Investigating the contribution of polarimetry in retrieving ice microphysical properties using Dual-Wavelength radar observations

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Methodology

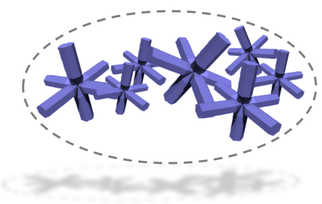
In this study the role and the evolution of ice crystals in the precipitation formation are extensively investigated using:

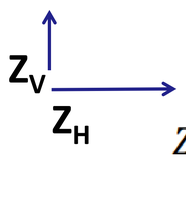
- Dual-Wavelength Ratio (DWR, [1]) measurements using two different radar bands with sensitivity for particle size.

$\lambda > D \rightarrow Z \sim D^6$

$\lambda \leq D \rightarrow Z \sim D^2$

- Polarimetric observations from two full polarimetric radars with sensitivity for particle shape.
  e.g. Differential Radar Reflectivity (Z_{DR})





ZDR>0

$$Z_{DR}[dB] = 10\log(\frac{Z_H}{Z_V})$$

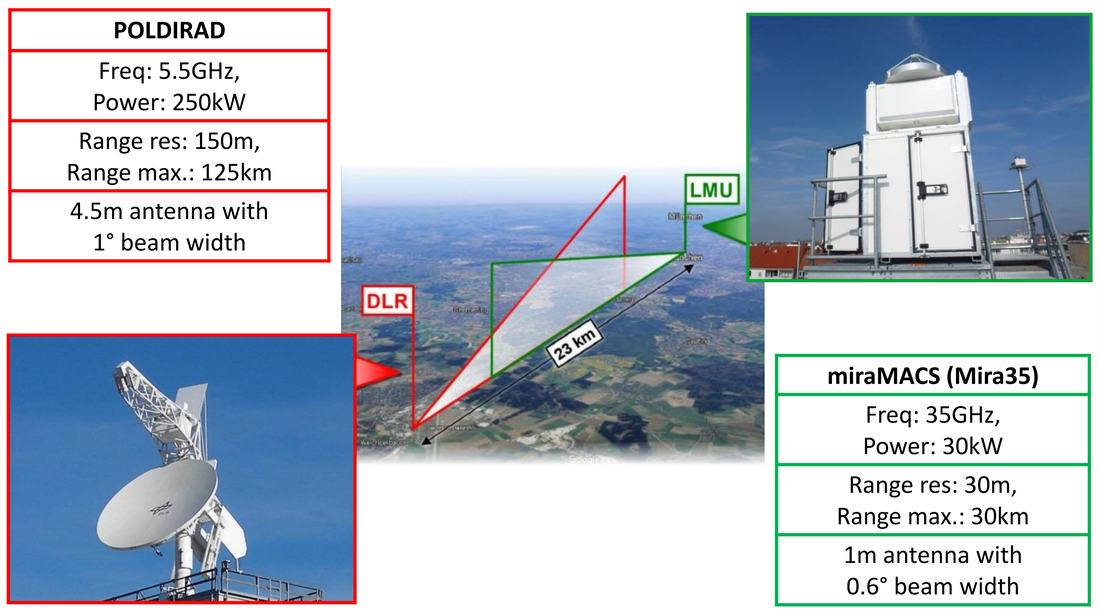
- Scattering simulations for a variety of ice particles shapes and sizes using the modified mass-size relation of Brown and Francis (1995) as presented in [2].

Microphysics retrievals for ice hydrometeors, e.g. characteristic size, shape, Ice Water Content (IWC), during snow events over Munich domain in January 2019.

Instrumentation

IcePolCKa (Investigation of the initiation of Convection and the Evolution of Precipitation using simulatiOns and poLarimetric radar observations at C- and Ka-band) project exploits the synergy of two different radars. The C-band POLDIRAD weather radar from the German Aerospace Center (DLR) in Oberpfaffenhofen and the Ka-band MIRA-35 cloud radar from the Ludwig Maximilian University of Munich (LMU).

POLDIRAD
Freq: 5.5GHz, Power: 250kW
Range res: 150m, Range max.: 125km
4.5m antenna with 1° beam width



miraMACS (Mira35)
Freq: 35GHz, Power: 30kW
Range res: 30m, Range max.: 30km
1m antenna with 0.6° beam width

Fig.1: IcePolCKa instruments and characteristics.

Dual-Wavelength and Polarimetry measurements

Case study from RHI scans on 09.01.2019 during a snowfall event over Munich.

