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 extend the Main-peak approach by Myagkov et al. to the full Doppler spectrum, enabling a spectrally resolved methodology. The topic is noteworthy, and the two study cases are interesting. However, the manuscript requires significant improvement and lacks clarity, particularly in the methodology. To ensure clarity and reproducibility, several aspects of the methodology must be elaborated. The article should be self-contained, allowing readers to fully understand the proposed approach without needing to consult the prior works of Myagkov et al. on shape retrieval and Baars et al. on horizontal wind retrieval. Why is the retrieval of the horizontal wind necessary? Additionally, the manuscript lacks error analysis for the spectrally resolved approach, and its possible limitations are not adequately addressed. For instance, which assumptions are made while comparing spectral polarimetric variables at different elevation angles? How does the method handle significant variability in Doppler spectrum width across different elevations? Furthermore, how are Mie scattering effects accounted for in shape retrievals, especially for the largest/heaviest ice particles? There is no information on the model part of the technique: which scattering model is used? Which ice particle types are considered? Addressing these issues, along with the detailed section comments and corrections provided, will substantially improve the manuscript. I recommend major revisions.

Comments/corrections/adding's

1) Introduction

Line 39: "Cloud Doppler radars, introduced by Wakasugi et al. (1986), provide backscattered signal…." Rephrase because cloud Doppler radars were not introduced by Wakasugi et al.

2) Instrumentation

Can the authors provide a clear set-up of the measurements? The mode RHI is mentioned, but later in section 3.3.1 the retrieval of the horizontal wind using the PPI mode is discussed. Therefore, it is not clear to the reader what the measurement sequence is: a combination of RHI and PPI? Also, the rotation speed of the radar for RHI and PPI measurements should be provided.

Table 1: add the Doppler velocity resolution for both MIRA-35.

3) Mira-35 radar in hybrid mode

Revision of Lines 115-153. Attention should be given to the section dedicated to the introduction of polarimetric variables. Rephrasing is necessary and there are some inconsistencies/errors in the text and equations. See below my recommendations.

Line 116: "….as a function of Doppler velocity ω …" My suggestion: either "….as a function of Doppler angular frequency ω …" or "….as a function of Doppler velocity *v* …"

Lines 116-117: No point above the capital letter for $E_h(\omega)$ and $E_v(\omega)$?

Equations (1) and (2) are not correct. The reflectivity is not directly equal to the average modulus square of received complex amplitudes. A constant is missing.

Line 121: "ZDR quantifies the difference between reflectivity measurements in horizontal (Zhh, Eq. 1) and vertical (Zvv, Eq. 2) polarizations, expressed in decibels (dB) (Eq. 3)." Eqs. 1-3 are not expressed in decibels. Be consistent with the text and equations.

Line 125: "At zenith-pointing direction, ZDR is zero. *At slant-pointing direction,* a positive ZDR value …."

Line 127: "The correlation coefficient (RHV) is a crucial parameter that quantifies the linear relationship between the Zhh and Zvv." Rephrase this statement, which is now not correct.

Lines 128-129: the sentence is not clear and that is not useful to describe Eq. 4 in terms of ratio, sum, square root, product… because that can be directly seen in Eq. 4.

Line 131: remove the point after 1.

Lines 131-132: "… a correlation coefficient of 1 indicates perfect correlation or alignment between horizontal and vertical polarizations, suggesting consistent scattering behavior." Rephrase. What is "alignment between horizontal and vertical polarizations"? What is "consistent scattering behavior"?

Line 135: "…. raindrops, with a spherical shape and ….". Replace "spherical" by "spheroidal".

Line 137: "…. a parameter frequently detected by cloud radars ….". Rephrase. A parameter is not detected.

4) Main-peak approach

Is the main peak approach code by Myagkov et al. available online?

Line 163: "This analysis provides insights into particle habits by utilizing a spheroidal scattering model". "A spheroidal scattering model". Which scattering model is used? and "spheroidal scattering model" is not the appropriate name.

Provide the equations of the polarizability ratio and degree of orientation. Explain how they relate to the ZDR and RHV measurements.

