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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Influence of entrainment of CCN on microphysical properties of warm cumulus" *by* J. W. B. Derksen et al.

J. Derksen

j.w.b.derksen@uu.nl

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Response to the reviewers of "Influence of entrainment of CCN on microphysical properties of warm cumulus" by Jeroen Derksen, Geert-Jan Roelofs and Thomas Röckmann. We want to thank both anonymous reviewers for their careful reading of the manuscript and their helpful comments. Based on their suggestions, we have altered the manuscript, as described below.

Referee 1
The two main comments of referee #1 were:
- The paper should be better integrated in existing literature.
- The interpretations of the results should be expanded.

In general, we added context on the topic of mixing in clouds, both on the dynamical as microphysical aspects, to the introduction. The added paragraphs can be found after the 3rd paragraph. In the last two paragraphs we have added some notes on the advantages and drawbacks of using a 1D model, compared to parcel, 2D or 3D models. This is further discussed in sections 4.2 and 4.3. We have added one paragraph on preconditioning of cloud air and one on the potential influence of inhomogeneous mixing on the droplet spectra in section 4.2 "Analysis of the base case" (third and last paragraph, respectively).

For more easily interpretation of the results, we have rearranged the "Discussion and Conclusion" and the "Initialization and Results" sections, i.e. creating a "Results and Discussion" section.

Answers to the specific comments:

We have moved "The initial CDCN ... the cloud base." one sentence and reorganized the sentences for readability purposes.

We have expanded part of the introduction, addressing the dynamical aspects of the mixing process.

We have expanded the paragraph concerning 3D modeling and added one regarding our motivation for using a 1D model.

We shifted "We remark ... data points" to the end of the preceding paragraph

We added a few sentences on the choice for 1.5 m/s as initial vertical velocity.

The sentence "For a smaller..." has been removed. Instead, we added between brackets: "(a direct result of the decrease of α)" one sentence earlier.

We have added a paragraph in the section "Analysis of the base case". It addresses

the difference in observed and simulated range in LWC, mentioning preprocessing of environmental air by evaporation of cloud droplets (either in or outside the cloud).

In the same section, we have added a paragraph concerning the process of inhomogeneous mixing and its influence on the droplet spectra.

We have adapted the units for N.

Referee 2
The main comment of referee #2 is directed at the dynamical limitations associated with a 1D cloud model.

In our study, we focus on the influence of entrained CCN on the microphysical properties, especially the droplet spectra. We acknowledge the fact that a 1D model has some important drawbacks, especially regarding inhomogeneous mixing, compared to models of higher dimensional order. On the other hand, the detail in which cloud drop evolution can be simulated, including activation of entrained CCN, is an advantage. Furthermore, the advantage of the 1D model over a parcel model is that droplets can interact vertically, e.g., rain droplets that sweep a whole cloud column. At present, 3D microphysical cloud modeling with sufficient temporal resolution to accurately resolve particle growth and activation is not very feasible due to the massive computational power needed, although it is a likely next step in cloud modeling research. The referee mentions the use of parcel trajectories, combined with a LES model. We agree that dynamically it would be more accurate, but on the microphysical scale major simplifications are made: homogeneously mixed, no interactions between parcels, no entrainment of ambient CCN.

In response to the referee's comments, we have expanded the introduction with more context on the topic of mixing in clouds, both of the dynamical as microphysical aspects. We also have added some notes on the advantages and drawbacks of using a 1D model, compared to parcel, 2D or 3D models. This discussion is also carried to the

sections 4.2 and 4.3. We have added one paragraph on preconditioning of cloud air and one on the potential influence of inhomogeneous mixing on the droplet spectra in section 4.2 "Analysis of the base case" (third and last paragraph, respectively).

For more easily interpretation of the results, we have rearranged the "Discussion and Conclusion " and the "Initialization and Results" sections, i.e. creating a "Results and Discussion" section.