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Atmospheric Measurement Techniques
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Discussions

Interactive comment on "A variational technique to estimate snowfall rate from coincident radar, snowflake, and fallspeed observations" *by* Steven J. Cooper et al.

Anonymous Referee #1

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In this study, the authors utilize MASC measurements of snowflake microphysical properties and particle fallspeeds to constraint a snowfall retrieval scheme applied on Ka-band zenith radar reflectivities. The snowfall amounts thus obtained are then compared with values obtained by using different combinations of retrieval assumptions for the particle model, PSD parametrization and average fallspeed. The paper is well-conceived and presents valuable content. I have two major comments and a few minor comments, mostly clarifications, that should be considered by the authors before publication.

Major comment :

1) In section 3 (results), you emphasize multiple times the non-uniqueness of snowfall

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retrievals from radar reflectivities and the issues that it implies: difficulty to assess which combination of retrieval assumptions is truly the best, compensating errors can lead wrong combinations of assumptions to snowfall accumulation in agreement with the reference, etc. The results are presented individually for 2 events and eventually merged into one table showing the total snowfall amount accumulated over five snow events. Given these counterbalancing error effects, I think showing the total snowfall amount error is not very informative and could be misleading. Alternatively, the average error (that you mention p.12, l.8) and its variability are in my opinion more relevant. I would suggest to add this information in Table 3 and discuss the values obtained in Section 3.4 Along the same idea, it would be interesting and relevant to analyze the temporal evolution of snowfall accumulation as retrieved using different retrieval assumptions and compare it with the rain gauge measurement, especially for the April 23 event where you use 2 different estimates of the PSD slope parameter for 2 different periods. For instance, a correlation analysis could provide relevant complementary information to evaluate what are the best combinations of retrieval assumptions and to quantify the sensitivity of the retrieval results.

2) In my opinion, the paragraphs related to fallspeed estimation require some clarifications. How are the fallspeed measured by the MASC inserted into the retrieval scheme? Are you using hourly average as illustrated on Figure 5? How is the fallspeed calculated when multiple particles are present in one MASC image? As you mentioned, Garrett and Yuter 2014 showed that MASC fallspeed measurements are strongly influenced by wind and local turbulence. This will have an impact on the average observed fallspeed but also on its variability. What is the fallspeed variability during the events of interest? You could for instance display this variability on Figure 5 (for MASC and Doppler radar). How was the MASC deployed during the campaign? Was it windshielded? Horizontal wind and turbulence have also a significant impact on the catching ratio of rain gauges. As a rain gauge is used for reference in this study, it would be useful to document the wind conditions during the events and discuss the impact on the results (if available).

Minor comments :

p2, l19-25: As this paragraph is about spaceborne measurements of snowfall, I would suggest to mention the more recent Global Precipitation Measurement (GPM) mission carrying a dual-frequency precipitation radar. Possible citation: Global Precipitation Measurement Cold Season Precipitation Experiment (GCPEX): For Measurement's Sake, Let It Snow, Skofronick-Jackson, Gail, et al. BAMS 2015. p3, l13: I think MASC is the acronym for Multi-Angle Snowflake Camera (not Multiple-Angle Snow Camera). p3, l17: You could add a reference for the Precipitation Imaging Package. p3, l30: we discuss the methodology p4, l10: lambda is the PSD slope [. . .] and D is the particle maximum dimension p4, l24: What do you mean by cubic ice dipoles? Ice dipoles arranged on a cubic grid? p5, l5: I am not sure we can call the SVI a disdrometer, maybe reformulate. P5, l1-14: What assumptions are used on the orientation of the particles in the model? p5, l18 (and others): For a publication in an international journal as AMT, I would suggest to convert all measurements in SI units and potentially keep the Imperial units in brackets. p5, l28: graupels p6, l27: Please clarify why you use this standard deviation value (2 dBZ) p7, l11-18: If I understood correctly, you use MASC-derived PSD slope parameter as a priori guess for the whole profile of KAZR reflectivities. If so, would it make sense to take into account the altitude in the variance of the slope parameter guess (sigma), as the MASC measurement of PSD is less likely to be representative of the real PSD higher in the precipitation column? p7, l28: are based only on the [...] p8, l2: S_y instead of Sy (subscript) p8, l15-16: Please precise the units for V and D. p9, l5: Are sector plates and hexagonal columns models also coming from CloudSat DDA simulations? I see a sector plate model on Figure 1 but not a hexagonal column. Please clarify this point. p9, l10: "a priori" is written two times. p9, l13: Even though C3VP slope parameter lies within the range of values measured by the MASC, it is almost 4 times larger than the measured value for certain events. I would move this sentence to page 10 after you showed that PSD slop parameter has the least impact on the variability in estimated snowfall accumulation. p9, l29: snow accumulation of p11, l24-27: More specifically, rimed snowflakes are expected to be more reflective, hence reducing the PSD number density for a fixed slope parameter. It may compensate somewhat the increased snowfall retrieval due to the higher density of individual particles. Is this heavy riming also present in the fallspeeds measured by the MASC and the Doppler radar, compared to non rimed events? If so, I would suggest to mention it in this paragraph. P12, l26: Multi-Angle Snowflake Camera p14, l5: Remove "vary" p14, l11-15: In this regard, you may want to cite the recent work by Praz et. al "Solid hydrometeor classification and riming degree estimation from pictures collected with a MASC" (AMTD, 2017) in which the authors developed a method to automatically identify the type of snowflake and the riming degree from MASC images.

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