Observing the vertical distribution of the hydrometeor mix with ground-based scanning polarimetric cloud radar

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PROM meeting, Kiel

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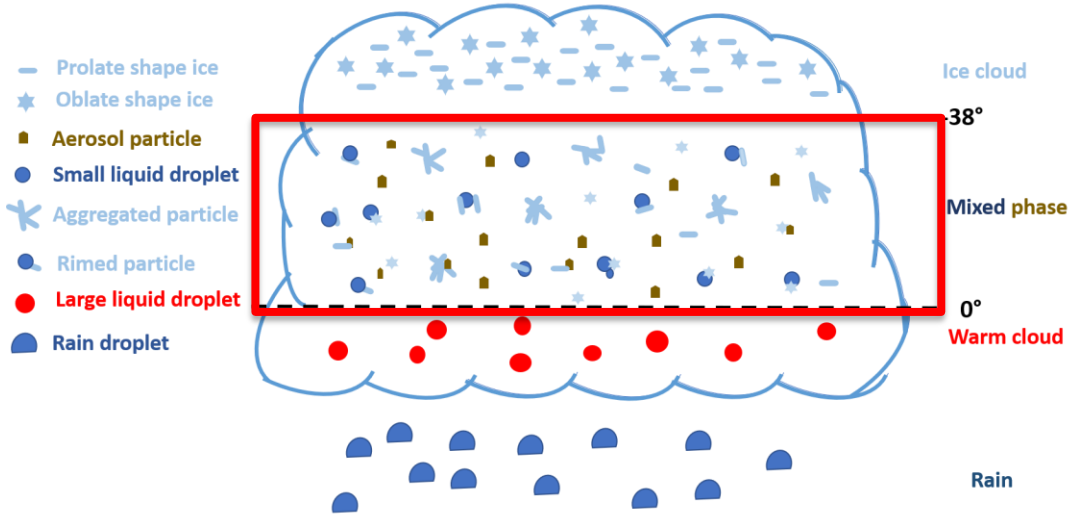
Motivation & Introduction

Hydrometeors types in cloud processes



Ice crystals:

- Originate under different ambient conditions (temperature, pressure).
- Evolution spans different environments causing more complex shapes.
- Remote sensing can provide information on shape and orientation (e.g., Myagkov et al., 2016a)

Our understanding of ice particle shape is not enough yet.

⇒ Extend main-peak approach developed by Myagkov et al. [2016a] toward detection of multiple shapes

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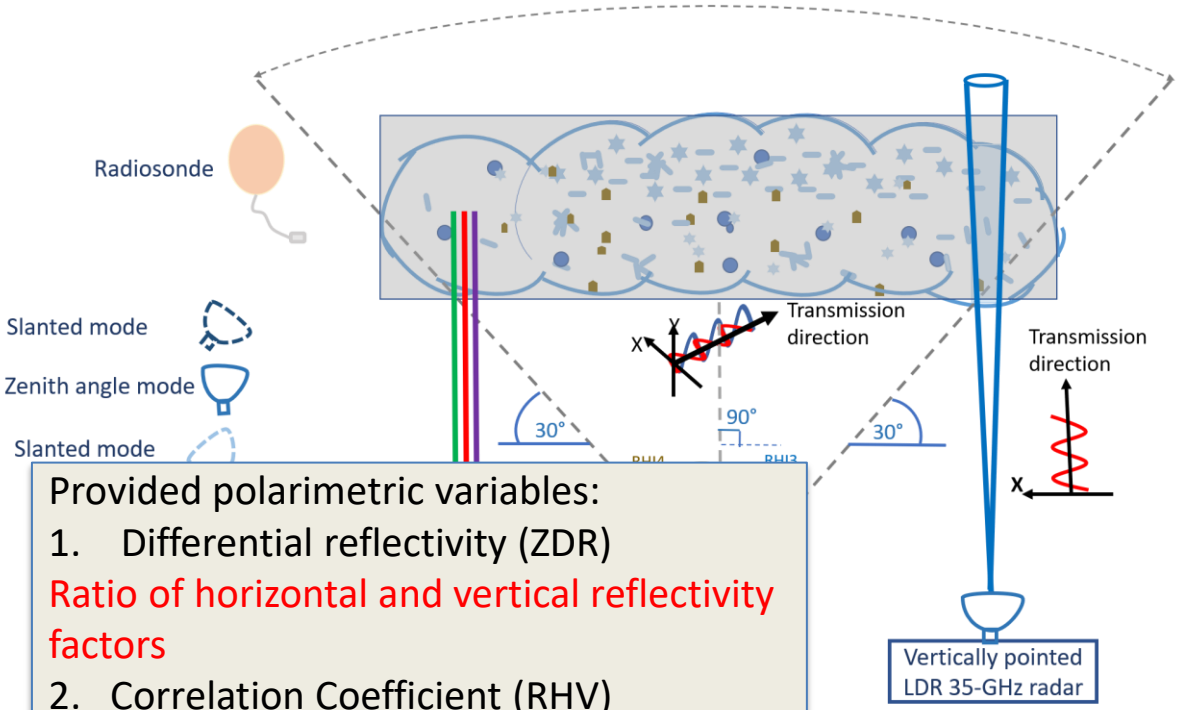
Analysis of the Composition of Clouds with Extended Polarization Techniques

