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Atmospheric Measurement Techniques Discussions

Interactive comment on "What millimeter-wavelength radar reflectivity reveals about snowfall: An information-centric analysis" *by* Norman B. Wood and Tristan S. L'Ecuyer

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Dear Reviewer #3, thank you for your feedback and requests for clarification. Please see our explanations below of our responses to your comments.

Requests for clarification

1. Yes, aggregation could lead to dry snow particles with properties that are very different from those used as a priori assumptions in the retrieval. In general, aggregation (and other microphysical processes) may change how mass, area, fallspeed, and scattering properties all vary with particle size D. The retrieval has some freedom to adapt

to this by altering the retrieved log(lambda) and log(N0) so that the forward-modeled Ze matches the observed Ze. Large differences, however, will likely lead to nontrivial retrieval errors.

For the 14 February anomaly, in addition to the evidence mentioned briefly in the manuscript, a collocated X-band Doppler radar (McGill University's VertiX) revealed a bright band at around 1 km AGL with Doppler velocities of around 3 m/s below this level. This is a large fallspeed for dry snow aggregates, but these might have been large, wet aggregates. The VertiX was not in operation for the 2 March anomaly. It's probably not possible to rule out that aggregation was involved in either anomaly.

Yes, there does seem to be underestimation for higher snowfall rates in Figure 7, balanced by overestimation to some degree as evidenced by events with positive fractional differences in accumulations shown in Table 1. This suggest there might be a benefit for making the particle model a function of the observed reflectivity, and should be investigated further.

We have revised the statement in the Discussion section (at about line 425 in the revised manuscript) to be more consistent with this clarification.

We have also added brief commentary in the 4th paragraph of section 4 (around line 340 of the revised manuscript).

2. Yes, log(N0) is still physically significant to the retrieval, since it does influence Ze and snowfall rate; however log(lambda) is more strongly constrained by the reflectivity measurement than is log(N0). That means that the retrieval must employ either "a priori" information or additional measurements to help constrain log(N0).

Regarding simple, averaged Z-S relationships, please see Figure 7 that has been added to the manuscript. The retrieval gives Z-S relationships that are temperature-dependent and that deviate from the plotted linear relationships obtained from published Z-S relationships. It seems likely that temperature-dependent functions could be

developed that mimic the Z-S behavior of the retrieval (but not the information-centric diagnostics). Please see also our response to reviewer #1.

Small comments:

Paragraph starting on line 29: No, there wasn't a conscious decision to omit W-band radars. For experiments like these, W-band radars, because of their primary application as cloud radars, are more often operated for cloud measurement from aircraft and less often for observing snowfall at the ground. We know that GCPEx and ICE-POP in addition to C3VP all deployed ground-based W-band radars. Two Department of Energy funded experiments (StormVEx, at Colorado's Storm Peak Laboratory and BAECC in Finland), also deployed ground-based W-band radars. A number of studies have used W-band radar observations as part of multi-frequency snowfall retrievals, which are not applicable to this work. Development of snowfall retrievals using single-frequency, ground-based radar observations at W-band is not common. Some work has been done using ground-based Ka-band radars for snowfall (e g., Matrosov et al., 2008, JAMC; Cooper et al., 2017)

We have revised the text starting around line 35 in the revised manuscript to include information about experiments with ground-based W-band radars.

Figure 11: Done, and symbol sizes were increased to improve clarity.

Line 381: We changed this to say simply that "The size distribution plays a significant role..."

Typos:

1. "Viasala Oyj" is changed to "Vaisala Oyj".

2. Regarding "unit" appearing on line 336, corrected, thanks.

Matrosov, S.Y., M.D. Shupe, and I.V. Djalalova, 2008: Snowfall retrievals using millimeter-wavelength cloud radars. J. Appl. Meteor. Climatol., 46, 769-777.

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Cooper S. J., N. B. Wood, and T. S. L'Ecuyer, 2017: A variational technique to estimate snowfall rate from coincident radar, snowflake, and fallspeed observations. Atmos. Meas. Tech., 10, 2557-2571, doi:10.5194/amt-10-2557-2017.

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