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Comment on acp-2021-203

Anonymous Referee #2

Referee comment on "Mass of different snow crystal shapes derived from fall speed measurements" by Sandra Vázquez-Martín et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-203-RC2, 2021

I have read the manuscript "Mass of different snow crystal shapes derived from fall speed measurements" by Vázquez-Martín, Kuhn, and Eliasson and I find it an interesting manuscript. The authors use a dataset of measurements of 2461 ice crystals including fall speed, area, and maximum dimension. From these data they derive particle mass using standard Reynolds – Best number approaches. The dataset is then broken down into 15 different particle habit classifications and relationships between maximum dimension and the other parameters are presented and compared to previous literature.

While it is a nice study that merits being published, there are a few shortcomings that I feel should be addressed before full acceptance.

The project is highly dependent on the Re – X number relationship for relating mass and terminal velocity. Traditionally, this is used in the other direction where Vt is being calculated as opposed to using Vt to pull out mass. I would like to suggest that the authors should consider the Heymsfield and Westbrook (2010) relationship. In that publication, they showed that a small modification to the Re-X relationship led to much better Vt calculations. The adjustment was a factor of the square root of the area ratio. It should be simple to determine the area ratio for the particles in the dataset and test this. Would the use of this modification improve the results (tighten the scatter)?

The dataset also presents an interesting opportunity for manual comparisons, which would also assist in the selection of the traditional Re-X relationship or the Heymsfield and Westbrook modification. The dataset is said to contain 317 needles and 103 “thick columns”. I expect that for at least a portion of these, it should be possible to geometrically estimate the mass. These particles will have the lowest area ratio values and thus would be impacted the most by the Heymsfield and Westbrook modification. It would be a great addition to the manuscript to include a small closure study between Vt, mass, and area with the Re-X relationship, either the traditional relationship or the modified relationship.

The authors go to great efforts to present results by different shape categories. As they point out though, remote sensing cannot identify the microphysical characteristics of particles, so shouldn’t we be emphasizing overall characteristics of the particle populations? Rather than emphasizing the differences in characteristics between different particle categories, I’d suggest showing more “average values” and characterize the uncertainty that could exist. I seriously doubt that weather modeling will get to the point where we can predict 15 different particle categories, so understanding the intimate details of each isn’t going to be too critical too soon.

Other comments:

The “Dataset” section could have an additional paragraph with a brief description / summarization of how the dataset was created. While the reader can obviously go to the two Vázquez-Martín et al publications for more information, a one paragraph summary could potentially save the reader some time.

Fitting the dataset: I applaud the appropriate use of data. Reasonable binning and using the median values is something that eludes many. Good job.

In general, it might be nice to have a table with the symbols / variables used. You use a lot of sub scripts and super scripts and tildes etc. While it is easy to follow what each means after reading it a few times, it took me a few times reading the equations to completely follow the variables.

Table 1: Some of your shape categories had as few as 37 particles. When you separated into size bins, did you have a minimum number of particles per bin? (Did you do six bins of 6-7 particles or 10 bins of 3-4 particles?) You might consider noting the temperature range that particles in each type were observed if that were possible, and, if possible, the number of days when observations of each particle type were observed. 5 winters of data may not seem biased, but if all 37 graupel particles were observed on one day, then there could be a bias.

Figure 1: The "fit to all data" appears to have a tighter uncertainty range. Also, the size range doesn't go as far as one might expect. Again, statistically, how far off would a user be if they used an average value and the particles were mostly one of the categories?

Figure 2: I'd suggest removing this figure as it doesn't seem important.

Figure 3: It would be interesting to look at the ratio of the powers in the mass to D relationship versus the Area to D relationship. Mitchell 1996 has many comparisons and Schmitt and Heymsfiield 2010 show that this ratio would be ~1.3 for fractal particles and of course, it would be 1.5 for spheres.