Oct-Nov 2014, Cabauw, NL



Provided polarimetric variables:

1. Differential reflectivity (ZDR)

Ratio of horizontal and vertical reflectivity factors

2. Correlation Coefficient (RHV)

Measure of how similar the horizontally and vertically polarized signal components are behaving in a pulse volume

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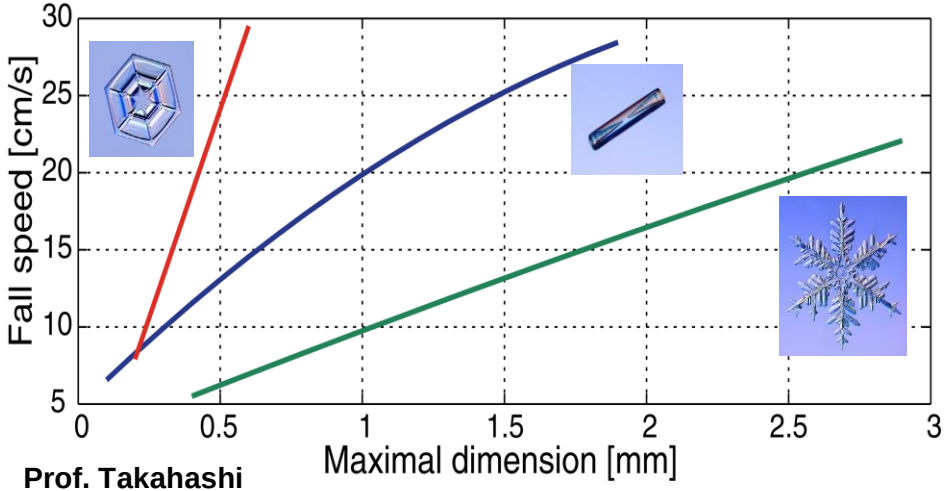
Basic idea for extension of the shape retrieval technique

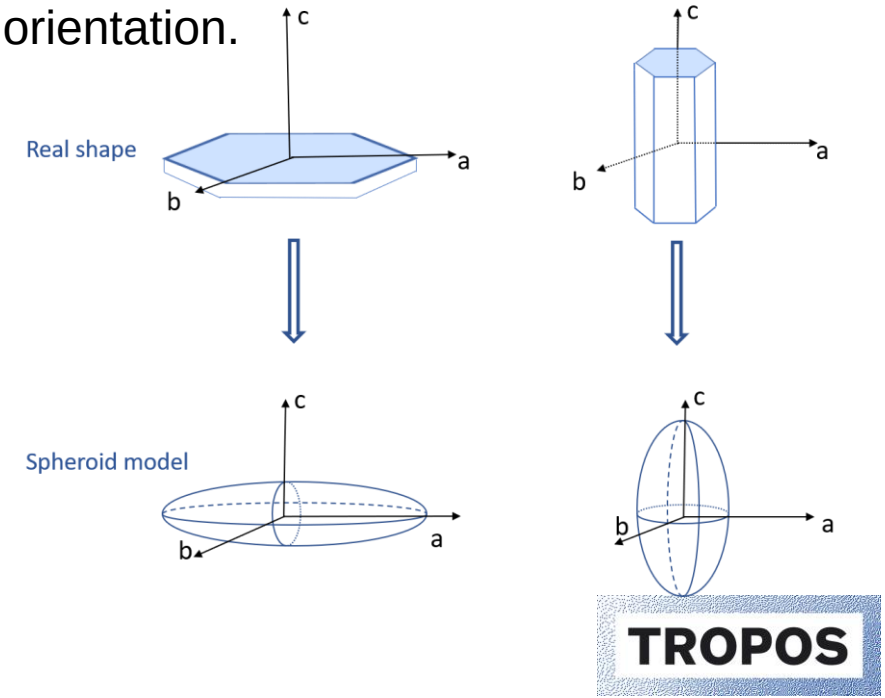
- Hydrometeor types have different fall speed.
- Received power of hydrometeor types depends on shape, size and concentration.

Size-fall-velocity relationships



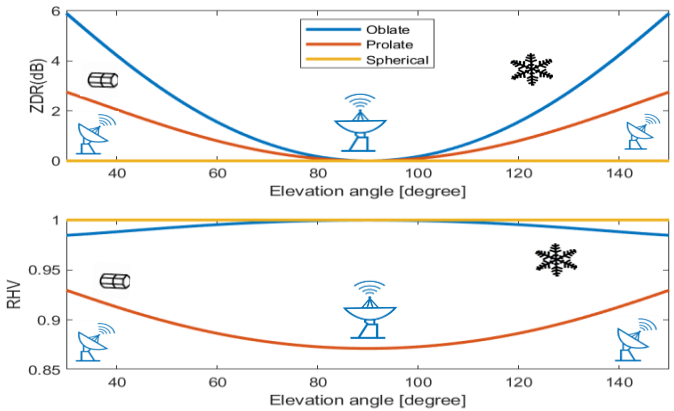
Prof. Takahashi

- Hydrometeors can be approximated by spheroids. Shape and orientation of these spheroids can be described with the so-called polarizability ratio and degree of orientation.

