

Atmos. Meas. Tech. Discuss., referee comment RC3
<https://doi.org/10.5194/amt-2021-306-RC3>, 2021
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Comment on amt-2021-306

Anonymous Referee #3

Referee comment on "Synergistic radar and sub-millimeter radiometer retrievals of ice hydrometeors in mid-latitude frontal cloud systems" by Simon Pfreundschuh et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-306-RC3>, 2021

Summary

This study presents the results of a synergic retrieval (radar + mw/sub-mm radiometer) of ice cloud hydrometeor vertically-resolver distributions. A previously published paper presented the technical details of the retrieval and tested it with simulation-based results. The present paper validates this retrieval using real co-located radar and microwave radiometer observations. This paper is very well written and organized. Results are divided mainly in two: an analysis of the accuracy of the retrieval by comparing the retrieved results with in-situ measurements of bulk IWC and PSDs, and an analysis of the validity/consistency of the forward model active and passive simulations (i.e., the RT framework).

General comments

The publication is fit for publication as the results are novel and the limitations and complexities involved are analyzed with care and detail. The main results I take is that particle habits are still un-constrained even with sub-mm frequencies and this is an important result on the edge of the ICI era. I recommend publication with only a few minor details/comments to be considered.

Minor comments and Typos

Line 69: Please include the time periods of these campaigns for completeness.

Line 107 and 108: Title 2.2 missing capital letter (In situ measurements). Also missing the capital letter in the first sentence of the paragraph below.

Line 109: For completeness I would recommend a better description of what it is meant by "high-level" and the "lower parts" of in situ-sampling. Perhaps it makes more sense to introduce in-situ measurements before the analysis of the co-location of flight tracks.

Line 130: Background properties of the atmosphere and the surface [...]

Line 132-133: Although readers are referred to Pfreundschuh et al. (2020) for a detailed description of the retrieval, perhaps a better synergy between the text and table 2 would add to the description here regarding the parameters of the PSD for the different species.

Line 136: [...] Atmospheric Radiative Transfer Simulator (ARTS, Buehler et al., 2018) is used [...]

Line 145: "In the first one, the bulk properties". Use lower case in "in the first one [...]"

Line 151: After the sentence that starts with "The updated values of [...]", for completeness perhaps the cloud ice PSD equation could be included in parentheses with the D_m , N_0^* and the shape parameter.

Line 152: single particle optical properties.

Line 154: "Since this is difficult". Please expand on this for completeness.

Line 175: retrieved hydrometeor size distributions.

Line 224: for which the best agreement.

Line 286: typo in "For, flight B984 [...]". Move the comma please.

Line 298: typo in "Secondly, the a clear backscattering"

Line 349: Just comment here. I wonder if for a real scenario, with the complexities of the vertical differences in particle orientation, habit phase, etc, this would add to 20% in the resultant observations at nadir.

Figure 10. The discussion mentions the large differences for 243 GHz, however flight B984 shows smaller residuals at this channel than the other two channels. Is there anything to add to the discussion regarding this? Also, there are large differences for 448 \pm 7.2 GHz, specially for flight C159. Could you comment on that too?

Figure A1: Have you looked at a similar figure for the other channels?

Figure 14: How do these results translate to IWP? Perhaps a general summary of such a Figure could add to the discussion of Figure 14.

Figure 15: I have a tough time with the gray of in-situ (sample)

Figure 14 and Figure 15. Results are presented for flight B984, which uses the HAMP MIRA 35 GHz cloud radar. Could you comment on possible differences with CloudSat CPR were

to be used.