Review of “Statistical Analysis on the Estimations of Solid Hydrometeors Growth Zones and Their Weather Conditions Using Radar Spectrum Width”, by Suh and Coauthors, egusphere-2023-947.

This is an interesting article with the goal of providing real-time guidance using radar for aircraft safety awareness of potentially adverse weather conditions. The article is well-written overall. My impression-and comments, have to do with some weaknesses in the representation of the physics of ice particle growth and aggregation, and fallout. My comments appear below. I have more comments but these are the primary ones I’d like the authors to consider.

Abstract. v and DN relationship. Isn’t it possible that the high value of v is due to there being a combination of dendrites and dendritic aggregates-dendrites fall at about 25 cm/s whereas aggregates fall at about 150 cm/s at altitude. And, in the NE region, the particles could all be aggregates and therefore have a low value of v. I suggest you consider the following. Look at the Doppler velocities, adjusted for vertically falling, and see if the growth zones you derive are consistent with single crystals or aggregates, and whether the velocities are consistent with dendritic aggregates in the dendritic growth zone and needle aggregates in the needle growth zone.

ANSWER: First of all, the authors truly appreciate your concerns and comments that helped us with the present study.

The authors believe that DN and NE can be sufficiently explained through simulation (Suh et al., 2023) and their microphysics obtained by the dual-pol radar variables (Suh et al., 2023; present study). In a previous study (Suh et al., 2023), a simulation (aggregate processes were not considered) of the aerodynamic characteristics of various solid hydrometeors according to the orientation of falling particles was performed. It was confirmed that DN shows high σ_v under the same atmospheric conditions, while NE shows low σ_v. The present study is about determining the GZ using GZDA applying the bulk method. The purpose is to present the representative boundaries of GZs for the entire analysis period, so it is not necessary to determine the growth of solid hydrometeors or secondary growth within the GZ. Actually, analysis from a microphysics perspective is not the main subject of this study.

The suggestions made by the referee had been thoroughly discussed with the authors in the analysis stage of this study. However, in the case of solid hydrometeors whose density is quite low compared to liquid-phased raindrop, their falling speed is significantly affected by airflow, including weak vertical flow. In other words, further analysis such as in situ observations will be necessary to explain the results but these kinds of data are not secured. That’s why the authors adopted the analysis strategy of the present study as a bulk scheme.

The authors appreciate the referee's advice and hope that the authors' opinions will be taken into consideration.

References:

Suh, S. H., Choi, E. H., Kim, H. I., & Jung, W. (2023). Possibility of Solid Hydrometeor Growth Zone Identification Using Radar Spectrum Width. Advances in Atmospheric Sciences, 40(2), 317-332.

Line 25. Needle type snowflakes. In general, I disagree with this. What happens when dendrites, formed at temperatures of -10 to -20C, and with a large cross-sectional area to aggregate, fall through the needle growth regime. The needles stick on the dendritic aggregates. Yes, needle aggregates can occur, but in the cases you show, dendrites from aloft will aggregate and fall through the needle growth layer.

ANSWER: The authors appreciate the referee's comments, and the authors agree with the referee's opinion. The referee's opinion can be explained by the major results of the previous study (Suh et al., 2023) of the present study.

