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Atmospheric Measurement Techniques Discussions

Interactive comment on "The importance of particle size distribution shape for triple-frequency radar retrievals of the morphology of snow" *by* Shannon L. Mason et al.

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We thank the reviewers for their constructive feedback on the manuscript. A recurring suggestion was that we apply the retrieval to more data than the 25-minute case study from 21 February 2014 originally used. We agree that this is desirable, reiterating that while the colocated remotely-sensed and in situ measurements of snow from BAECC 2014 are extremely valuable and of a high quality, the number of cases are limited. A related comment was that we should more clearly acknowledge the limited measurement period to which our retrieval was applied. In addressing both of these suggestions, we have both included an additional case study and de-emphasised the

retrieval of the PSD shape parameter in discussing the results.

During the snow experiment intensive observation period of BAECC there were three cases in which all three radars were zenith-pointing during a snow event, and where the snowfall at the surface was not affected by melting (the cases shown in Kneifel et al. 2015). The snowfall at the surface during one of these cases (7 February 2014) was insufficient for the in situ snow retrieval of von Lerber et al. (2015). We have therefore expanded our study to include 60 minutes of snowfall from the 16 February 2014 case. This case also includes riming, but is notable for the presence of secondary ice production due to rime splintering (the Hallett-Mossop process). These secondary needles rapidly aggregate, such that the radar measurements in this case are dominated by large aggregate snowflakes with a very open structure, while the in situ measurements include a mixture of graupel, large aggregates, and needles.

In applying our retrieval to this case, it was evident from PIP measurements that the PSD shape was nearly constant, but that significant changes in the triple-frequency radar signature could be attributed to the presence of large aggregates of needles, consistent with the findings of Leinonen and Moisseev (2015). We have therefore expanded the scope of the study to include the effects of variations in the internal structure of aggregates, which are represented within the SSRGA. We hope the reviewers agree that expanding the study to address both the PSD shape parameter and the internal structure of aggregates strengthens this effort to better understand and interpret the parameters affecting triple-frequency radar measurements.

To summarise, we have made the following changes:

- The title is now, "The importance of particle size distribution and internal structure for triple-frequency radar retrievals of the morphology of snow"
- We added a coauthor, Leonie von Terzi at the University of Cologne.
- We expanded our discussion of the coefficients of the SSRGA, especially those

relating to the internal structure of aggregate particles, in Sections 2.1 and 3. L. von Terzi's contribution to the study was to perform simulations of aggregation of various monomers and their SSRGA coefficients; we use this to identify aggregates of needles as having triple-frequency radar signatures with especially low values of DWR_{35-95} compared to aggregates of other monomers.

- Section 5 now uses the 16 February case study to explore triple-frequency radar measurements and retrievals from a case featuring rime splintering. This is a very distinct situation from the first case study, and combined the two cases cover the wide range of triple-frequency radar measurements from during BAECC 2014.
- The discussion and conclusions (Section 6) have been substantially re-written to be more concise, while addressing the expanded scope of the paper.

Specific comments:

The greatest concern is about the representativeness of the measurements obtained from the 10 minutes of rimed and 15 minutes of aggregated snow from the case study. This may not be sufficient to draw generalized conclusions about how this approach and overall novel methodology works. Slightly different environmental conditions could potentially produce altered results. The recommendation is to increase the number of cases for your radar analysis, perhaps 4-5 should suffice. Measurements from different geographical/climatological regions could also help to solidify your findings. If there is not much difference between the updated and the findings from the current version of the manuscript, add few paragraphs and/or table describing the statistics of the new dataset and retain the rest of the current analysis. If large discrepancies occur, the suggestion is to present a case with the statistics close to the one obtained from all

available measurements. In this way, the generalization of the results would be justified.

As addressed in our general comments above, unfortunately a further 4 or 5 suitable snow events were not measured during BAECC 2014, but we have expanded the study to include a second, longer case study in which the snowfall differs significantly from the 21 February case. We take the broader point that our results for these case studies are not necessarily generalizable: the two contrasting case studies help to demonstrate this, and we have substantially re-written our discussion and conclusions to better represent the remaining uncertainties.

Technical corrections

We have gratefully made the following changes:

P7 L8: (Kneifel et al., 2015) should be Kneifel et al. (2015)

Figure 4: Add the temperature contours to the image if available.

Figure 9: "PSD shape μ" should be "PSD shape parameter μ"

P21 L10-14: This sentence is a bit hard to follow, perhaps split it in two.

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