

## Review of “Technical Note: Equilibrium droplet size distributions in a turbulent cloud chamber with uniform supersaturation” by Krueger (acp-2019-932)

The submitted study investigates steady-state droplet size distributions in a turbulent environment. These distributions, including several moments and other quantities, are derived analytically by considering the microphysical processes of droplet growth by diffusion and their removal by sedimentation, as well as an (artificial) droplet production term. These theoretical results are compared with recent measurements by Chandrakar et al. (2018), adding valuable information for the interpretation of the aforementioned measurements but also the quantification of droplet size distributions by measurements in general.

All in all, this well-written technical note gives new and interesting insights into the development of droplet size distributions. Overall, the manuscript is in an almost publishable state. Nonetheless, I have some very minor suggestions below. I fully support the publication of the manuscript in Atmospheric Chemistry and Physics.

### Minor Comments

Sec. 2.4: I believe that Srivastava (1991) also requires some recognition in this subsection. He investigated, also analytically, the mean, standard deviation, and dispersion of droplet spectra, including the effects of droplet surface tension.

P. 4, ll. 28 ff.: A supersaturation of 10 % is relatively high for a typical cloud. For plotting the analytical solutions, a more realistic value of 0.1 % is used. I suggest to also use this lower supersaturation in the Monte-Carlo calculations of section 3. However, this will not change any conclusions.

P. 5, ll. 11 – 12: I would emphasize that the “stochastic nature of the droplet fallout process” includes the assumed stochastic rearrangements of the droplets along the z-axis, i.e., turbulent motions, since the sedimentation process itself is deterministic.

Sec. 4.2: It is possible to speed up the derivation of  $w(s)$  using  $v(r)$ . By acknowledging that  $v = dN/dr$  and  $w = dN/ds = dN/dr^2$ , where  $N$  is the total number of droplets, we see that  $dN = v dr = w dr^2$ . Hence,  $w = v/(dr^2/dr) = v/(2r) = D/2 \exp(-Cr^4/4) = G \exp(-Cs^2/4)$ , using that  $G = D/2$  and  $s = r^2$ .

Eqs. (12) and (17): Because Eqs. (12) and (17) clearly violate the assumptions  $v(r_0) = w(s_0) = 0$ , it might be helpful to state – again – that the analytical solutions are only defined for  $r > r_a > r_0 > 0$  and  $s > s_a > s_0 > 0$ .

P. 7, l. 10: The first term of the equation contains one minus sign too much.

Eq. (26): Also this deviation can be shortened:  $I(R) = 1 - f(R)$  with  $f(R)$  already derived in Eq. (22).

P. 21, l. 20: The usual citation for the phase relaxation timescale is Squires (1952).

### Technical Comments

P. 2, l. 26: Throughout the paper, the author uses plural personal pronouns (“we” or “us”). Thus, this single “I” feels odd.

P. 3, l. 27; p. 4, l. 6; p. 4, l. 26: For clarity, add parentheses to the equations for the fall out probability:  $(u/h)\Delta t$  and  $(k_1 r^2/h)\Delta t$  instead of  $u/h\Delta t$  and  $k_1 r^2/h\Delta t$ , respectively.

P. 4, l. 31; p. 5, l. 9: Since the analytical solution will be introduced further below, I suggest adding a “to-be-determined” in front of “analytical solution”.

P. 6, l. 1:  $A(r)$  has been previously introduced as the “production of (activated) droplets from the injected aerosol” (p. 3, ll. 8 – 9). Here, it is called the “production of droplets by activation”. Although these processes are identical in the described framework, I suggest homogenizing the terminology.

Eq. (18): I would add a comma (",") to the end of the equation.

Figs. 3 and 4: An opening parenthesis ("(") is missing in the ordinate title.

P. 10, l. 14: I would add a comma (",") to the end of the equation.

P. 11, ll. 20 – 22: This comment feels too technical. I would omit it or state this information in a footnote.

### **References**

Chandrakar, K. K., Cantrell, W., and Shaw, R. A. (2018). Influence of turbulent fluctuations on cloud droplet size dispersion and aerosol indirect effects, *Journal of the Atmospheric Sciences*, 75, 3191–3209.

Squires, P. (1952). The growth of cloud drops by condensation. I. General characteristics. *Australian Journal of Chemistry*, 5(1), 59-86

Srivastava, R. C. (1991). Growth of cloud drops by condensation: Effect of surface tension on the dispersion of drop sizes. *Journal of the Atmospheric Sciences*, 48(13), 1596-1599.