Review of ACP-2021-506

In this manuscript, the authors used a cloud parcel model to investigate the characteristics of cloud droplet spectral evolution by condensation and collision and coalescence for various background CCN distributions and different updraft conditions. Then the impact of hygroscopic seeding material on cloud droplet spectral broadness was examined. The model they used seemed very appropriate for calculating cloud droplet growth processes in an adiabatic cloud parcel, limiting numerical diffusion by adopting moving bin boundaries for calculating condensation processes. The limitation was that this model did not take into account the entrainment and mixing processes, which certainly affect cloud droplet growth processes and droplet distributions in real clouds. However, for examining cloud droplet spectral broadening at earlier stages of cloud development, such limitation may be tolerable. The described impact of hygroscopic seeding material seems somewhat expected. Certainly seeding effect would be pronounced when seeding particles are big and such effect would be diminished when background CCN include many big particles. The scientific contribution of this manuscript mainly comes from the development of hybrid bin scheme that can be used for calculating condensational growth process without numerical diffusion. I think that this manuscript deserves publication in ACP after minor revision, addressing the comments I made below.

Major comments:

It is good to see that the Ostwald-ripening (OR) effect on droplet spectral broadening can also be significant under non-oscillating vertical velocity conditions. In a strict sense, however, what was presented in this manuscript was not exactly the same as the OR effect described in Yang et al. (2018), where the spectral broadening occurred since larger droplets grew but smaller droplets shrank. Such phenomenon can occur easily under oscillating vertical velocity condition: during updraft all droplets can grow but during downdraft larger droplets can still grow but smaller droplets may evaporate as they may become deactivated. In this manuscript, vertical velocity was always positive (updraft), although the value itself varied. So all activated droplets grew throughout the ascent regardless of their sizes but the important point was that the radius growth rate of larger droplets could be higher than that of smaller droplets near cloud base altitudes especially under low updraft conditions, resulting in broadening of the cloud droplet distribution. Such spectral broadening can also be called the OR effect but the subtle difference from Yang et al. (2018) should be noted. In fact, the characteristics of spectral broadness of droplets that are grown by condensation under different CCN and updraft conditions were extensively examined by Yum and Hudson (Atmospheric Research, 2005), which clearly explained with cloud parcel model calculation and theoretical assessment that it was the differences between the ambient (cloud) supersaturation and the equilibrium supersaturations of different size droplets that determine spectral broadness of condensationally grown droplets: at lower ambient supersaturation, the differences between the ambient supersaturation and the equilibrium supersaturations of different size droplets are relatively larger than those at higher ambient supersaturation, and therefore broader spectra. Yum and Hudson (2005) should be cited when discussing the dependence of spectral broadening on supersaturation.

The description of Eq (1) is a little confusing. The indices i and k appear together for m and D. Does it mean that there exist multiple k values for each droplet size bin boundary, i? According to Table 1, a specific kappa value is associated with a specific mode of aerosol particles. So I guess that a specific k value is associated only with a certain range of i values. This should be clearly stated.

Line 173: Are the temperature and vertical velocity profiles different for different aerosol conditions or are they given as initial conditions? Temperature in the cloud parcel may become slightly different for different initial aerosol conditions since latent heat release can be slightly different. But the vertical velocity profile should have been prescribed. This sentence can misleadingly indicate that vertical velocity profile can be affected by the given initial aerosol distribution. This may be so but I doubt that the model took that into account.

Line 211: What the model calculates is the adiabatic LWC in the sense that the model does not allow heat exchange and mixing of the outside air. However, this adiabatic LWC can be different for different updraft conditions because different supersaturation (indicating the amount of excess vapor remaining without being condensed) can be generated for different updraft conditions, as demonstrated in this manuscript. What the authors indicate in this sentence is the maximum adiabatic LWC that can be obtained in the pseudo-adiabatic process which assumes that all excess water vapor is condensed and just saturation is maintained during the ascent. Make it clear.

Line 261: It is stated that seeding has no significant effect on the growth rate of the drops formed on background aerosol particles. I would guess that adding seeding material would increase total droplet concentration and decrease the supersaturation, leading to broader spectra even only for the droplets formed on background aerosols. What were the change or difference of total droplet concentration and supersaturation caused by seeding?

Line 339: Background CCN concentration does not decrease. The number of activated cloud drops from background CCN may decrease. Rewrite the sentence.

In all size distribution plots, y-axis label is written as N/dlog(r), not dN/dlog(r). Are you sure? Then what does N mean here?

Figure 3: What do closed circles mean? No explanation is given in caption or in the text.

Figure 4: Integration of droplet size distribution would produce total droplet concentration. If I do that for the two droplet size distribution for two different updraft shown in Fig. 4a, I would find that the total droplet concentration is higher for the lower updraft. The y-axis is in log scale. So the actual difference of the concentrations might not be as dramatic as shown in the plot but it should still be true that the concentration is higher for the lower updraft. I do not understand this.

Figure 8: E is not clearly defined in the caption. Make it clear.

Table 4: What is NCM? No explanation in caption or in the text.

Minor comments:

L178: rewrite w_1.

L212: vapor flux → vapor surplus

L238: Move "(Wehbe et al., 2021)" to the end of the previous sentence.

L251: remove 'of' in front of *bg*.