Review of Identification of multiple co-located hydrometeor types in Doppler spectra from scanning polarimetric cloud radar observations by Majid Hajipour, Patric Seifert, Hannes Griesche, Kevin Ohneiser, and Martin Radenz for AMT.

In this article, the authors build upon the Main-peak approach introduced by Myagkov et al., extending it to encompass the full Doppler spectrum. This extension allows for a spectrally resolved methodology. The topic is relevant, and the two case studies presented are engaging. The revised manuscript shows clear improvement, and the authors have briefly addressed the Main-peak approach as requested by the referees. I appreciate the thoughtful responses to the previous comments and questions.

However, the manuscript still requires further revision for publication. A list of comments, corrections, and suggested additions is provided below, including both substantive and minor points. Given the number of small inconsistencies and typographical errors, I recommend a careful and thorough proofreading of the revised version. At this stage, the manuscript falls between requiring major and minor revisions.

Comments/corrections/adding's

1) Separation Rayleigh/Resonance Scattering Regime

Based on the measurement of the spectral differential phase, it is possible to detect where the resonance scattering regime starts in the Doppler spectrum (Mak et Unal, 2025). That can be of use for the analysis of large ice particles (part 1).

Mak, H. Y. L., and Unal, C. (2025): Peering into the heart of thunderstorm clouds: insights from cloud radar and spectral polarimetry. Atmospheric Measurement Techniques, 18(5), 1209–1242. https://doi.org/10.5194/amt-18-1209-2025

2) Instrumentation

Lines 103-105: To explore the polarimetric capabilities of the MIRA-35 cloud radar was not the unique goal of the ACCEPT campaign. Therefore, I propose to rephrase:

"The ACCEPT measurement campaign was led by the Leibniz Institute for Tropospheric Research (TROPOS) in Leipzig, Germany, with partners from the Technical University of Delft and METEK GmbH in Elmshorn, Germany. One of its goals was to explore the polarimetric capabilities of the MIRA-35 cloud radar. A second objective was the study of ice particle growth processes in mixed-phase clouds using spectral polarimetric S-band radar measurements (Pfitzenmaier et al. 2017, Pfitzenmaier et al. 2018).

Pfitzenmaier, L., Dufournet, Y., Unal, C. M. H., & Russchenberg, H. W. J. (2017). Retrieving fall streaks within cloud systems using Doppler radar. Journal of Atmospheric and Oceanic Technology, 34(4), 905-920. https://doi.org/10.1175/JTECH-D-16-0117.1

Pfitzenmaier L., C. M. H. Unal, Y. Dufournet, and H. W. J. Russchenberg: Observing ice particle growth along fall streaks in mixed-phase clouds using spectral polarimetric radar data, Atmos. Chem. Phys., 18, 7843–7862, 2018. https://doi.org/10.5194/acp-18-7843-2018.

3) Main-peak approach

Line 192: “These measurements are then compared with simulated values based on spheroid model that assumes the particles are shaped like spheroids (3D ellipsoids)”. Mention already here that Rayleigh scattering is used. The reader should not wait for the conclusion to know this important information.

4) Spectrally resolved approach

Figure 1: this figure suggests that 5 different types of particles can be retrieved with the Doppler spectrum partitioning, but that is not the case. Make a note of this in Figure 1 caption.

5) Second case study 03 Nov 2014, 20:30-20:45: Secondary ice formation

4-a) Figure 10 is not discussed (only 1 sentence, Lines 523-524). I suggest to add a small paragraph to comment the key features of the precipitating cloud case illustrated in Figure 10 (20:00-21:00).

4-b) Lines 538-540: The polarizability factor and degree of orientation cannot be discussed in the melting layer and in rain using the Rayleigh scattering assumption, which is not valid at 35 GHz for these hydrometeors. Remove these lines.

4-c) Lines 588-590: “Indications are given that the branches of oblate ice crystals, such as dendrites fell off, in addition….”. Can the authors clarify this statement? Which indications? Is the presence of dendrites in the study case justified? Until now, there was no discussion about the presence of dendrites….

The authors cannot write such a statement without any justification other than “Indications are given”. Justify/explain in the article.

6) Summary and Conclusions

5-a) Lines 609-611: “The author notes that the possible reason for the smaller influence of non-Rayleigh scattering on polarimetric variables is that they are differential (rather than absolute) quantities representing differences/ratios of radar parameters at two orthogonal polarizations.”

Considering any mm-wavelength radar or hydrometeor type or polarimetric variable, this statement is not correct. To my knowledge, in general, non-Rayleigh scattering influences polarimetric variables.

5-b) Lines 618-620: “In the presented study, the homogeneity was evaluated based on (1) inspection of the required monotonic relationships between polarimetric parameters and elevation angle, and (2) the appropriateness of the horizontal wind correction.”

Significant variations in Doppler spectrum width were not considered?

5-c) Lines 621-622: “The ACCEPT campaign, conducted in Cabauw, the Netherlands in 2014, aimed to assess the capabilities of both the main peak approach and the spectrally resolved approach.”

Based on earlier comment (see instrumentation section), replace the sentence by “One of the aims of the ACCEPT campaign, conducted in Cabauw, the Netherlands in 2014, was to assess the capabilities of both the main peak approach and the spectrally resolved approach.”

7) Acknowledgements

Line 653: “….. and to the team of the CESAR Observatory in Cabauw and Delft University of Technology, NL, for their support ….”

Minor comments/corrections/adding’s

1) Abstract

The abstract consists of three parts identical. Please, correct this.

