1 Comments from reviewer 1

We would like to thank the reviewer for reading our manuscript and providing helpful feedback.

1.1 Specific comments

Reviewer comment 1

Line 87: Although it probably doesn't matter much to the passive frequencies being simulated, it would make more sense to me to extend the retrieved hydrometeor content at the sixth bin above the surface downward rather than the reflectivity, since the reflectivity is likely not constant (due to attenuation).

Author response:

We would like to thank the reviewer for this thoughtful comment that draws attention to an aspect of the retrievals that we may have paid too little attention to. It is of course true, that the assumption of constant reflectivity through the ground clutter region down to the surface is a very crude one. The liquid hydrometeors retrieved in this region affect the retrieval of frozen hydrometeors aloft through the radiative background of the passive observations and forcing the retrieval to fit the constant reflectivity down to the surface may thus affect the retrieved concentrations of ice hydrometeors.

To investigate the effect of this simplification, we suggest a slightly different approach than the one proposed by the reviewer: Instead of enforcing constant hydrometeor concentrations from the upper boundary of the ground clutter region down to the surface, we retain the constant reflectivities from before but set the uncertainties associated with the affected bins to infinity. This instructs the retrieval to ignore the reflectivities from those bins but retains the possibility of adapting the concentrations of liquid hydrometeors to be consistent with the passive observations.

Fig. 1.1 and Fig. 1.2 show the effect of this change in the retrieval setup on the observation residuals as well as the retrieved ice water content. The only prominent change in the results is the misfit in the radar bins that were excluded from the retrieval. Retrieval residuals and retrieved concentrations of ice hydrometeors remained unaffected. We thus conclude that this design decision, albeit questionable, has only an insignificant effect on the results presented here.

Reviewer comment 2

Table 2: For the Dm corresponding to IWC, what is the meaning of the "A priori mean" value of "IWC = 10^{-6}"? Shouldn't the a priori mean be in units of length (as with RWC)?

Author response:

The a priori mean for D_m was chosen so that the corresponding ice water content has a constant value of 10^{-6} kg m^{-3} throughout the atmosphere.

Changes in manuscript:

To make this clearer, we will change the entry in the table from '$IWC = 10^{-6}$' to 'Chosen so that IWC = 10^{-6} kg m^{-3} at all levels'. The updated table in shown in Tab. 1.1.

Table 1.1: Retrieval quantities and a priori assumptions used in the retrieval. The relation for the a priori mean of $\log_{10}(N_0^*)$ is taken from Cazenave et al. (2019).

Quantity	Retrieved parameters	A priori mean	A priori std. dev.
Ice water content (IWC)	$\log_{10}(N_0^*)$	$-0.076586 \cdot (T - 273.15) + 17.948$ with T temperature in K	2
	D_m	Chosen so that IWC = 10^{-6} kg m^{-3} at all levels.	500 μm
Rain water content (RWC)	$\log_{10}(N_0^*)$	7	2
	D_m	500 μm	500 μm
Cloud liquid water content (CLWC)	$\log_{10}$(CLWC)	From ERA5	1
Relative humidity (RH)	$\operatorname{arctanh}(\frac{2 \cdot \mathrm{RH}}{1.1} - 1.0)$	From ERA5	1

1.2 Typographical errors

Again, we would like to thank the reviewer for pointing out these mistakes, which we will of course all correct in the revised version of the manuscript.