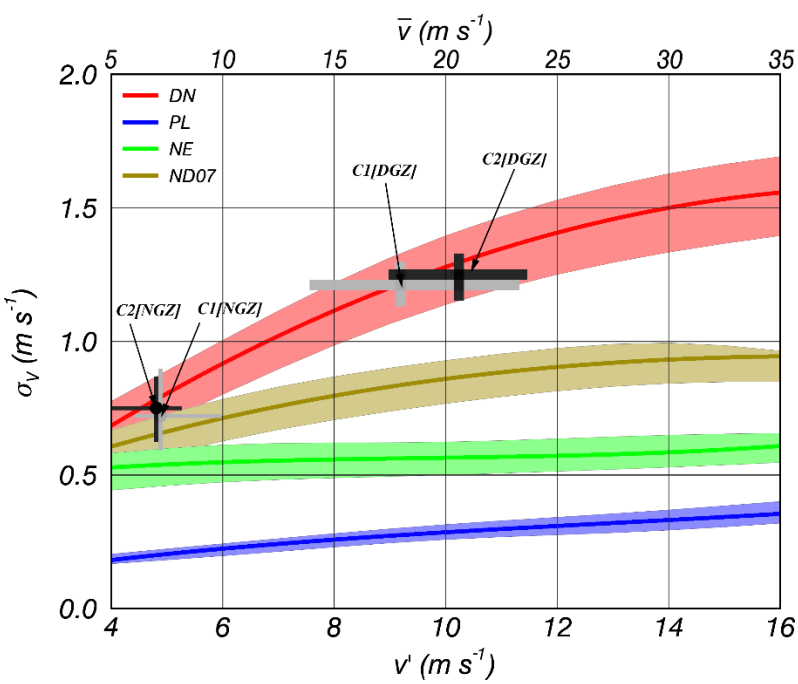


Figure A-1. Plot of the interquartile of observed σ_v with $\bar{v}$ and the simulated σ_v at different *v'* from 4 to 16 m s^{-1} at θ = 19°. Red, blue, green, and gold solid curves and Shaded areas represent the mean and standard deviation of σ_v for DN, PL, NE, and ND07 respectively. The grey and black thick (narrow) lines are the interquartile of σ_v and $\bar{v}$ for DGZ (NGZ) in C1 and C2.

This figure is the result obtained from a simulation considering the aerodynamic conditions for

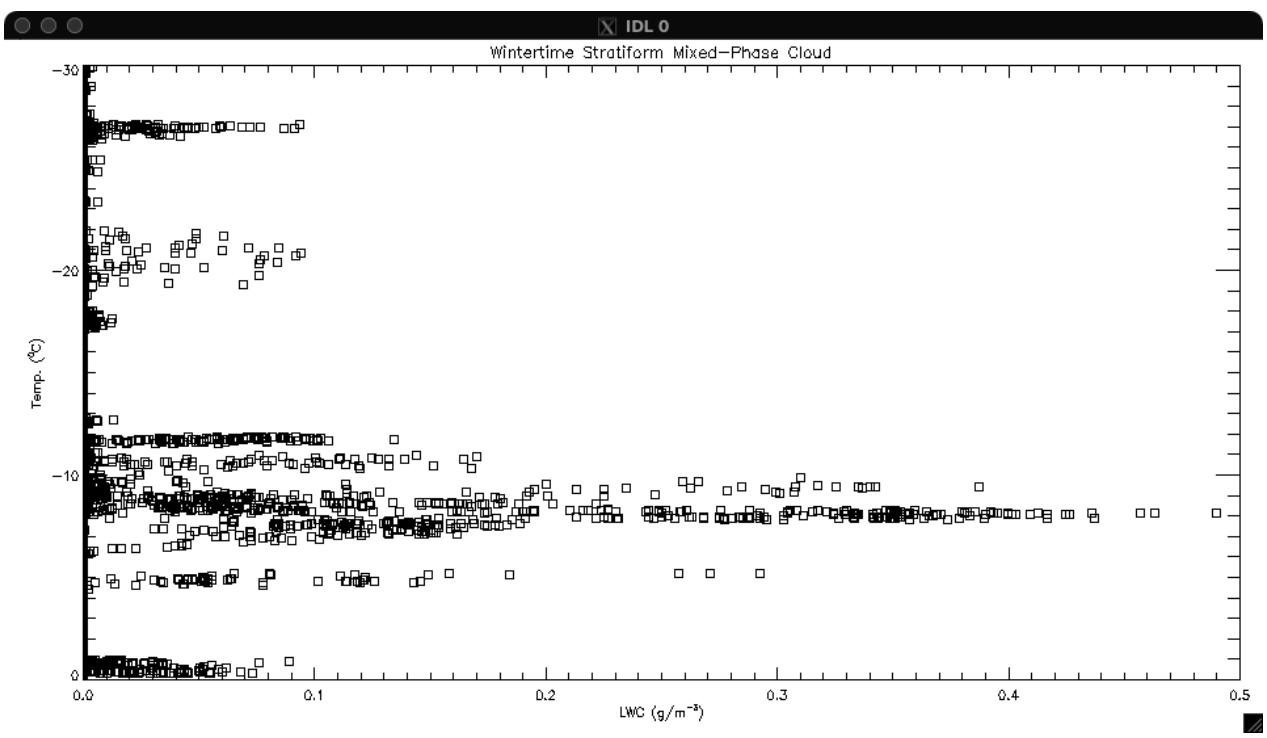
each solid hydrometeors, and shows that the simulated results for the mixed condition of NE with DN at a ratio of 30% tend to be more similar to the actual measured value than σ_v for pure NE. This explains that the zone defined as NGZ contains aggregates or various types of solid hydrometeors came from the upper layer. Also, a sufficient amount of prolate type hydrometeors, defined as NE, must be present to appear a lower σ_v compared to other layers.