2) Introduction

Lines 87-89: The following paper could be added:

Mak, H. Y. L., and Unal, C. (2025): Peering into the heart of thunderstorm clouds: insights from cloud radar and spectral polarimetry. Atmospheric Measurement Techniques, 18(5), 1209–1242. https://doi.org/10.5194/amt-18-1209-2025

3) Instrumentation

3-a) Line 114: remove “also”

3-b) End of Table 1, typo: “…… can be estimated by assuming ….”

4) Mira-35 radar in hybrid mode

4-a) Lines 144-145: “……. which are representative of the horizontally ($E_h(\omega)$) and vertically ($E_v(\omega)$) components of the received waves.” Also, place a dot above the capital letter *E*. These components are complex.

4-b) Line 148: “ZDR quantifies the ratio of reflectivity measurements in horizontal (Zhh, Eq. 1) and vertical (Zvv, Eq. 2) polarizations, (Eq. 3).”

4-c) Line 153, typo: Also, the constants …..

4-d) Line 154: Remove “Radar cross section (RCS)”. The constants C1 and C2 do not depend on the RCS, $E_h(\omega)$ and $E_v(\omega)$ do depend on the RCS (square-root of RCS).

4-e) Lines 158-160: “The correlation coefficient (RHV) is a crucial parameter (defined by Eq. 4) that quantifies the similarity between horizontally ($E_h(\omega)$) and vertically ($E_v(\omega)$) polarized backscattered signals.” Place a dot above the capital letter *E*.

4-f) Lines 160-162: “It provides insight into the diversity of particle shapes and orientations within a radar resolution volume and is typically expressed as a value between 0 and 1.”

4-g) Lines 162-163: “A correlation coefficient of 1 indicates perfect correlation between horizontal and vertical polarization signals, implying that the backscattered signals are identical in phase and amplitude.”

5) Main-peak approach

5-a) In Eq. (8), remove the subscript “e”, which is not present in the text.

5-b) Line 211: Is ξ_g the axis ratio?

5-c) Line 226: “Finally, to derive ZDR and RHV, the horizontal and vertical complex scattering amplitudes are calculated using the polarizability ratio and the degree of orientation across different elevation angles. “

5-d) Line 234, typo: “distribution”.

5-e) Line 238, typo: Not “than” but “then”.

6) Spectrally resolved approach

6-a) Lines 250-253: “The width of the Doppler spectra is thereby characterized by size- and shape-dependent fall velocities of the particles, which are super-imposed by influences of turbulence and (predominantly in case of off-zenith antenna pointing angle) horizontal wind variability that cause additional broadening of the spectrum (Radenz et al., 2019).”

6-b) Line 274, typo: “mean square error function”

6-c) Line 279: “During averaging of all ZDR and RHV values …..”. Mention how many values can be expected for this average.

7) The influence of air motion on the Doppler spectra observed by a scanning cloud radar

Line 295: …. onto the gravitational downward motion of particles …..

8) Retrieval of horizontal wind

8-a) Line 306: “…. and radial wind velocity Vw.”

8-b) Eq. (12): is it not $V_w = V_h \cos(\beta \pm \pi - \alpha)\cos(\psi)$? To have negative radial wind velocity when the particles approach the radar. The wind direction being defined from where the wind comes from.

9) First case study 07 Nov 2014, 09:15-09:30: retrieval of various hydrometeor types

9-a) Figure 4 caption: ……. (see Figs. 7-9). Typo in the right parenthesis.

9-b) Line 391, typo: …. high values of radar LDR ….

9-c) Line 444: …. The SNR stabilizes at approximately 60 dB. I think it is much less. 25 dB?

9-d) Lines 457-458: "Since different parts might identify oblate-shaped particles at heights around 3km (parts 1, 2, 3, and 4) and prolate-shape particles at part 5, a height of 3km is chosen for a detailed depiction of the data analysis procedure."

From the discussion of Figure 7 above, the authors mention that at this height (around 3 km), the particles are spherical-shaped in parts 1-3, oblate-shaped in part 4 and prolate-shaped in part 5. Therefore, rephrase the sentence for consistency with the discussion of Figure 7.

9-e) Figure 8 caption: I suppose that the time period 09:16:09 – 09:18:08 UTC is considered and not only the time 09:15:09 UTC.

9-f) Figure 8 caption: ….. and for each part of the spectrally resolved spectra, shape and orientation retrieval ……"

9-g) Figure 9: I don't see the horizontal lines displaying the temperature levels.

10) Second case study 03 Nov 2014, 20:30-20:45: Secondary ice formation

10-a) Lines 528-529: "In middle altitudes (X-Y km) …….. In lower altitudes (Z-X km) ….." Be specific and indicate the height range considered.

10-b) Figure 12 caption: the time (20:01:09-20:11:26) is not correct.

10-c) Line 542: "…. between the melting layer and 2.75 km height ……"

10-d) Line 558: "… RHV decreases with increasing part number …."

10-e) Figures 16 and 17 caption: ….. and for each part of the spectrally resolved spectra, shape and orientation retrieval ……"

11) Summary and Conclusions

Lines 602-603: "In particular, by incorporating Rayleigh scattering, we assume that particles are small with respect to the deployed electromagnetic waves." I suggest to

remove this sentence. It is redundant compared to the next sentence. The next sentence suffices.

Line 611, typo: .... were elaborated .....

Line 638:" ..... would be to apply implement techniques ....." Suppress either "apply" or "implement".

Line 639, typo: "Then more insights ....."