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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The role of the particle size distribution in assessing aerosol composition effects on simulated droplet activation" *by* D. S. Ward et al.

Anonymous Referee #1

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This paper studies the dependency of the aerosol composition effects on the particle size distribution for simulated cloud droplet activation. In a first step a cloud parcel model was used to simulate the activation of aerosol particles to cloud droplets for different values of aerosol number concentration, size and hygroscopicity as well as for the updraft velocity and temperature. Based on these results, it was stated that the sensitivity of CCN activation to compositional changes depend on the location of the dry critical radius for droplet activation relative to mean radius of the size distribution. In a second step, these results were used as a look-up table for the simulation of the dependency of mixed-phase orographic clouds on aerosol hygroscopicity and size with the Regional Atmospheric Modeling System (RAMS). The distribution of precipitation

shows a moderate sensitivity to extreme and unrealistic changes in the hygroscopicity parameter κ

In general this paper is well written and presents interesting results with the implication that the chemical composition of aerosol particles can be neglected for high supersaturation clouds. If the authors can address my comments below I recommend this manuscript for publication.

Comments:
1) For the creation of the lookup tables for the RAMS droplet activation scheme I would suggest to improve the resolution of κ between 0.01 and 0.1. As it was shown in Reutter et al. (2009) (see Fig. 8) the sensitivity of the cloud droplet number concentrations is largest for values below $\kappa = 0.1$ in all atmospheric regimes. Therefore a linear interpolation between 0.01 and 0.1 is maybe too coarse.

2) Also for the choice of the RAMS sensitivity simulations I have the same suggestion to improve the number of simulations for κ values between 0.01 and 0.1, because here I would expect the greatest sensitivities (as it can be seen e.g. in the values for the spillover ratios in Table 3.).

3) Page 4206, line 18 ff: Additionally of using the difference in precipitation between A1 and A7 the difference of runs within a realistic range of κ (e.g. 0.05 to 0.2) would be helpful. At least for the A-cases also a significant difference in the precipitation fields should be visible according to the spillover ratios given in Table 3 without an extreme κ range.

4) As the authors report, McFiggans et al. (2006) state that the number of particles

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and the gradient of the size distribution determine CCN activity. Later the authors say that they kept the geometric standard deviation σ_g constant, because Antilla and Kerminen (2007) showed that moderate variations in the prescribed values of σ_g played only a minor role. Nevertheless, Antilla and Kerminen (2007) also showed that the shape of the particle mode could be as important as the mean size of the mode at low updraft velocities. Therefore I would be interested to see the sensitivity of the results on the geometric standard deviation, at least for the updraft-limited regime.

5) Fig.2: The authors should address the non-monotonic behaviour of the curve in Fig.2 c). What is the reason for local maximum of $S(\kappa)$? Reutter et al. (2009) reported problems with the model resolution for low supersaturations, which is the case for the updraft limited regime in Fig. 2c. Is it the same in this case?

6) Page 4193-4195: Model setup: It would be nice to have the technical details here at this place rather than a reference. Especially the time steps as well as the number of bins are interesting for an easier comparison with other studies. Also it would be nice to find the range of the initial values of T, w, N_{CN} and r_g rather than in the reference of Saleeby and Cotton (2004). For example, was w really varied between 0.01 and $100\,\mathrm{m\,s^{-1}}$? Is this a realistic range for this studies?

Minor comments:
Page 4191, line 27-29: replace ms^{-1} with $\mathrm{m\,s}^{-1}$
Page 4196, line 5-6: replace ms^{-1} with $\mathrm{m\,s}^{-1}$
Page 4196, line 15: "...averaged over THE all THE initial conditions..." remove both "the"
Page 4197, line 3: replace ms^{-1} with $\mathrm{m\,s}^{-1}$
Page 4201, line 21: here "diameter" is used, later and throughout the paper it is "radius"

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Page 4203, line 19: missing space , replace 750m with 750 m
Page 4204, line1: missing space, replace 4000m with "4000 m twice
Page 4207, line 24: air parcel, not air parcels
Fig.1.: replace ms^{-1} with m s^{-1} in the axis label
Fig. 2.: replace ms^{-1} with m s^{-1}in the caption
Fig.3.: unit is missing for $N_{CN} = 1000$
Fig.6 and Fig.7: especially in Fig.7 details are hard to recognize. Maybe enlarge pictures and/or use colors.

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