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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 #2

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The manuscript presents a very interesting study on how additional descriptors of ice particles can be used to better constrain a connection between scattering and physical snowflake properties. The manuscript is well written and with exception of a few minor problems is easy to understand. Because I would like to see the authors response to several of my comments, I would like to suggest to publish the paper if the authors address those concerns adequately.

Major comments:

1. The authors are modeling snowflakes as collection of solid ice spheres with a prescribed mass, D and SAV. How realistic this assumption is? Leinonen and Moisseev

(2015) have argued that using spheroids (or spheres) of solid ice in place of the crystals leads to the formation of much denser aggregates. Or in the other words is it possible to match mass, D and SAV of a realistic snowflake using a set of spheres?

Leinonen, J., and D. Moisseev (2015), What do triple-frequency radar signatures reveal about aggregate snowflakes?, J. Geophys. Res. Atmos., 120, doi:10.1002/2014JD022072.

2. While modelling scattering from soft spheroids, the authors have used the assumptions that ice particles are randomly oriented. This assumption is supported by the presented observations of orientation angles as shown in Fig. 2. However, this assumption contradicts dual-polarization and multi-frequency radar observations, see work of Matrosov et al for example. For example, differential reflectivity values, Zdr, characteristic of aggregates lie in the range from 0 to 1 dB. This range can be reproduced by soft spheroids with aspect ratio of 0.6 and a preferential horizontal orientation. If the random orientation is assumed the expected Zdr value would 0 dB. A possible explanation of the discrepancy is the difference in an optical and microwave definition of particle shape. Imagine that an ice particle consists of a horizontally aligned spheroid and an attached dendritic crystal, such that the crystal orientation angle is different from 0. If most of the spheroid mass is much larger than that of the dendrite than for radar scattering calculations the particle can be assumed to be spheroidal and horizontally aligned. The shadow image of the particle would be different from the spheroid, and the orientation angle of this complex particle is different from 0. At the moment, we don't know what is the best assumption of a particle shape and what is the relation between optical and microwave particle properties of ice particles. Therefore, we should use models that covers a larger range of possible backscattering properties. I suggest that instead of random orientation the authors would use a spheroid with a preferential horizontal orientation.

3. The authors state that they use observations from 47 snowstorms observed in Utah and 7 storms in Barrow, which resulted in $4.3 \cdot 10^5$ and 10^4 snowflake observations.

The number of snowflakes sounds to be too small. I would expect that $4.3 \cdot 10^5$ would be a good number of snowflakes recorded during a single snowstorm. Of course, this number depends on the instrument sampling volume and how often observations are made. Both of which are not discussed in the paper. Could you please include more information on how the measurements are made, how PSD are computed, how often images are taken, etc.

Minor comments: 1. There is a lot of discussion about the snowflake complexity, while the main focus of the paper on SAV. It is a little bit confusing? Could you consider them together or explain how you compute SAV from observations?

2. In the paper, the snowflake complexity parameter is used to describe ice particle properties. On page 6. the authors mention that for particles with D>=3 mm the complexity parameter is larger than 1, which corresponds to aggregates. What about heavily rimed aggregates? Would the complexity parameter and SAV be different from 1? It is not directly related to this study, but I have seen other studies where this parameter is used as an indicator of riming. I would be interesting to know, whether this parameter can be used as a riming indicator for all types of particles, regardless of their initial complexity.

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