5) Spectrally resolved approach

I recommend to the authors the extension of the block diagram of Figure 2, where the main peak approach block would appear. Further a zoom of the main peak block, with

inputs and outputs, can be worked out in a second Figure. Presently, without reading in detail the papers Myagkov et al., it is challenging to understand the spectrally resolved technique. The reader should be able to understand the paper without having to read preceding papers.

There is no information on the error analysis.

How is Mie scattering regime accounted for? For example, for Part 1.

Line 185: “Consequently, the Doppler spectra observed with a vertically pointing cloud radar offer insights into the variability of sizes and shapes of the ice particles”. Information on the shapes of the ice particles for zenith-pointing cloud radar cannot really be obtained.

Lines 198-199: “The amount of 5 parts was empirically chosen for this study, because usually not more than that amount of different particle shapes can be expected in a cloud volume”. Can you provide a reference for this statement?

Lines 199-200: “Increasing the number of parts would result in a reduced amount of available data points per Doppler spectrum part which would lead to increased uncertainties. This statement should be developed. “Which amount of data points for the spectrally resolved approach is recommended? Why? I missed a discussion on this point in terms of possible errors.

Lines 203-204: “Instead, we assume that the fall attitude of the individual hydrometeor types contained in the cloud volume is similar at all elevation angles.” Was the same assumption made in the main peak approach?

6) Retrieval of horizontal wind

Figure 3: compared to V_f and V_h, V_R is not well scaled. Correct this.

Lines 241-242: “…. while the sine’s curve amplitude *yields the wind velocity* V_h *multiplied by the cosine of the elevation angle,* ψ”

Lines 242-243: “Additionally, the entire curve’s displacement from the zero velocity *relates to* the precipitation fall speed.”

Lines 243-244: “We used the approach of Baars et al. (2023) to derive the horizontal wind components.” Describe shortly this approach.

7) Aliasing problems and effects of horizontal winds on the determination of the vertical velocity component.

Line 257: mention what f_n is.

Lines 267-270: The methodology of dealiasing needs to be shortly extended for clarity and reproducibility.

Eq. 10: V_R should be replaced by V_D.

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

Figure 4 caption: ……. on November 7, 2014. Correct the date.

Lines 293-294: Between 09:15 and 09:30 UTC, a deep cloud …. which caused precipitation after 09 UTC. Check the time consistency. If it rains from 09:00 UTC, it means that the deep cloud is present before 09:15. Rephrase.

Line 295: The evolution of the mixed phase in this deep cloud…. Why is this deep cloud a mixed-phase cloud? I miss the argumentation here.

Line 335: …. The SNR stabilizes at approximately 60 dB. I think it is much less. 25 dB?

Figure 6 caption: there are errors in the sequence (a)-(o): …. (*l*) RHV in part 2…..(*i*) ZDR, and (n) RHV in part 4, …..

Lines 345-347: Why is it possible to conclude that below 4 km based on RHV and ZDR the particles are prolate (part 5). Provide a short explanation and reference.

Lines 358-361: provide a reference.

Figure 7 caption: error in the sequence (a)-(l): …. (g) RHV spectrum before splitting….

Lines 362-372: in this paragraph the retrieved polarizability ratio shown in Figure 8 is discussed. However, there is no word about the retrieved degree of orientation, part of Figure 8 as well. Why?

Line 363: “For the sake of readability, error bars are omitted in this case ….” OK, but some text related to the error bars should be written in section 3.2. How are the error bars estimated?

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

Figure 9 caption: The highlighted period…. are applied. Rephrase the sentence. Also, I don’t see the highlighted period in the figure.

Figure 13 caption: there are errors in the sequence (a)-(o): …. (*l*) RHV in part 2…..(*i*) ZDR, and (n) RHV in part 4, …..

Figure 14 caption: error in the sequence (a)-(l): …. (g) RHV spectrum before splitting….

Figure 15 caption: error in the sequence (a)-(l): …. (g) RHV spectrum before splitting….

Lines 462-463: “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….

10) References

The authors should review the reference list.

For example,

uncomplete reference: Melnikov and Sraka, 2013.

Spell-check: Hajipour, M et al. 2024: ….studies…..