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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 #1,

Thanks very much for your comments and suggestions, which we have generally adopted. Our responses to the major and minor comments are as follows:

Responses to major comments:

1. Thanks for this feedback. It seems likely that in this comment "overall performance" refers principally to our description of the agreement of retrieved and observed precipitation rates (e. g., Figure 8 of the revised document) and of the agreement in seasonal

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accumulation achieved by the retrieval in comparison to that obtained from measured values. We have extended the statement at the end of Section 4, paragraph 1 to elaborate on the C3VP data's roles in the development of the microphysical and scattering models. Further, we have added a statement near the beginning of Section 4, paragraph 4 indicating that the agreement of observed and retrieved snowfall rates is not unexpected. A similar statement regarding the accumulation comparisons has been added near the beginning of section 4, paragraph 5. Finally, we reiterated this point in paragraph 2 of section 5 (Discussion and conclusions).

Other principal results discussed in section 5 include the instantaneous retrieval uncertainties and sources of uncertainties in the retrieved state (paragraph 3), information content (paragraph 4), sources of model-measurement uncetainties (paragraph 5). These results depend mostly on the estimates of observation and forward model uncertainties plus forward model sensititivies and would be at most only weakly sensitive to the concerns raised by the reviewer.

We would appreciate further feedback if these modifications do not target the particular issue intended by the reviewer.

2. One of the benefits of this retrieval approach is that the retrieval can, on-the-fly, determine appropriate weights to apply to the information in the observations versus information provided by the a priori. Since Z alone cannot uniquely determine S, a priori information of some form is required. For simple statistical retrievals, this a priori information is generally embedded in the statistical relationships. It's not clear to us that this information-based weighting would be provided in a simple statistical retrieval.

That said, simple temperature-dependent statistical relationships that would provide estimates of snowfall rate and their uncertainties could be constructed. See, for example, Figure 7 of the revised manuscript to see how Z-S for this retrieval varies with temperature. There are some drawbacks:

First the differences in sensitivity and information that are made explicit with this

method tell us quantitatively that a Z-lambda approach would not be sufficient. It's clear that the retrieval requires information about N0 that is not provided well by the Z measurement, so a priori information about N0 is required. Diagnostics like this would not be obtainable in a simple statistical retrieval.

Second, consider what must be done when observed snowfall rate values are found to depart substantially from the retrieved values (i.e., the retrieval fails). With this method it's straightforward to compare the retrieval's assumptions, which are explicit, against observations to determine the cause of the retrieval failure. With a statistical approach, in which the a priori assumptions are typically not explicit, the causes of retrieval failure are much less transparent.

Responses to minor comments:

1) Done. We have revised the referenced sentence (in the first paragraph of section 2.1.1, in the text following equation 8) to read "That work used in-situ measurements and remotely-sensed X-band reflectivity observation of snow from C3VP...".

2) Yes, this is correct. The microphysical properties (m(D) and A(D)) and generic shape (which with m(D) and A(D) determine the scattering properties) used different ranges of the C3VP observations owing to differences in the availability of the required observations.

In W15, first, observations from 4 snowfall events were used to estimate the PDFs of microphysical properties (m(D) and A(D) but not shape). The data described in Table 1 of this manuscript for 6-7 December 2006 and 26-27 January 2007 are from small time periods of three of these events (SYN1, LE1, and LE2) during which the ACR was operated. Second, given m(D) and A(D), particles of different generic shapes or habits were modeled and radar scattering properties were calculated. ACR observations from the "13 days from 2 December 2006 to 26 February 2007" were then used to determine the generic shape that best reproduced the observed reflectivities. See our response to major comment #1.

3. While the FD12P and other instruments involved in the study were mostly autonomous and ran continuously during snowfall events, the ACR required an attending operator and so ran for shorter periods of time within the events. Note that the durations shown in Table 1 are substantially shorter than those shown for the events used in W15.

4. We have revised the paragraph (3rd paragraph of section 4.2, near line 405 of the revised manuscript) to introduce earlier the constant sensitivity to log(N0) in contrast to the varying sensitivity to log(lambda).

Typos and awkward phrasing:

L57 (original manuscript): "evaluating" changed to "estimating".

L125: "based in" is our intended wording.

L191: "Northewest" changed to "Northwest".

L276: To clarify, we have written this as "0.00", which is the actual value to two decimal places.

L444: "reduced by reducing" is our intended wording.

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