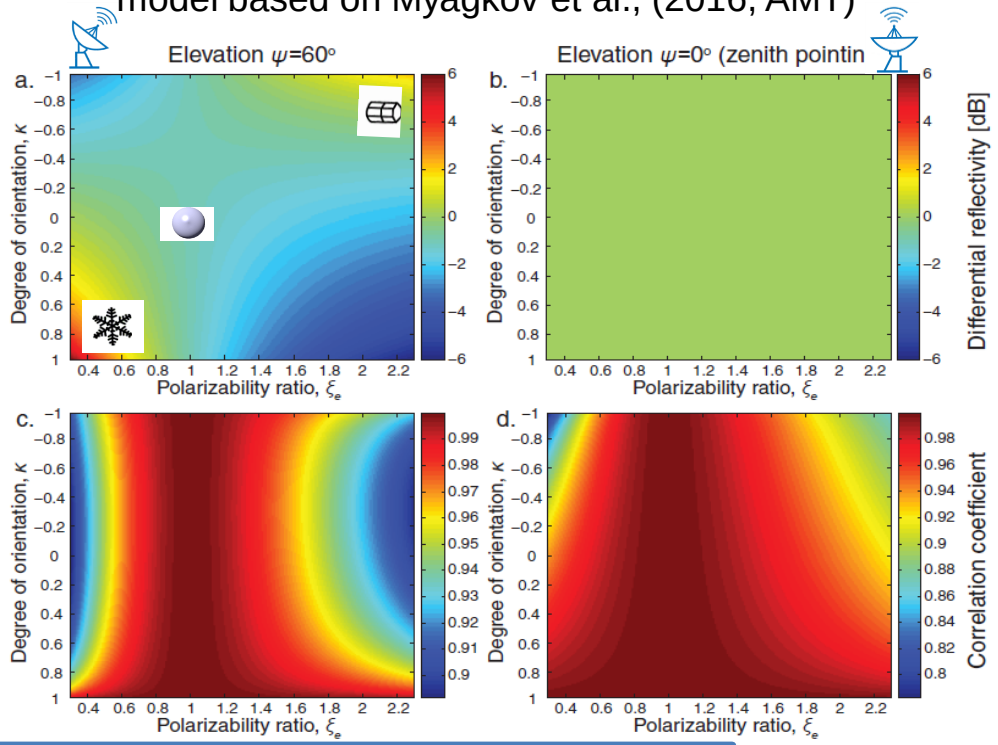


Modeling of ZDR and RHV as function of hydrometeor type and elevation angle

- ✓ Polarizabilty ratio: Density-weighted axis ratio varies in range [0.3, 2.3]
- ✓ Degree of orientation of symmetry axis: varies in range [-1, 1]



model based on Myagkov et al., (2016, AMT)



✓ Combined analysis of ZDR and RHV yields information on particle habits and orientation.

