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Interactive Comment

Interactive comment on "Diffusional and accretional growth of water drops in a rising adiabatic parcel: effects of the turbulent collision kernel" *by* W. W. Grabowski and L.-P. Wang

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We thank the reviewers for the insightful comments and suggestions. We revised the paper following their comments. Below we respond to the specific points.

REVIEWER 1.

1. We now show results for the simulation with 320 bins.

2. The fact that droplets remain in the parcel is obvious from the model equations. We added a comment on that in the text.

3. We used the same rms velocity for both dissipation rates. In the parameterization, the dissipation rate and rms velocity can vary independently. In reality, the rms velocity

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Interactive Discussion

Discussion Paper

and dissipation rate may be correlated [see, for example, Fig 1. of Riemer and Wexler (JAS, 2005; RW below)]. In general, the enhancement increases slightly with u' for a fixed dissipation rate, see for example Table 4 of XWG08. If we take a fitted value of about 2.5 m/s of RW's Fig. 1, then divide it by sqrt(3) to correct the error in defining u' in RW, we get 144 cm/s for dissipation rate of 100 cm2/s3. The effect of changing u' from 202 cm/s to 144 cm/s on coalescence growth time is roughly 10% according to the data of Table 4 of XWG08. The net effect is likely smaller than 10% in the parcel model as the diffusional growth is coupled.

Overall, the effect of preferential concentration (i.e., the accumulation effect) and the effect due to turbulence-induced relative velocities (i.e., the turbulent transport effect) both contribute to the enhancement. For smaller cloud droplets, the turbulent transport effect dominates. For larger cloud droplets or for droplets close in size, however, the accumulation effect may become equally important. These have been documented in Ayala et al. (2008, New J. Physics, 10, 075015).

4. Since both reviewers had problems with interpretation of these figures, we modified the caption. We hope these revisions clarify the issue.

5. We added the reference to Part II of Berry and Reinhardt's 1974 paper.

6. This comment is echoed by comment 1 of the second reviewer. We do not agree with these suggestions as in our view bringing up the role of turbulence in the diffusional growth detracts the reader from the main focus of this paper. However, to satisfy the reviewers we added a paragraph with a few references to the introduction. In general, we believe that the role of small-scale turbulence on diffusional growth in adiabatic parts of a convective cloud (which is the focus here) is insignificant.

7. We are not sure if the reviewer comment concerns our model results or observations. We modified the text to better expose the point we make.

8. Corrected.

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REVIEWER 2.

1. Please see our response to the point 6 of Reviewer 1 comments above.

2. The text the reviewer has in quotes is not part of our paper. The closest statement is in the discussion section and it reads: "Since collisional growth is inefficient for droplet radii smaller than 10˜μm, considerable time is spent with mostly diffusional growth before autoconversion phase of the collisional growth is initiated." Figures 9 and 10 show that diffusional growth is present through the entire simulation as the parcel continues to rise. We are uncertain if a precise definition of the time the autoconversion phase sets in can be established and what this would bring to the analysis. The start of the accretion phase, which moves the drops into drizzle sizes, is more important for precipitation development and we focus on it.

3. We have modified the caption to explain how to read the binwise mass transfer rate, namely, the scale of mass transfer rate is contained in the time scale axis marks. The way the transition times are determined is detailed in text (i.e., using the curvature of the radar reflectivity evolution or the shift of the maximum collisional growth rate) and these times are impossible to deduce by just looking at the figures. The corresponding times for the radar reflectivity to reach a few important levels are marked in the plots to provide some indication of the transition.

4. We expanded the discussion of the numerical broadening and added a new figure to further illustrate this aspect (Fig.˜15 in the revised manuscript). For the collisional growth, we refer to papers that show convergence of numerical techniques (albeit different that we use). We also expanded the discussion of numerical broadening for the diffusional growth combined with the representation of droplet activation.

5. We are not sure what the reviewer had in mind here, but we assumed that the issue concerns the role of turbulence in diffusional growth of cloud droplets. This is addressed in response to Reviewer 1 point 6 above.

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6. We agree that clouds (both precipitating and nonprecipitating have spectra significantly broader than those discussed here. We would think that this is mostly because of entrainment as shown by numerous studies in the past. This aspect, however, is not relevant for our study as we apply an adiabatic parcel model.

If we understand correctly the second part of this comment, the reviewer wants to know how turbulence affects the evolution of the spectral width. The new Fig. 15 provides the answer.

7. We added a new figure (fig. 15) to the discussion section to illustrate the points we make in the text. We hope this is sufficient.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 14717, 2008.