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Interactive Comment

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.

M. Salzmann et al.

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We appreciate the comments of this referee but do not agree with many aspects of the criticism.

Referees #4 and #5 indicated difficulty accepting the use of artificial tracers in this study. Such tracers are applied in several studies on which this one builds; however, we apparently directed the text too much towards those who have been involved in these previous simulations, and clearly need to provide a better discussion of the motivation and interpretation. Please consult the reply to Referee #4 in order to find out about a change in the revised manuscript regarding this issue.

Referee #5 finds the conclusion that using LSF versus bubbles to initiate deep convection can lead to completely different results regarding the role of the retention coefficient for tracer transport trivial. As indicated in the reply to Referee#4, while one might qualitatively anticipate some differences between the cases and the model setups, we did not expect to find nearly opposite results when comparing the runs with isolated storms initiated by a bubble to the cloud system resolving runs. The release of tracer from freezing hydrometeors provided an efficient transport pathway to the upper troposphere only in our bubble runs (as expected based on previous studies in which bubbles were used to initiate deep convection) but not in the LSF runs. While bubbles have been used in previous model studies in which the sensitivity of tracer transport towards the retention coefficient has been examined, LSF has to our knowledge been used here for the first time in such a study. The large difference clearly shows the need for further studies. This need for further studies is now indicated in the abstract and the discussion of possible artifacts related to LSF was extended. In the original manuscript it is stated that "it can not completely be ruled out that artifacts occur in the LSF runs, e.g. due to the homogeneous nudging of the u and v wind components, although there is no obvious reason why this should happen." In the revised version of the manuscript, the following sentences have been added: "Another potential source of artifacts in the LSF runs would be enhanced formation of cloud droplets in the inflow region due to the application of horizontally homogeneous water vapor forcings. However, condensation in the inflow regions is strongly linked to storm dynamics, i.e. convergence and lifting, and even if a notable enhancement due to horizontally homogeneous water vapor LSF occurred, it would almost certainly not be sufficient to explain why a tracer dissolved in cloud water is not transported to the upper troposphere as indicated by Figs. 8e and f."

The degree of sensitivity of the results are towards using various bin and bulk microphysics schemes remains to be investigated. Thus far, two cloud modeling studies (Barth et al., 2001; Yin et al., 2002) have indicated that the retention coefficient plays an important role for the transport of tracers. One of the studies (Barth et al., 2001) used a bulk microphysics scheme and the other one a bin microphysics scheme, and

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in both studies, bubbles were used to initiate deep convection. The study by Yin et al. (2002) used a very simplistic representation of dynamics. The comparison between the ARM A LSF and the ARM A BUB run suggests that using bubbles may result in an over-estimate of the influence of the retention coefficient on the vertical transport of highly soluble tracers. In the STERAO storm studied by Barth et al. (2001), the high surface elevation and small liquid water region may also play a role, but this is difficult to judge without further studies, and LSF are not available for this case. Sensitivity runs (not shown) with the original WRF version of the Lin et al. microphysics scheme yielded qualitatively similar results, but this scheme is in many aspects similar to the one used in this study.

To our knowledge, this is the first study regarding the role of the retention coefficient in which more than one storm is studied. The number of case studies is, however, limited by the amount of work to set up and evaluate these runs and by the available computer time. Fig. 10 of the revised manuscript suggests that the updraft in the ARM A BUB case is not extremely tilted. Windshear is, however, very common in both mid-latitudes and the tropics for dynamical reasons.

Replies to the additional comments:

K_H and K_V are both calculated. The minimum for K_H was effectively set to 12 $m^2\,s^{-1}$. Whether it was actually necessary to set a minimum for K_H in order to keep the model stable or whether it would have been stable without setting such a minimum is not clear from the runs we performed.

Regarding the effect of aqueous phase chemistry on H_2O_2, the following sentence was added to Sect. 6 of the revised paper:
"Note that in regions far from SO_2 sources, such as the TOGA COARE region, aqueous phase chemistry can be expected to play only a minor role for H_2O_2 (see Sect. 6.2 of the supplement to Tost et al., 2007)."

$R_{k,j}$ are calculated inside the microphysics scheme, as indicated on page 10779, line

19 of the original manuscript.

We would like to point out that the first sentence of the comment starting “This paper ... “ is misleading. We find that using LSF results in significantly enhanced scavenging, and not in significantly reduced scavenging.

Reference

Yin, Y., Carslaw, K. S., and Parker, D. J.: Redistribution of trace gases by convective clouds - mixed phase processes, Atmos. Chem. Phys., 2, 293–306, 2002.

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

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