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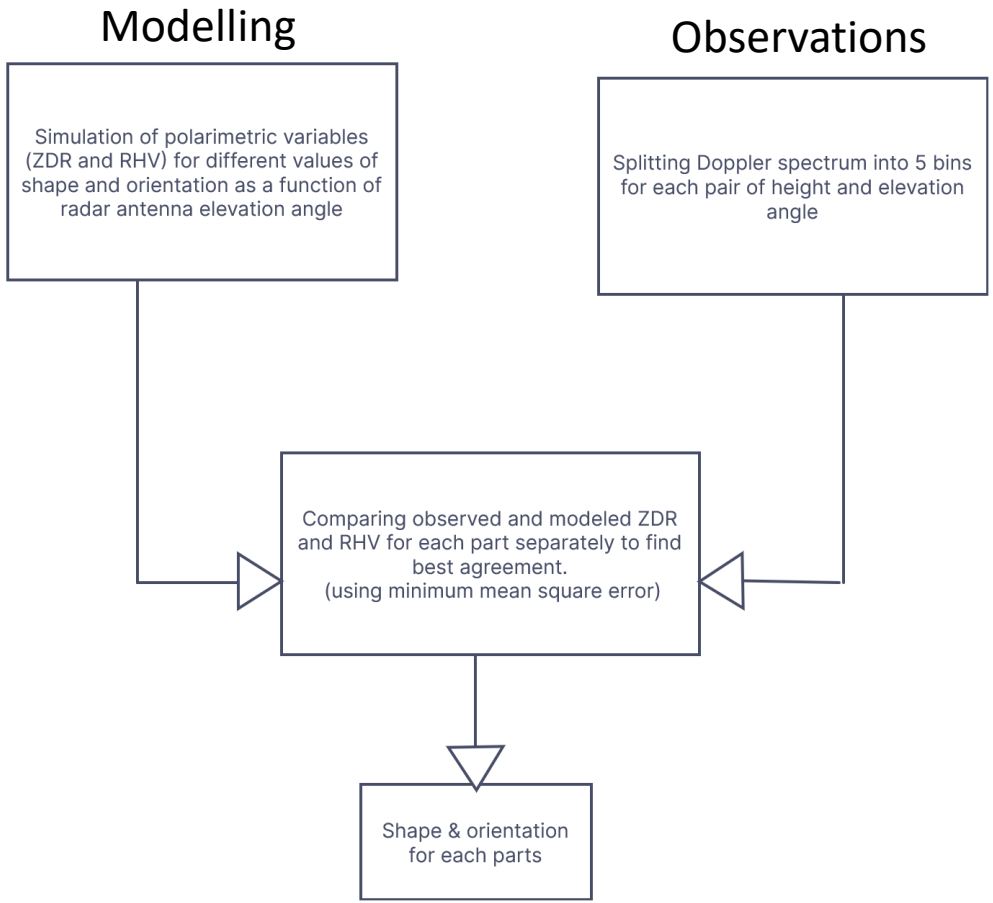
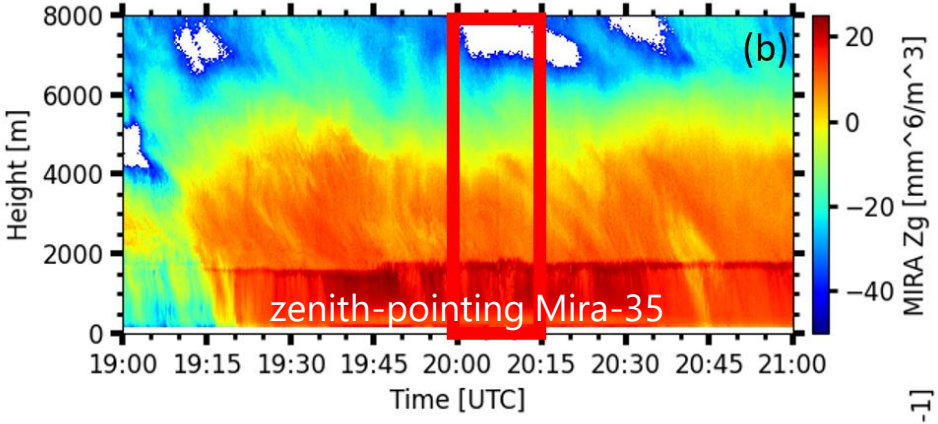
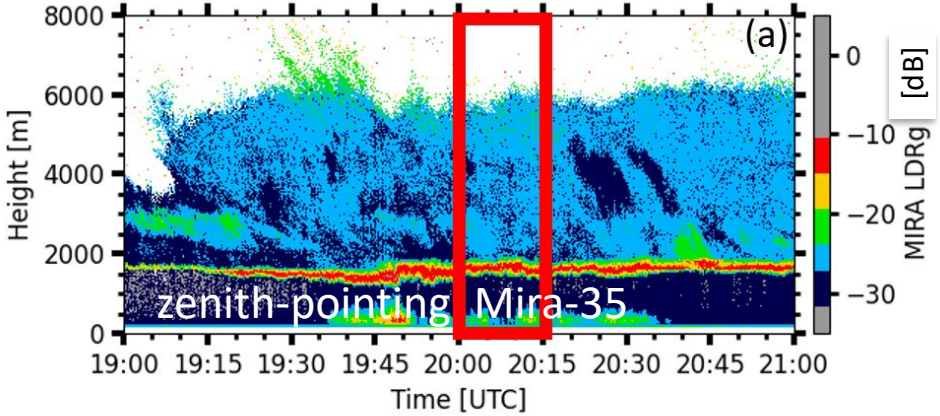
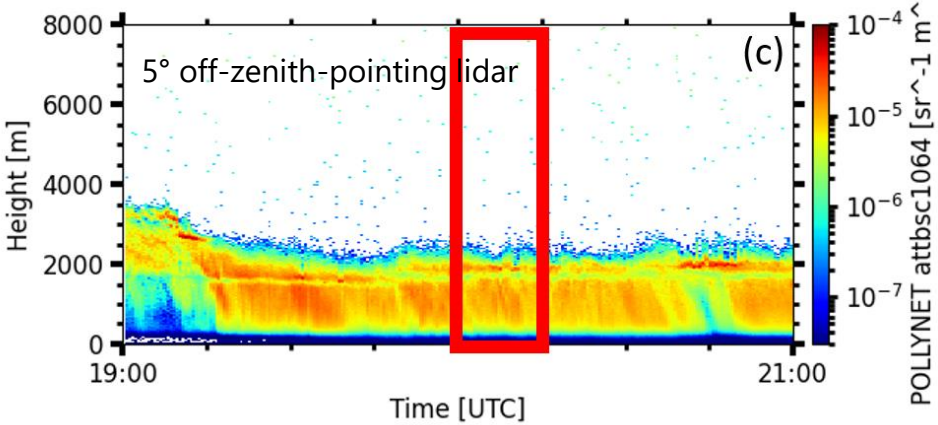
Spectrally resolved approach: Improvement of the main peak appraoch

