas phase during riming. Despite recent efforts by Stuart and Jacobson (2004) to explain the large range of values (from almost zero to one) from a number of laboratory studies, large uncertainty still exists regarding the retention coefficient of H_2O_2.”

Note, that the suggested reference by Voisin et al, 2000 is a mixture of two references. Title and coauthors are from Snider et al., 1992. We chose to include both.

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Interactive comment on Atmos. Chem. Phys. Discuss., 6, 10773, 2006.