Review of "Technical note: Phase space depiction of CCN activation and cloud droplet diffusional growth" by Grabowski and Pawlowska (egusphere-2024-4104)

This manuscript introduces a phase space that helps to understand the activation, deactivation, condensation, and evaporation of haze particles and cloud droplets in a unified fashion. The phase space is applied to the results of two simulation cases, a turbulent rising parcel and a convection cloud chamber. Overall, this manuscript addresses an interesting and relevant topic. I have reviewed a previous version of this manuscript submitted to the Journal of the Atmospheric Sciences. The most important change from that version is its framing as a Technical Note, which I consider very appropriate as the manuscript does not contain substantial new findings but provides a concept to be applied in future studies. I consider this manuscript adequate for publication in Atmospheric Chemistry and Physics once my comments are addressed.

Major Comments

Does it make sense to distinguish Q3 and Q4 for all radii smaller than the activation radius? Conceptually, the regions Q3 and Q4 of the phase space are distinct, with the prior representing evaporation and the latter condensation. This is probably adequate for (super-)saturated conditions that a particle experiences inside the cloud. Outside the cloud, haze particles are usually in equilibrium with their environment, which is sustained by quick changes between evaporation and condensation (time series in Fig. 7). Thus, I recommend to introduce a fifth region to consider this equilibrium state. It should cover the entire range of $S - S_{eq}$ values, and all radii up to the equilibrium radius at saturation, $r_{eq} = \left(\kappa\, r_d^3 / A\right)^{1/2}$, which is obtained from equating (1) to 0.

Minor Comments

Sec. 1: I enjoyed reading this introduction to cloud droplet formation. However, I was wondering why the authors did not include the diffusional growth equation (and maybe an equation for the development of supersaturation in an adiabatic parcel). This would naturally integrate some of the dynamics considered in the introduced phase space.

Ll. 87 – 89: References to Nenes et al. (2001) and Mordy (1959) seem to be appropriate.

Ll. 241 – 243: What exactly is "not well visible in the right panel"?

L. 398: In the abstract (ll. 18 – 20), the authors promised to use the phase space to identify differences in droplet formation in the analyzed cases. This line seems to be the only location where this is actually done. Could the authors comment a little more on the differences of droplet formation in "natural and laboratory clouds"?

Technical Comments

Ll. 32 ff.: Change "Koehler" to "Köhler".

Ll. 43 ff.: Change "paper" to "technical note".

Ll. 250 – 258: Is "GYK24" different from "GKY24"?

References

Mordy, W. (1959). Computations of the growth by condensation of a population of cloud droplets. *Tellus*, *11*(1), 16-44.

Nenes, A., Ghan, S., Abdul-Razzak, H., Chuang, P. Y., & Seinfeld, J. H. (2001). Kinetic limitations on cloud droplet formation and impact on cloud albedo. *Tellus B: Chemical and Physical Meteorology*, *53*(2), 133-149.