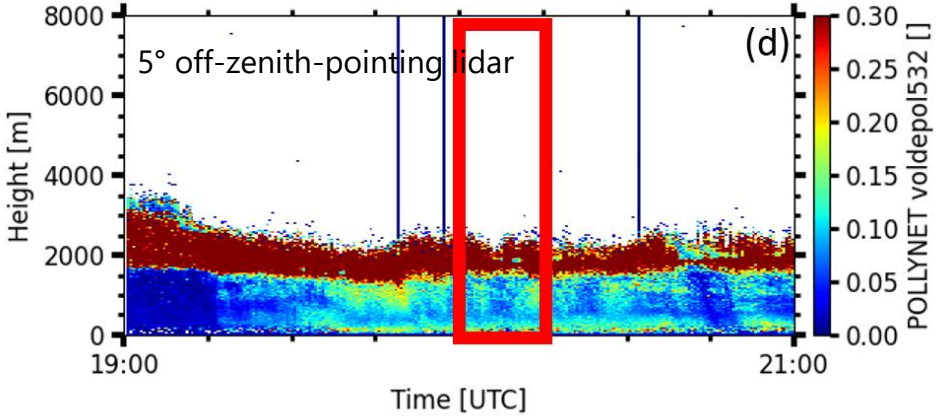


Case studie: 3 November 2014, 20:00-20:15 UTC, Cabauw, NL

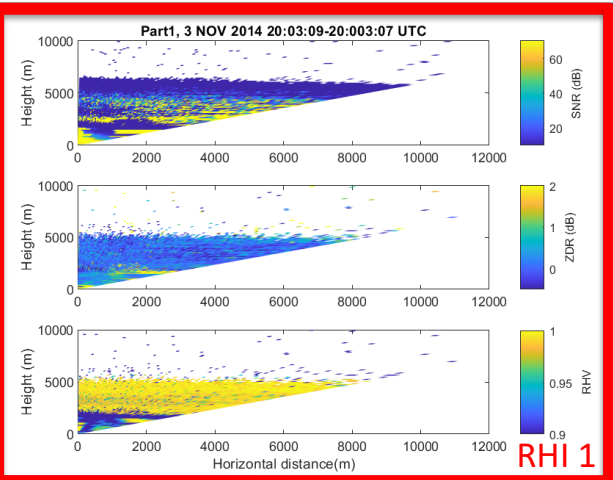




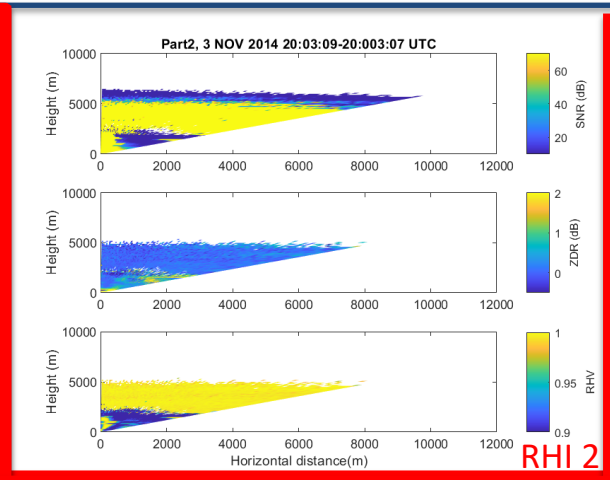




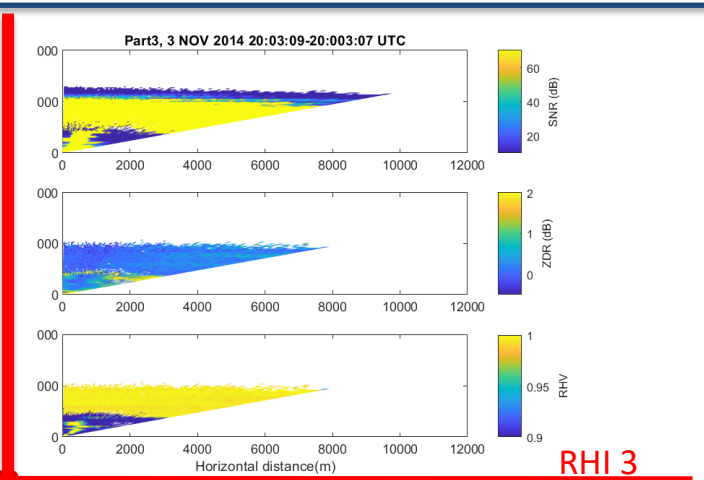
RHI plots of SNR, ZDR, and RHV for each of the 5 Doppler spectral parts



