Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC3
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Comment on amt-2021-227

Anonymous Referee #3

Referee comment on "Triple-frequency radar retrieval of microphysical properties of snow" by Kamil Mroz et al., Atmos. Meas. Tech. Discuss.,
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This manuscript describes a snow microphysical property retrieval algorithm that employs multi-frequency radar simulations. A novel aspect of this study is that no a priori particle size distribution (PSD) parametrization is used as part of the retrieval scheme. Instead, direct airborne PSD measurements, combined with state-of-the-art ice scattering models, are used in forward three-frequency radar simulations to retrieve microphysical properties that are then compared to independent and concurrent airborne microphysical observations. Two key findings that are not entirely unexpected, but still extremely valuable as quantifiable evidence for the community's benefit, are that multi-frequency radar and Doppler velocity measurements are key observables needed to produce optimal snow microphysical property retrievals.

Despite being limited to one case study, this study is an extremely useful addition to the literature as a proof-of-concept study that will provide useful guidance on future sensor development to ultimately produce more accurate snow property retrievals. The snowfall remote sensing community will benefit from lessons learned in this study. I find the manuscript written in a succinct and easily understandable fashion, yet provides sufficient analytical heft that conveys valuable results. I encourage its eventual publication after the following minor comments are considered by the authors.

- Line 48: Should a different dielectric factor of liquid water be applied to the W-band radar reflectivity forward model simulations? This is a very basic methodological question, but causes much consternation among researchers applying or modeling radar simulations. The fact that the authors state that the 0.93 value is appropriate for "standard temperatures and frequencies below the Ka-band" might cause some confusion as to why this value is not altered for W-band simulations.

- Line 52: Minimizing W-band attenuation complications is another novel aspect of this study. The authors rightly highlight that W-band attenuation must be considered at longer distances from the radar under many circumstances, but the fact that these simulations are created using microphysical observations allows the authors to simplify the proof-of-concept message in the study.

- Figure 1 caption: I suggest adding the explicit year of the Morrison and Grabowski reference to the caption for completeness.

- Lines 56-59 elicit a general methodological question: over what time span are the binned PSD observations aggregated? I cannot offer a strong opinion of the optimal time sampling needed to produce robust binned PSDs, but it would be good to advertise this value to the community. I presume PSD variability over short time scales is deemed somewhat muted for this stratiform event, but I would still appreciate the authors advertising the time scale used for PSD measurements that are utilised in the forward radar reflectivity model.

- Line 60: Is the snowflake size automatically measured by analysis software? If so, do appropriate references exist for this procedure?

- Line 84: Minor typographical error. Change to "density *of* ice particles"

- Line 98: It appears as if a reference is missing (REF).

- Lines 98-110: This seems like a reasonable and creative method to deal with the complexity of possible snowflake morphology and atmospheric conditions.

- Figure 2 caption: I suggest explicitly writing that the top row are expected values and the bottom row standard deviations of the quantities.

- Figure 3: I suggest enlarging the font contained in various figure legends. The values are very difficult to read.

- Figure 3: Panels d, e, and f show reflectivity observations for each radar frequency. Might it be better to show DWR values instead since DWR is explicitly shown in Fig. 2? Or somehow creatively combine DWR with the single frequency values shown? This is not a mandatory suggestion by any means, but I am left wondering if showing DWR observations might also be beneficial to better connect with meaningful information contained in the observations.