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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Using snowflake surface area-to-volume ratio to model and interpret snowfall triple-frequency radar signatures" *by* Mathias Gergely et al.

Anonymous Referee #1

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Review of "Using snowflake surface area-to-volume ratio to model and interpret snowfall triple-frequency radar signatures" by Mathias Gergely, Steven J Cooper, and Timothy J Garrett.

Summary:

The authors present relationships between particle effective diameter, mass, and complexity, based on several days of snowstorm observations from two different locations. The 2D observation of complexity is then applied to construct 3D realisations of snowflakes, based on individual spherical elements, to subsequently use in scattering calculations. Compared to other snowflake scattering models, the authors find

that their 3D realisations – taking into account the variety of snowflake complexity – better cover the observed range of of radar scattering values given by the radar dual wavelength ratio.

General review:

This is a very well-written and well-presented study, covering a new aspect of snowflake modelling from an insightful perspective. The use of triple-wavelength observations for snowfall retrievals is very promising and it is important to have original studies such as this to consider the various snowflake characteristics that influence the radar signatures. Given the quality and the novelty, this paper should be considered for publication subject to minor revisions.

Minor comments:

1. SAV versus complexity

The section from p.11, line 25 to p.13, line 3, is difficult to follow. It reads as if ksi (SAVf/SAVs) is a completely new characteristic of snowflake structure, but in many ways it is simply a 3D consideration of the complexity, chi. Instead of perimeter divided by area (1D versus 2D), SAV considers area divided by volume (2D versus 3D). This discussion culminates in equation 11, where indeed ksi is shown to be uniquely related to chi. This set of paragraphs would be better placed in section 3.2, perhaps after p.10, line 15. Alternatively, the set could be entirely removed, as it does not seem to add much to the discussion. In particular, it is not clear where in section 4.2 the result is shown that variation of the exponent q has some effect on radar scattering.

2. SSRGA snowflake parameterization validation

The authors appear to suggest that the W04 and N13 SSRGA snowflake parameterizations are not supported by observations in terms of their DWR curves. However, the W04 model was shown to compare very well against triple-frequency observations of stratiform ice clouds in southern England (Stein et al. 2015). Stein et al. (2015)

furthermore relate the “maximum in DWR Ka/W” (p.17, line 1) to the fractal nature of aggregate snowflakes. Similarly, “the indicated range of observed snowfall triple-frequency radar signatures” on p.18, line 4, does not consider the southern England study. The authors should therefore also rephrase “this characteristic behaviour with a strong maximum of DWR Ka/W at intermediate values of Lambda”, as it may not be universal.

Stein, T. H. M., C. D. Westbrook, and J. C. Nicol (2015), Fractal geometry of aggregate snowflakes revealed by triple-wavelength radar measurements, Geophys. Res. Lett., 42, 176–183, doi:10.1002/2014GL062170.

3. Riming

The authors’ consideration of how riming affects snowflake scattering behaviour and the resulting triple-wavelength DWR curves appears to conflict with the simulations of Leinonen and Szyrmer (2015). In that study, the DWR curves look like a selection of curves spanning the range between the W04 and N13 curves in the current Figure 7. This contrasts starkly with the authors’ expectation that riming leads to a curve similar to ksi=1, with low DWR Ku/Ka. The authors should comment on the findings of Leinonen and Szyrmer (2015) in relation to their discussion of the effects of riming on snowflake characteristics. (Also p.17, line 33 onwards).

Leinonen, J., and W. Szyrmer (2015), Radar signatures of snowflake riming: A modeling study, Earth and Space Science, 2, 346–358, doi:10.1002/2015EA000102.

4. Practical application

The first avenue for future research (page 22, line 4-8) would indeed be “interesting”, but it seems rather impractical. Having unique ksi(D) relationships for each individual snowfall event would not be useful for NWP model development or even microphysical modelling studies, as it would simply be too much effort to implement. It would also seem rather impractical for operational snowfall rate retrievals. The authors should

provide slightly more detail on how their research could be applied in practice.

Selected other comments:

Figure 2. There ‘s a lot going on in these figures. The numbers in the bottom right should be removed and instead directly quoted in the caption. The average orientation should be removed as well (grey box in bottom left panel) and quoted in the caption.

p.6, line 10: Why is it necessary to combine the data into a single data set for complexity, but not for N(D)?

p.6 line 14 and line 20: The distribution in figure 3 seems skewed. The median should be a better measure of typical complexity rather than the mean.

p.8 line 10: Is this modification done randomly?

p.9, line 5: What does Delta mean here?

Figure 6. Again rather busy. The lines at 5mm and 10mm with boxed saying D=5mm and D=10mm are unnecessary, even though they are referred to in the text.

p.18, line 27: “the maximum of DWR is already found at lower values of DWR” – this is confusing, possibly a typo and Lambda is meant?

p.18, line 33: The “un-hooking” makes the curve behave more like the W04 and N13 curves in Figure 8. Similarly, the truncation makes the N=125 curve in Figure 9 behave more like the W04 and N13 curves as well. Not sure what to make of this.

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