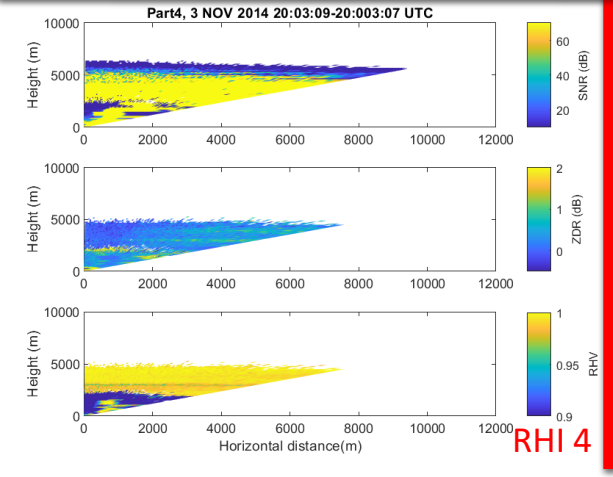
RHI 1



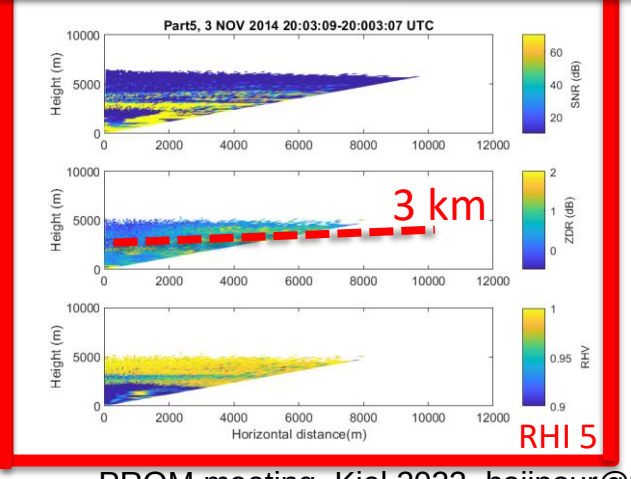
RHI 2



RHI 3



RHI 4



RHI 5

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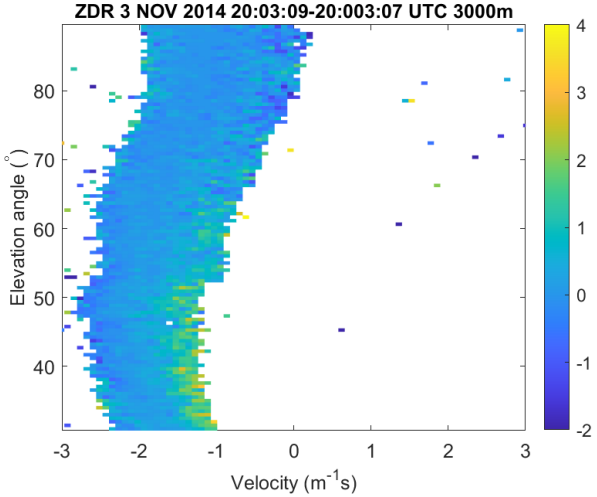
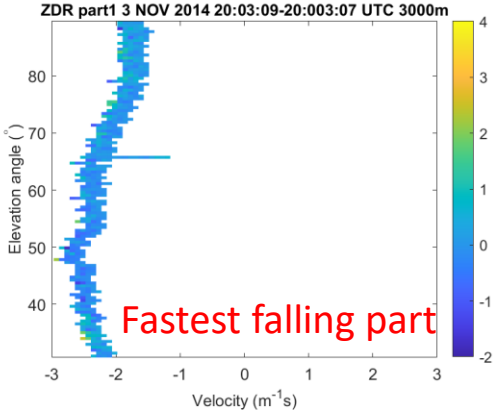
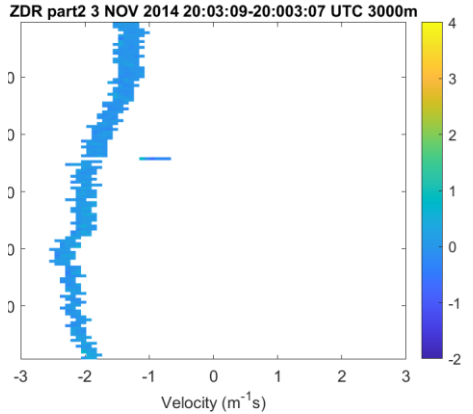
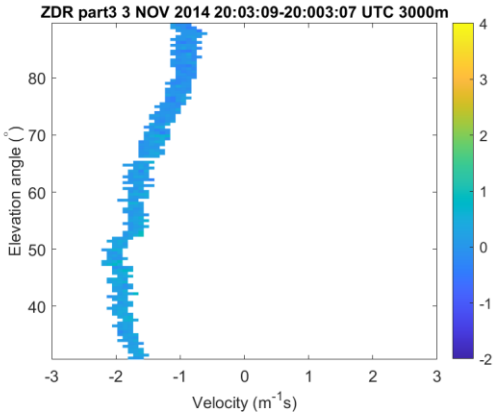
ZDR profile for all spectral parts at height = 3000m