References:

Suh, S. H., Choi, E. H., Kim, H. I., & Jung, W. (2023). Possibility of Solid Hydrometeor Growth Zone Identification Using Radar Spectrum Width. Advances in Atmospheric Sciences, 40(2), 317-332.

204-206. Supercooled droplets are often found in wintertime storms-see below. I disagree with this sentence. It needs to be rewritten.

ANSWER: Thank you for sharing this helpful information. 'can only have' has been changed to 'usually have'.



Figures 4, 5 and 6. A temperature scale is needed, maybe a second ordinate axis on the left side.

ANSWER: A temperature scale in Fig. 4-5 will be added. Thank you.

215-229. You mention what the SW numbers refer to earlier. You may want to mention it again here.

ANSWER: The explanation of the abbreviations of the analysis cases has already been provided in Lines 110-112, and the paragraph mentioned by the referee explains the observational characteristics of each case and is not intended to re-emphasize the abbreviations of the cases.

4. Discussion. 331-333. The physics behind this sentence is not correct. The growth rate is dependent upon the temperature, relative humidity, and difference in the water vapor density at this relative humidity and the vapor density at saturation with respect to ice. Water vapor density does not depend on the altitude but rather the temperature. An obvious example is where there is a temperature inversion or when the relative humidity is low near the surface. This section needs to be rewritten.

ANSWER: We apologize for the confusion caused by a mistake in words. What the author wanted to talk about was water vapor contents, that is, the mixing ratio (g kg^{-1}). This is a function of atmospheric pressure ($r_s = e_s\varepsilon/Pe_s$, ε=0.622) and is related to supersaturation (g m^{-3}), which is one of the main factors determining hydrometeor growth (Nakaya and Terada, 1935; Barbir, 2012).

The saturated mixing ratio is inversely proportional to atmospheric pressure for the same temperature. In other words, the lower the atmospheric pressure (as the altitude increases), the higher the saturated mixing ratio. Additionally, the amount of water vapor in the stable condition is inversely proportional to altitude (e.g., Fan et al., 2010). It can be explained that as the altitude of DGZ increases, the supersaturation to grow DN sufficiently may not be satisfied.

Therefore, the original sentence has been modified as follows.

Line 332-334:
Supersaturation, which has a crucial influence on the growth of solid hydrometeors, can be determined by amount of water vapor, in other words, a mixing ratio (i.e., Nakaya and Terada, 1935; Barbir, 2012), it is determined by the atmospheric pressure. Additionally, the amount of water vapor in the stable condition is inversely proportional to altitude (e.g., Fan et al., 2010). In short, the growth rate of the representative solid hydrometeor in each GZ can be affected by its altitude.

It is written in a discussion session as it is the author's inference. If you have any further discussions about this, please let us know any time.

References:

Barbir, F. (2012). PEM fuel cells: theory and practice. Chpt. 4 Reactant Humidity, Academic press.

Nakaya, U., & Terada Jr, T. (1935). Simultaneous observations of the mass, falling velocity and form of individual snow crystals. 北海道帝國大學理學部紀要, 1(7), 191-200.

Fan, J., Comstock, J. M., & Ovchinnikov, M. (2010). The cloud condensation nuclei and ice nuclei effects on tropical anvil characteristics and water vapor of the tropical tropopause layer. Environmental Research Letters, 5(4), 044005.

Minor Comments

Change "Freezing Level" to "Melting Level" everywhere

ANSWER: We apologize for the confusion. Problems with two sentences in Line 208 and Line 220 were confirmed, and these were replaced with sub-zero level.

204: can only have. usually have solid hydrometeors.

ANSWER: Thank you.

247: Contrarily >Conversely

ANSWER: Thank you.

345: will? or is possible?

ANSWER: We want to use the expression 'will be possible' by suggesting only possibilities for now. Thank you.

Andy Heymsfield, NCAR