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Atmospheric Chemistry and Physics Discussions

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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.

Anonymous Referee #2

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The article by Salzmann et al. discusses results from model simulations in which the importance of retention of soluble tracers during freezing is discussed. They find that the retention of soluble tracers during cloud drop freezing is sensitive to the manner in which the model initiates deep convection. It should be pointed out that it is the microphysical processes that are sensitive since the retention of dissolved species during freezing solely depends on whether freezing occurs or not. The findings in this paper are intriguing but create more questions than answers.

In the article results are shown from four different model simulations, which include a

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tropical, oceanic case, an isolated storm situated on the high plains of the USA, and convection occurring near the Southern Great Plains site in Oklahoma. Having storms of different character indicates the possible robustness of the results, but also complicates the answers. Tropical, oceanic storms tend to have lower vertical velocities than the continental, midlatitude storms. These lower vertical velocities often result in smaller production of hail/graupel, which implicitly indicates that different microphysical processes dominate the storm compared to the midlatitude continental storms. The Oklahoma and high plains storms also have different characteristics because of the higher elevation and the relatively drier air in the high plains. With high (colder) cloud bases, the high plains storms have a smaller region of liquid water which increases the influence of the ice phase on the storm structure. The Oklahoma storms, with warmer cloud base temperatures, should have a more extensive liquid water region allowing for a larger region where soluble constituents can dissolve into the cloud hydrometeors. Whether the precipitation, and ultimately the scavenging and removal of dissolved species, is formed via the same processes in each of these types of storms remains to be answered.

Major Points

1) Contrasting convection initiated by thermal bubbles versus convection initiated by large-scale forcing (LSF): When convection is initiated by LSF, the environment in which the convection occurs is changed, while the environment for the thermal bubble initiation maintains similar conditions to the initial state (as long as the bubble does not overwhelm the environment). As a consequence, the characteristics (dynamics, microphysics) of the convection will differ between the two initiation methods. This result can be seen in Figures 6b and 6d. The thermal bubble initiated convection does not reach the same heights as the LSF-initiated convection and there is a distinct cloud base at 1.5 km altitude whereas cloud water exists at the surface of the LSF-initiated storm. The differences between LSF-initiated convection and thermal bubble initiated convection must be thoroughly discussed in the paper because of its importance to the

resulting soluble tracer results.

2) Because the distribution of soluble tracers depends on the microphysics processes, these processes must be discussed. Determining which processes are controlling the fate of the soluble tracer is critical.

3) The paper discusses results from a TOGA-COARE simulation of tropical, oceanic convection as well as from two continental, mid-latitude convective storms, 10 July 1996 STERAO storm and 27-30 June 1997 ARM-SGP convection, Each of these simulations is of convection of a different type. Thus, the results discussed here not only present differences based on initiation methods but also show differences between different types of storms. Separating effects from the types of storms versus the initiation method must be examined and discussed. By doing so, we should be able to learn about the importance of microphysics on soluble tracers for a variety of conditions.

4) Are there too many storms simulated and discussed? A thorough discussion of each storm did not occur. Cross-section plots of the hydrometeors were shown for two cases but not the others. Vertical velocity, etc were shown for only two cases also. Sensitivity tests were done for one case, but not others. It is difficult to compare the different results when the information is incomplete.

Specific Points

1. What microphysical processes are occurring and which ones are dominating the formation of precipitation?

2. Are the results discussed the total mixing ratio for the species, or gas-phase-only mixing ratios? The adsorption of gases onto ice likely will have less of an effect when discussing total mixing ratios.

3. How do the simulated results compare to observed radar reflectivities for each of the cases? Are cloud bases actually as low (∼0 km) as that seen in the large-scale forcing simulations?

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4. Why are the time-averaged, domain-averaged cloud bases at the surface for the large-scale forcing simulations? (Figure 3)

5. The paper discusses results from 4 simulations somewhat haphazardly. For example, there is no presentation of TOGA-COARE peak vertical velocities. The domain-averaged profiles of tracer T2 are not included.

6. P. 10788. I'm not sure it is a competition between different storms but perhaps between different processes occurring in each of the storms. Can this be sorted out?

7. P. 10788, line 27. Clegg and Abbatt (2001) [J. Phys. Chem. A, 105, 6630-6636] show that gas-phase H_2O_2 uptake onto ice is small (this should be mentioned in the article). I do not think adsorption is a major uncertainty for H_2O_2.

8. P. 10790, lines 12-18. The Stuart and Jacobson (2003, 2004, 2006) papers discuss the theory of retention of dissolved species during freezing of drops. These papers should provide a theoretical framework for addressing both the retention and adsorption processes. [2003 paper: J. Geophys. Res., 108, D6, 4178, doi:10.1029/2001JD001408; 2004 paper: J. Geophys. Res., 109, D07305, doi:10.1029/2003JD004197; 2006 paper : J. Atmos. Chem., 53, 13-42, doi: 10.1007/s10874-006-0948-0]

Technical Details

P. 10777, line 10: What are the units of C_g and C in each of the hydrometeors (mass mixing ratio or concentration)?

P. 10777, line 25 is –> are

P. 10780, line 21: A comma is needed after "1997)"

P. 10781, line 5: To be consistent, the size and temperature perturbation for the STERAO storm initiation should be included.

P. 10782, line 5: I don't think the reader should have to go to Salzmann et al (2005) to

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find out if the simulation represents observations. There should be a sentence or two explaining their findings.

P. 10782, line 24 –> to a large extent, also

P. 10786, line 24 tropsphere –> troposphere

P. 10786, line 25: Is there a dependency on water vapor concentration?

P. 10787, line 16 bases –> basis

P. 10788, lines 1-12 and cited figures: Are the gas-phase only or the total mixing ratios shown and discussed?

P. 10789, line 5 is –> are

P. 10789, line 28 multiply –> multiple

P. 10791, line 11 downwards –> downward

Fig. 3 caption should state that it is for the ARM case

Fig. 3 legend does not need to include T1 in the ice, snow, and graupel because only the released T1 tracer is shown.

Fig. 4, Fig. 6, Fig. 8 vertical axes for the STERAO storm should begin at 1.5 km mean sea level instead of 0 km above ground level. It is more appropriate when comparing results to other storms.

Fig. 11 caption "the with" –> with the

Fig. 11 caption: Should it be qtot > 0.01 and not qtot < 0.01?

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

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