Figures

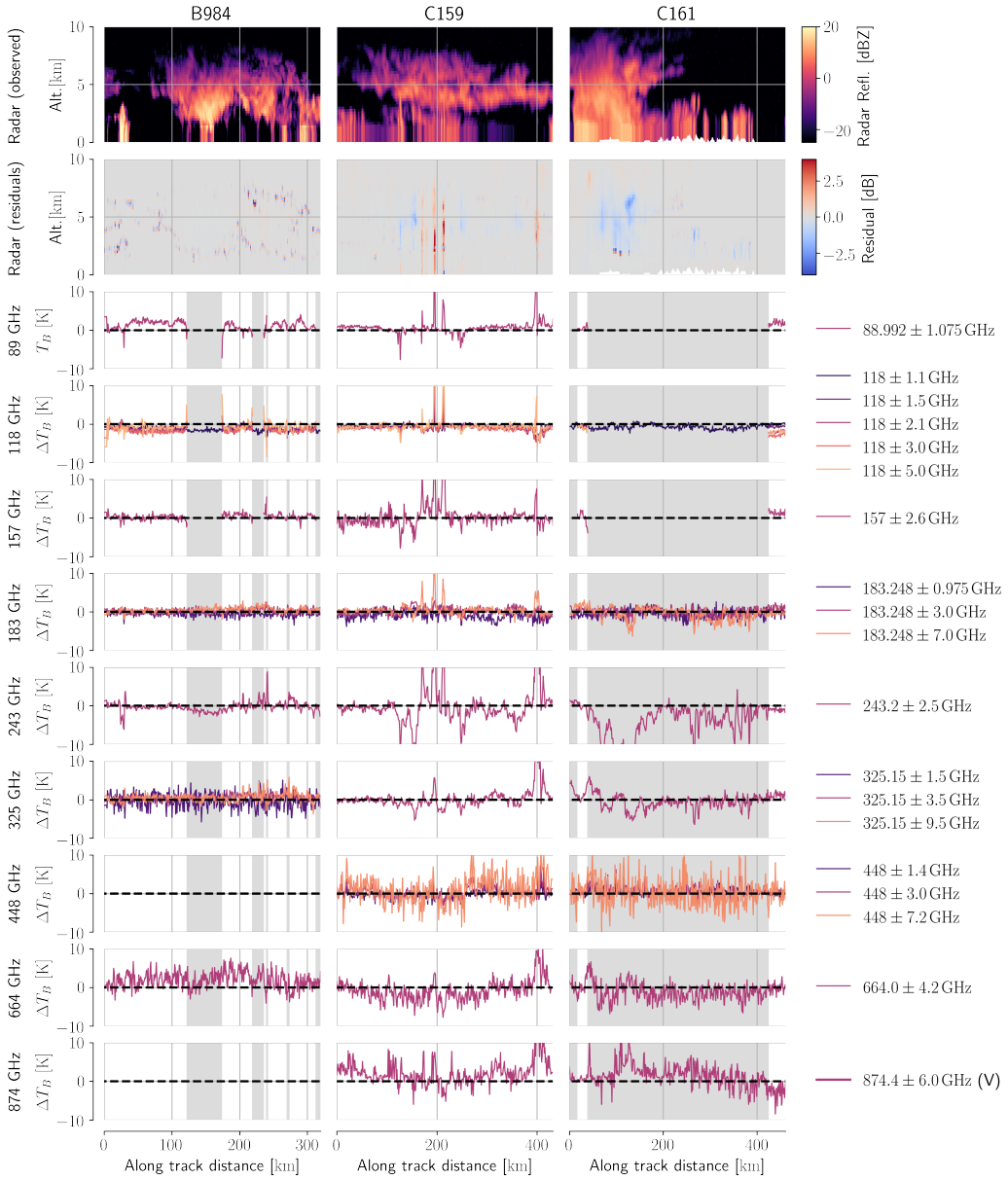

Figure 1.1: Like Fig. 4 from the manuscript but with modified observations errors of the radar bins affected by ground clutter set to a 10^6.

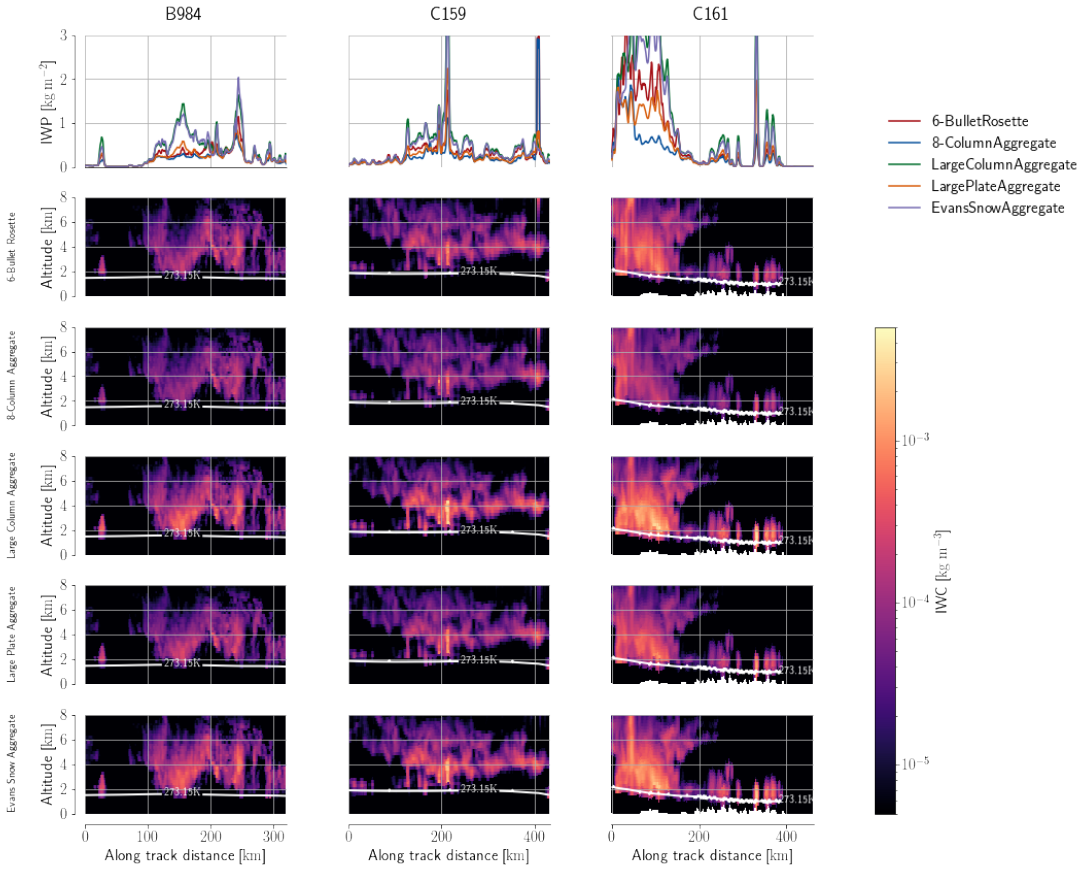

Figure 1.2: Like Fig. 11 from the manuscript but with modified observations errors of the radar bins affected by ground clutter set to a 10^6.

Bibliography

Cazenave, Q., Ceccaldi, M., Delanoë, J., Pelon, J., Groß, S., and Heymsfield, A.: Evolution of DARDAR-CLOUD ice cloud retrievals: new parameters and impacts on the retrieved microphysical properties, Atmos. Meas. Tech., 12, 2819–2835, https://doi.org/10.5194/amt-12-2819-2019, 2019.