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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosols' influence on the interplay between condensation, evaporation and rain in warm cumulus cloud" *by* O. Altaratz et al.

O. Altaratz et al.

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Reply to reviewer #1: We would like to thank the reviewer for his beneficial remarks that helped us improving the manuscript. A lot of extra work and test simulations were done according to the reviewers comments but only a part of it was added to the manuscript in order to prevent large increase in length.

Answers to the specific comments:

1) The description of the model used is very concise. Adding more information about things like aerosol description in the model would not increase the length of manuscript considerably, but it would make it easier to read.

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More information about the aerosol distribution was added to the model description:

"The aerosol spectrum is approximated by superimposing three lognormal distributions with parameters representing a maritime air mass (Jaenicke, 1988). The total number concentration of aerosol is 295 cm-3. In this study we assume that all the aerosols are CCN." The formula was added to the manuscript with a table for the parameters of the distribution.

2) Pollution aerosol was placed in the single bin in the aerosol size distribution. Is this realistic? Is it possible that using the wider distribution also for pollution aerosol, the drizzle and precipitation formation might be affected? This is an important question as one of the main findings of the manuscript is the larger raindrops with increased aerosol loading.

In this study we intended to check the effects of increase in pollution aerosols (fine mode) on the cloud properties. The size distribution of urban /industrial aerosol has a significant peak around 0.2-0.3 micron (Dubovik et al. 2002). In the study we changed the distribution by simply adding more fine mode 0.3micron particles. We checked the sensitivity to this by using a several narrow distribution (between 0.1 to 0.5 micron) for the aerosols size distribution and the results were similar to the ones presented in the paper and the raindrops were similarly larger for the polluted clouds.

3) The grid used in the model is quite coarse although the simulation area is not very large. This raises a question about the possible changes in results, especially at the cloud boundaries if a better resolution would be used. It might be difficult to run simulation with higher accuracy, but some discussion should be added about the choice of the resolution.

The resolution of the grid was chosen based on some limitations of the model for the case that all the schemes are stable numerically. In order to test the question raised by the reviewer regarding the processes in the cloud boundaries some test simulations were conducted with 50 m resolution. The evaporation processes in the boundaries

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were checked. The results show that the differences between the 3 clouds are almost identical in trends to the ones described in the manuscript with slight differences in clouds top heights. Currently we are improving the model to simulate clouds in higher resolution.

4) The maximum number of cloud droplets formed in polluted cases is actually enhanced more than the number of CCN added. I think this issue needs to be explained. Also giving some number value for the clean aerosol size distribution used would make reading of the manuscript easier.

The maximum numbers of cloud droplets in a cloud is not only determined by the nucleation process, dynamical processes can create accumulation zones where the number of droplets can be greater than the number created by nucleation at any certain point. This is the case also for the polluted clouds. In addition, it is possible that in the polluted clouds the supersaturation field is slightly higher than in the clean cloud and a higher number of natural aerosols are activated. Examination of the mean number of cloud drops through the cloud will give lower values than the maximum and the differences between the mean drops numbers of the different clouds are lower than the number of added CCN. The total number concentration of aerosol is 295 cm-3. It was added to the text in the general description of the aerosols.

5) There is some discussion about the horizontal wind speeds and the effect of aerosols on that. Could the figure describing wind fields as well as liquid water content be useful in this context as the strength of updrafts are not presented or given in the manuscript for different cases? Updraft velocity also affects incloud residence time of air parcels and thus precipitation formation. I leave this matter for authors to decide.

Information was added to the manuscript regarding the vertical motion in the clouds (updrafts and downdrafts) based on both reviewers comments. The updraft velocity was not added to the figures due to manuscript length considerations.

1) Section 3.2.1: "The appearance of the maximal value of the updraft in the cloud is

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delayed as the cloud is more polluted, in accord to the delay in rainfall initiation. The maximal values are 4.3 m s-1 for the clean cloud (at 34 min of simulation), 4.5 m s-1 for cloud 2 (at 44 min) and 4.4 m s-1 for the most polluted cloud (at 48 min)."

"The downdraft values at clouds top at 22 min of simulation are -0.6 m s-1 for the most polluted cloud and -0.2 m s-1 for the clean cloud, indicating higher evaporative cooling in the polluted cloud at this stage."

6) I agree with Referee #2 that the difference in cloud height can not be addressed in the way it is done. As the vertical grid spacing is 100m, it is misleading to say that difference in cloud top height is 100m between clean and polluted cases, as it can be something less or more as only the maximum value of liquid water mass mixing ratio at certain grid-level is used to define the cloud top.

The line is changed:" At this stage, cloud top-height is almost similar for all clouds."

7) As some sensitivity tests are done, like said in conclusions, could it also be said if the differences between polluted and clean cases are similar on average as in the simulations presented.

We tried few different profiles and aerosol distributions in order to check the consistency of the raindrop size as a function of pollution loading. In all cases when there was a rain production, the trend was the same i.e. larger drops for polluted clouds. Of course the properties of the clouds were different for different profiles. The full description of the cases is beyond the scope of the paper.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 12687, 2007.