Atmospheric Measurement Techniques Discussions

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Comment on amt-2022-174

Anonymous Referee #2

Referee comment on "Sizing ice hydrometeor populations using the dual-wavelength radar ratio" by Sergey Y. Matrosov et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-174-RC2, 2022

The manuscript presents a statistical, measurement-based approach to relate ice hydrometeor size to dual-wavelength radar ratio, using airborne X- and W-band radar and in-situ measurements. The observed correlations are convincing.
The relations are more robust when a horizontal (rather than vertical) W-band radar beam is used, which the authors argue is due to more pronounced non-Rayleigh scattering in this configuration. The authors broaden the discussion to study other correlations between radar and in-situ measurements, e.g. single frequency reflectivity. Other relations between different characteristic particle sizes are presented.

General comments

I found the manuscript interesting and the study very well conducted, with a both concise and rigorous description of the method. The results are highly valuable, with an extensive measurement-based study of relations between DWR and particle sizes.
However, I believe some aspects could still be improved in order to leverage the impact of this study and possibly make the results useful to a broader part of the scientific community.

Below are a few remaining questions which I recommend the authors consider addressing. The first point in particular is, in my opinion, very important.

1. How general are the observed correlations?

From the perspective of a potential user whose aim is to retrieve characteristic sizes from dual-frequency radar measurements, some information may be missing. It would be relevant to include more information on the data that were collected. For example, how many data points were included - how long were the time periods used (after the preprocessing steps which include e.g. removing mixed-phase conditions) to compute the coefficients of Fig 6? What were the flight conditions like, in terms of (for example) altitude, temperature, total water content…? Similarly, the authors mention the presence of various particle habits, but this could be expanded (e.g. indicate the classes of particles present in the entire dataset used, mention the presence of riming if any...). All this could help the reader get an idea of how general the derived relations are, and how they might hold in various environments.

2. Could a little more be said about the vertical beam results?
The authors point out that the DWR-Dv relations are more robust when using the horizontal beams. Unfortunately, most long-term radar observations are either space-borne or ground based and thus rely on vertical beams; hence, I wonder if a little more could be said on the DWR-Dv relations with vertical beams. Is the spread completely "random", or perhaps could it be easily related to varying particle habits, aspect ratios...? for example a suggestion could be to color-code the scatter plot e.g. on Fig. 4 with particle type or aspect ratio.

3. How do the results compare to model studies?
While I understand and value that the paper’s focus is an observational study and not a modeling work, I believe a bridge between the two approaches would be of high interest. Indeed, there have been numerous model-oriented investigations of multi-frequency radar measurements in the past decade (including but not limited to Kneifel 2011, 2015, Leinonen 2012, Ori 2015, Mason 2019, Oue 2021). Even without studying in-depth the accuracy of various models/parameterizations, perhaps some literature results could be used almost as is for comparison (e.g. similar as Matrosov 2019, but with the appropriate frequencies?).

Specific comments

Sect. 2.1 How were the radars calibrated?

l. 107 How is the liquid drop mean volume diameter computed (and the LWC)? With the CDP probes?

Fig. 2: I recommend the authors re-do this figure. It is 1) very stretched, and 2) the colorbar of the radar data (plots c - f) is not adjusted (it goes down to -20 dBZ but there are no such low values). This makes the reading quite difficult.

l. 156 Which probes were used for the hydrometeor classification? Are all the size ranges included?

Fig. 3: Please indicate the scale on the images. It could be relevant to also show the HVPS images at the corresponding time steps: on the right panels, the particles are large and the 2DS images are not very telling.

Fig. 8: It would be interesting to also have some results on the observed correlations between DWR and the other characteristic sizes. Is Dv the characteristic size which correlates the best with DWR?

l. 289-293. The mass-size relation of ice hydrometeors can vary significantly depending on the particle population (e.g. Mason 2018, Leinonen 2021) . Why was this specific relation chosen? What would be the impact of changing it? Perhaps distinguishing particle types would cause some differences.

l. 319: Same question – why this relation? was it found appropriate in the ICICLE dataset? Otherwise, would the results differ significantly with another relation? Did the ICICLE payload not include some direct TWC / IWC measurements (perhaps these were not available)?

Technical comments

l. 46 "remote sensing algorithms" ☐ "remote sensing retrievals"?
l. 77 "from this regime occurring" ☐ "occur"
l. 77 "which sizes" ☐ "whose sizes"
l. 164 "Sassen et a" ☐ "Sassen et al."
l. 166 "the later one" ☐ "the latter one"
l.230 "The RMSD values of observed Dv values from the best power-law fits...": perhaps simply "The RMSD of the best power-law fits"
l. 289 "is sometimes used instead D0" ☐ "is sometimes used instead of D0"
l. 303 "The ICICLE microphysical data based statistical relation" ☐ a little unclear
l. 320 two spaces after "m-D relation"