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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Towards the connection between snow microphysics and melting layer: Insights from multi-frequency and dual-polarization radar observations during BAECC" *by* Haoran Li et al.

Anonymous Referee #2

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I would like first to sincerely apologize to the authors and the Editor for being late in providing my review.

1 Summary

This manuscript presents the analysis of vertical radar profiles at different frequencies, conditioned to the amount of riming in the ice phase above the melting layer and to the

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intensity of precipitation (as rain) at the ground level. This analysis suggests that the precipitation intensity is a strong / main driver of the variability of the vertical profiles of polarimetric signature as seen by radars at X, Ka and W band, as well as by an operational C-band radar.

2 Recommendation

Building on scattering simulations and on a classification technique to identify the (qualitative) degree of riming, the analysis of the vertical profile of polarimetric radar variables collected at 3 frequencies (x, Ka and W) for an ensemble of rain events exhibiting a clear melting layer is relevant to the readership of ACP. I have some concerns (see list of comments below), the main ones being the limited size of the data set used in the end (11.5 hours) and the associated uncertainty on its representativity (in particular in terms of dominant microphysical processes) and the uncertainty associated with the riming classification. Overall, this manuscript could be published in ACP after the questions and concerns listed below have been properly addressed.

3 General comments

1. In the end, the analysis is based on 11.5 hours of rain... This is not that much, and the representativity of these 11.5 hours should be discussed. Related to this question, one of the main conclusions of this work is that the precipitation intensity is the dominant factor in explaining the features of the ML and the polarimetric profiles. To strengthen this conclusion, could the authors rule out the possibility that in the considered 11.5 h there is a particular dominant process that relates to precipitation intensity and hence “bias" the analysis? In my view

this is a possible concern because precipitation intensity (attractive because easier to measure in rain and important for hydrological applications) reflects many processes (riming, analyzed here, but also concentration, vertical wind, etc.) and they are not individually considered in the present study.

2. Section 3.2 “Diagnosing snowflake rime mass fraction": it is an interesting approach presented here, but the goodness-of-fit of the fitted power laws should be provided in Table 1, as an indicator of how well these power laws do capture (or not...) the variability of the data, in particular because Fig.1 does not suggest a very good fit. In addition, the sanity check presented in Section 4.1 (Fig.3) is not super convincing: there seems to be a lot of overlap...

3. Figures 4 to 9: the median profiles are plotted, but the reader has no information about the variability of the individual profiles. I strongly encourage the authors to indicate (by thin lines, bars...) the variability around the median profiles, so one can assess if the differences seen between the median profiles are more or less significant.

4. The analysis is conditioned to unrimed vs rimed snowflakes. In the case of the rimed snowflakes, there is no discussion (I may have missed it...) about the altitude at which riming occurs and that can vary from one event to the other. If so, the vertical profiles of radar variables above the ML could be much more variable than the unrimed cases.

5. Conclusion 3 should be revisited: the fact that Z_{dr} is decreasing because of aggregation is well established. And the signal in Kdp at 3000 m above the ML may correspond to the particular events considered but may not be a general feature.

4 Specific comments

1. P.7, l.5-6: the effect of supercooled liquid water droplets on W band is mentioned earlier, but it seems nothing about X and Ka band. This should be clarified (as well as the 1 dB threshold).
2. P.8, l.4: over how many profiles in total have those 4147 been selected? To have an idea about the selection.
3. Figures 2 and 3: I suggest to use transparency to better visualize the possible overlap between rimed and unrimed cases.
4. P.10, title of section 4.2: should it be “Vertical" instead of “Vertically"?
5. P.10, l.24: not so obvious to me, could the authors please elaborate a bit more about the explanation of the later response of ρ_{hv} for unrimed snowflakes?
6. figures 4 to 9: why is there a black solid line at the minimum altitude in all the plots? Is it signal or an artifact?
7. Figure 5: there is no comment about the fact that below the ML, the DWR(X,Ka) profile is higher for the rimed cases and progressively converges toward the unrimed profile when PR is increasing.
8. P.12, l.7: it is mentioned that the reflectivities at X and Ka bands are matched at clout top. Would it be more correct to mention precipitation top, as it is not sure to that a radar at X band would always see the cloud top?
9. Figure 8: the note about the not-shown $Z_{\mathrm{W,rain}}$ is unclear to me. How is the reflectivity profile at W band normalized?
10. P.,16, l.2: “intense" rather than “intensive"?

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