Atmospheric Measurement Techniques Discussions

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Reply on RC1

Sergey Y. Matrosov et al.

Author comment on "Sizing ice hydrometeor populations using the dual-wavelength radar ratio" by Sergey Y. Matrosov et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-174-AC1, 2022

Responses to the reviewer 1 comments

We thank the reviewer for constructive comments. Below are the responses to these comments.

Minor comment 1: Manuscript title: Consider adding which types of clouds this retrieval applies to or include the ICICLE campaign as these results were not extensively tested on other cloud/system types.

Response: To address this comment we now specifically mention in the abstract that ICICLE measurements were conducted in winter-time midlatitude frontal clouds. Additionally, in the main text we mention that the ice water content and temperature values in observed clouds varied in approximate ranges of 0.002– 2 gm^{-3} and -2^{o}C – -24^{o}C, respectively.

Minor comment 2: L90: More details on the microphysics are needed. What combinations of probes were used (e.g., PIP vs. HVPS) for the composite size distributions? What size ranges were used for the 2D-S and PIP/HVPS when combining the distributions? How were the probes oriented?

Response: The PIP particle spectrometer was used as a backup for the HVPS. Since all composite PSDs were calculated using HVPS, the statement about PIP (line 85-86) was excluded from the text to avoid confusion. To address the comment about the calculation of composite DSDs the following text has been added at the end of section 2.1: "Calculations of composite PSDs for ice cloud segments employed 2D-S and HVPS measurements in the following size subranges: 40mm to 670mm (at 10mm pixel resolution) and 750mm to 3.84cm (at 150mm pixel resolution), respectively." The HVPS was mounted to measure vertical projection of cloud particles, whereas the 2D-S probe allowed measurements of both vertical and horizontal projections of ice particles. Composite 2DS-HVPS PSDs were calculated for particles having the same projections. However, occasionally in case of malfunctioning of the 2D-S vertical channel, the measurements of the horizontal 2D-S channel were used for calculation of composite PSDs.

Minor comment 3: 2b and L156: Can you comment on whether only 2D-S images were used in the habit classification? I assume this is the case. If so, you should mention that the true habit breakdown may be different than shown since larger crystals may constitute aggregates from columns or planar crystals.

Response: The image recognition processing to identify habits of cloud particles (Korolev and Susman, 2000) was applied to the measurements of the OAP-2DC probe (Knollenberg, 1981). Because of its more coarse pixel resolution (50μm) the OAP-2DC particle imagery provided a better results of particle habit classification compared to the 2D-S. Particle images of 2D-S, because of its high pixel resolution (10μm), are subject of diffraction and out-of-focus effects. These effects degrade results of identification of particle shapes, and therefore, the 2D-S measurements were not used for ice particle habit recognition. The habit recognition was tuned that way that aggregates of irregular particles and needles fall in the category of "irregular particles". However, the category "dendrites" included aggregates of dendrites. Both complete and partial (i.e., larger size particles) particle images were used for the habit classification. Inclusion of partial images in the processing enabled an extension of the image recognition analysis to about 5 mm. The information given above was included in the revision.

Minor comment 4: L176 & Fig. 4: "…provide a better fit…" could probably use a statistic quantifying this agreement.

Response: This statement (Fig. 4 is for the Flight 20 data) is clarified in the revised manuscript. It is pointed out now that the polynomial approximation is better fitted for DWR greater than about 10-13 dB. Note also that RMSD values for power-law and polynomial best fits are given when discussing data from multiple flights given in Fig. 6.

Minor comment 5: L220: Specify the DWR and Dv bin increments used to generate Fig. 6.

Response: The bin sizes in this figure are 1 dB and 0.5 mm for DWR and D_v, respectively. The statement about it is added in the revised manuscript.

Minor comment 6: L292: Can you elaborate on the prefactor in the Brown and Francis m-D relationship? The value listed doesn't seem to reflect the a = 7.38 x 10^-11 g μm^-1.9 in their study after converting to cgs units. Further, their study used a Dmean definition for particle size (Hogan et al. 2012; DOI: 10.1175/JAMC-D-11-074.1), while this study uses a Dmax definition (L329).

Response: Indeed, the cgs unit prefactor coefficient 0.0033787 (note there was a typo in the original manuscript) in the m-D relation used in our study corresponds to a larger coefficient compared to the one in the B&F study (the exponent coefficient of 1.9 is the same). The prefactor coefficient used in our study was found as a result of comparisons of the PSD-to-mass calculations and bulk IWC measured by the isokinetic probe (IKP, Davison et al. 2011). This allowed finding coefficients *a* and *b* in the power-law m-D relation (where D is a larger particle projection, unlike in the B&F study) that provide best matching of the IWC calculated from PSDs and that measured directly by the IKP. The corresponding explanation is given in the revised manuscript. Note that the choice of the coefficient in the m-D relation only affects Deff (eq. 9) but not other characteristic sizes considered here. We are sorry for the confusion caused by the original text.

Minor comment 7: Fig. 8 nicely demonstrated how the different definitions of characteristic size relate to Dv. The end of Sec. 4 alludes to how this analysis "can facilitate meaningful comparisons of characteristic particle sizes from different retrievals" but falls short of demonstrating this link to the DWR measurements. To extend upon the Dv-DWR fits shown in Fig. 4, have the authors thought about adding a figure showing either a power law or a polynomial fit for each combination of characteristic size – DWR?

Response: We added a following statement in the revised manuscript: "approximate relations between the characteristic particle sizes other than D_v and DWR can be readily obtained from the D_v-DWR relations (Fig. 6) by expressing these sizes in terms of D_v using best fit power-laws shown in Fig. 8". For example, to obtain a relation between MVD and DWR, relations MVD=0.74 $D_v^{0.75}$ (Fig. 8a) and D_v=0.94 $DWR^{0.53}$ (Fig. 6a) can be combined to obtain $MVD=0.74(0.94DWR^{0.53})^{0.75}=0.71DWR^{0.40}$.

Technical correction 1: L103: References should be moved to be in line with the rest of the sentence rather than in parentheses.

Response: Fixed.

Technical correction 2: L208: process -> processes

Response: corrected.

Technical correction 3: L315: MacFarquhar -> McFarquhar

Response: corrected.

Technical correction 4: L322: From -> from

Response: corrected.