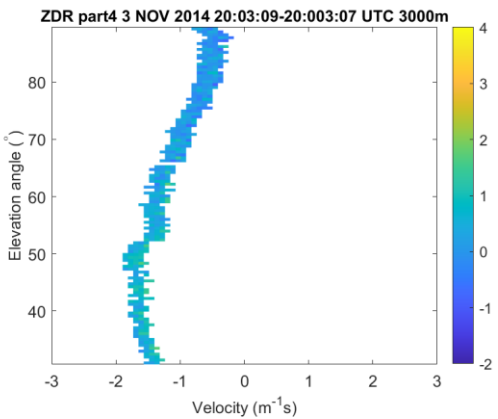


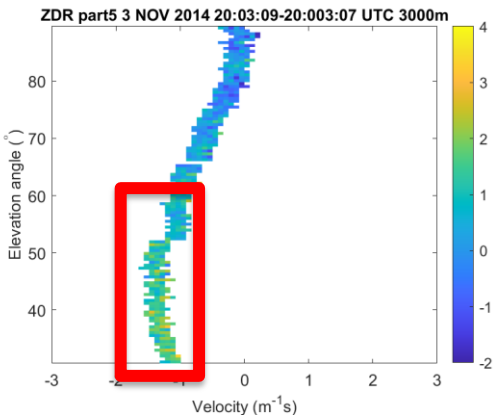
✓ vertical velocity corrected for effects of Doppler folding and angular effects





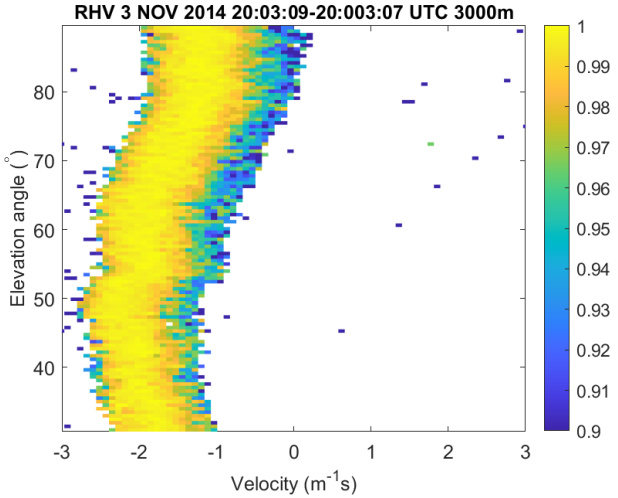


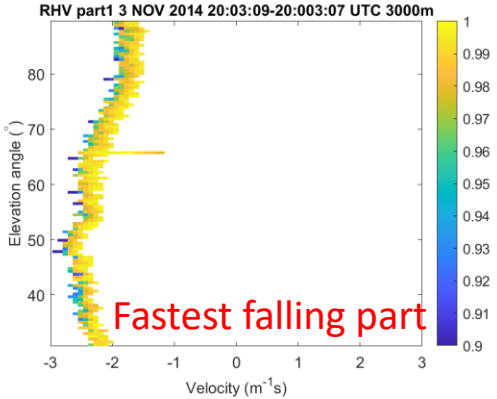




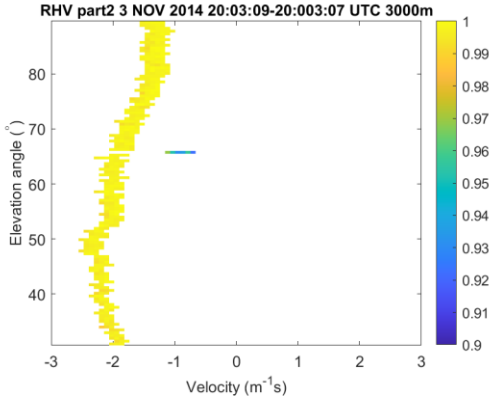
Slowest falling part

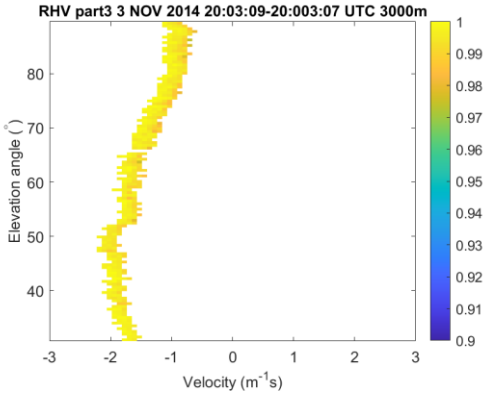
RHV profile for all spectral parts at height = 3000m