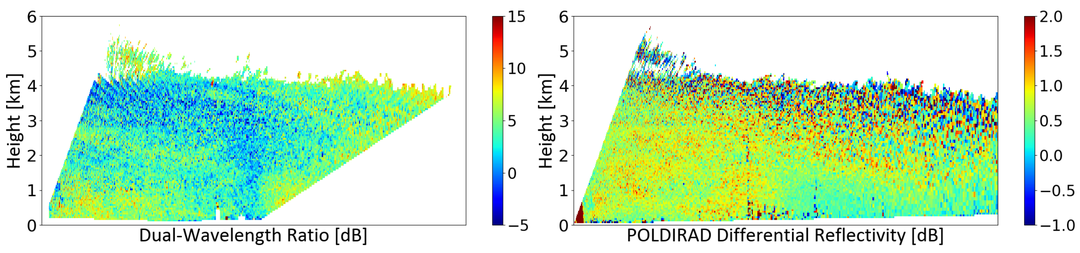


Fig.2: DWR is calculated using the logarithmic difference of radar reflectivities. Polarimetric variables, e.g. ZDR from POLDIRAD will contribute to retrieve ice microphysics information. Both variables refer to RHI scans on 09.01.2019 at 11:18 UTC.

Higher values of DWR below 2km indicate the presence of larger ice particles while smaller particles were detected above that height. The larger particles were found to be more spherical as ZDR values are close to 0.

The detected smaller particles above 2km were more aspherical as the CFAD of ZDR is broader.

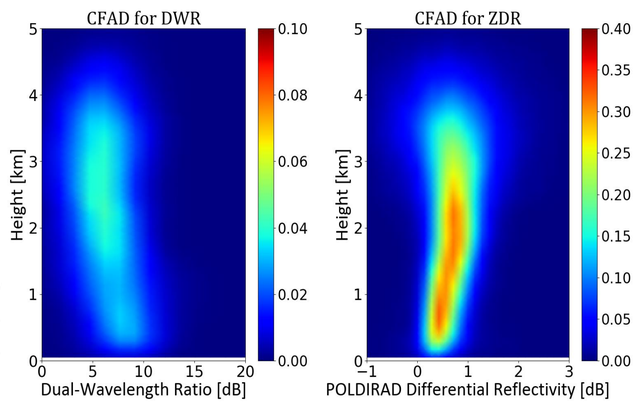


Fig.3: DWR and ZDR Contoured Frequency by Altitude Diagrams (CFAD) for 09.01.2019 (whole measurement day).

Ice Water Content, Shape and Size retrievals

Scattering properties for ice particles were calculated using PyTmatrix [3] varying the Median Volume Diameter (MVD), the shape parameter of the Gamma Size Distribution and the Ice Water Content (IWC).

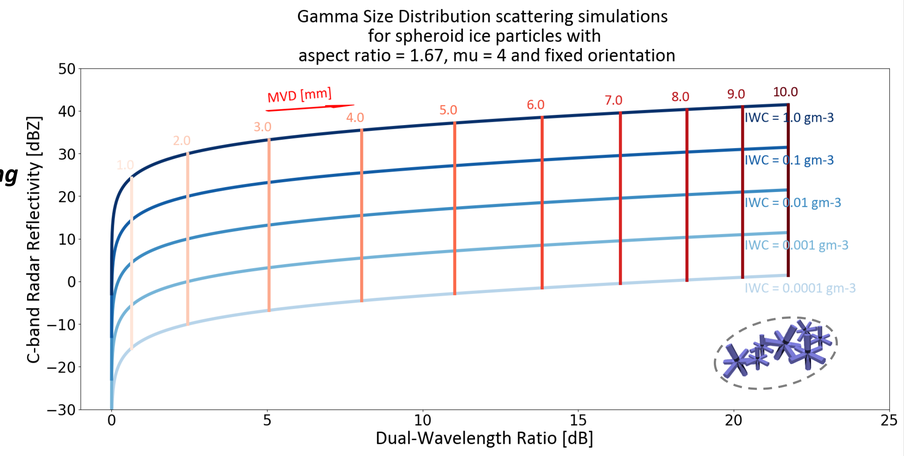


Fig.4: Scattering simulations for horizontally aligned oblate spheroid ice particles

Conclusion

- For the used mass-size relationship, simulations showed largest sensitivity to IWC, MVD and Aspect Ratio.
- 3 measurements (Z_{Ka}, Z_C, Z_{DR}) will be used to retrieve 3 variables, i.e. IWC, MVD and Aspect Ratio, of ice particles.
- All calculations are saved in Look-Up Tables (LUTs) for upcoming retrievals.

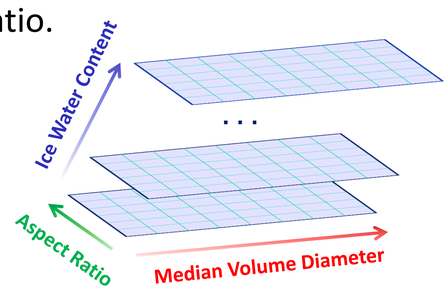


Fig.5: Current structure of the IcePolCKa LUTs.

References

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[2] Hogan, R.J., L. Tian, P.R. Brown, C.D. Westbrook, A.J. Heymsfield, and J.D. Eastment, 2012: Radar Scattering from Ice Aggregates Using the Horizontally Aligned Oblate Spheroid Approximation. J. Appl. Meteor. Climatol., 51, 655–671

[3] Jussi Leinonen, "High-level interface to T-matrix scattering calculations: architecture, capabilities and limitations," Opt. Express 22, 1655-1660 (2014)

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