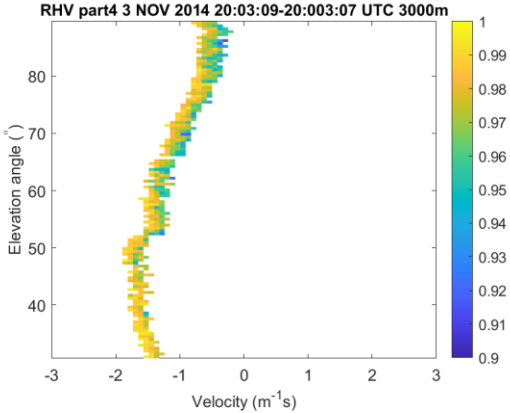


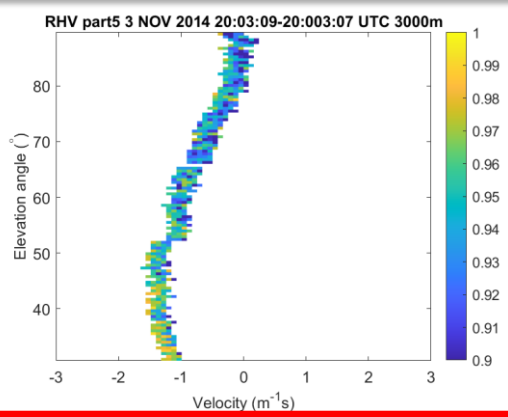


Fastest falling part



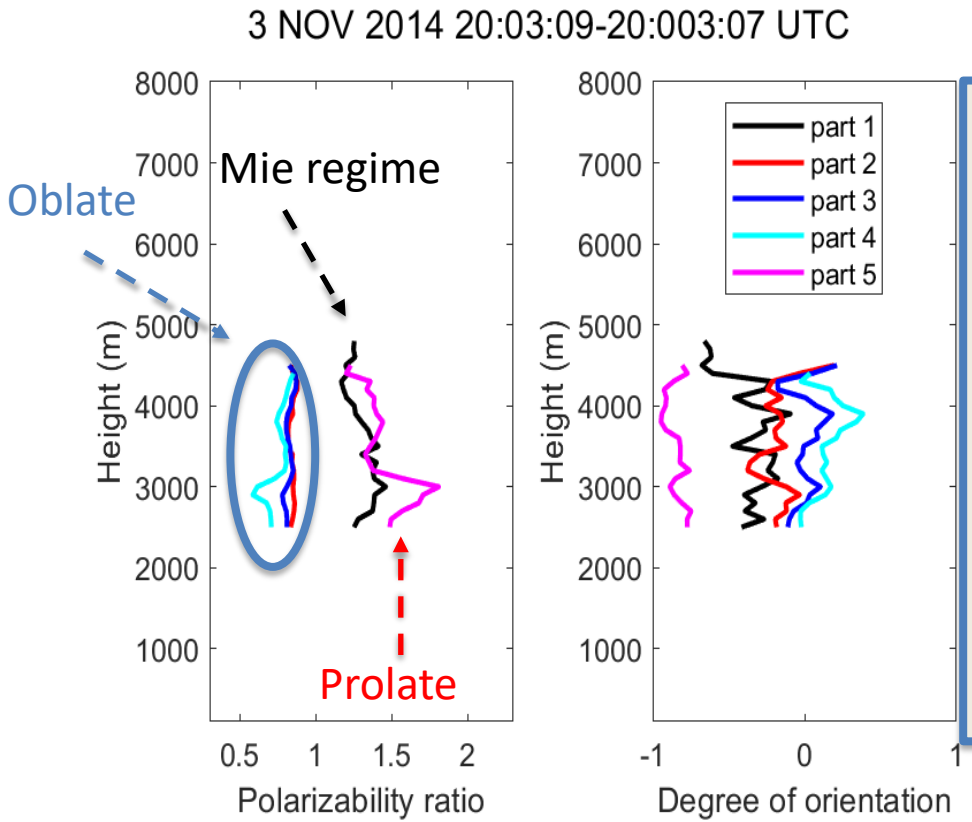






Slowest falling part

Shape retrieval results obtained bt spectrally resolved approach



- In cooperation with the German Weather Service (DWD) to implement spectrally resolved approach on C band radar to avoid Mie regime effect.

1. processing scheme is ready for the C-Band HDF datasets.
2. There are some undetermined issues with the spectral data in the DWD observations. (**planned to continue in future**)

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Summary & Conclusion

- Shape is one key parameter for identification of mixed-phase cloud processes.
- Hydrometeor shape can be observed by polarimetric cloud radar.
- Combined analysis of ZDR and RHV yields information on particle habits and orientation.
- Original main-peak approach can only retrieve one shape/orientation of the signal-dominating hydrometeor type. Sub-populations cannot be detected.
- Spectrally resolved approach:
  1: is able to retrieve multiple hydrometeor types in a cloud volume.
  2: allows to filter for Mie effects
  3: enables the identification of growth processes.

Thanks for your attention!

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