Cloud radar spectral polarimetry for atmospheric research

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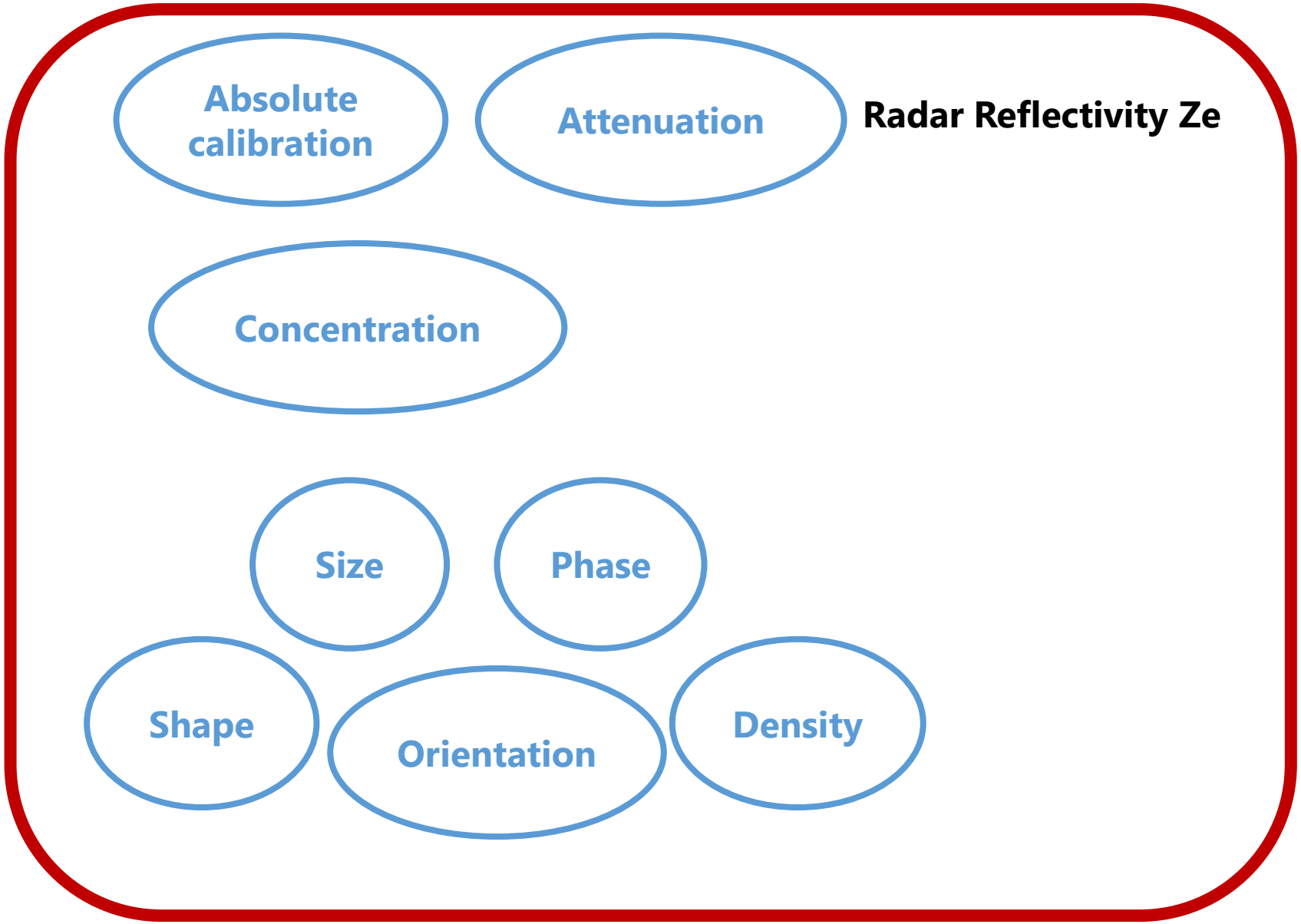
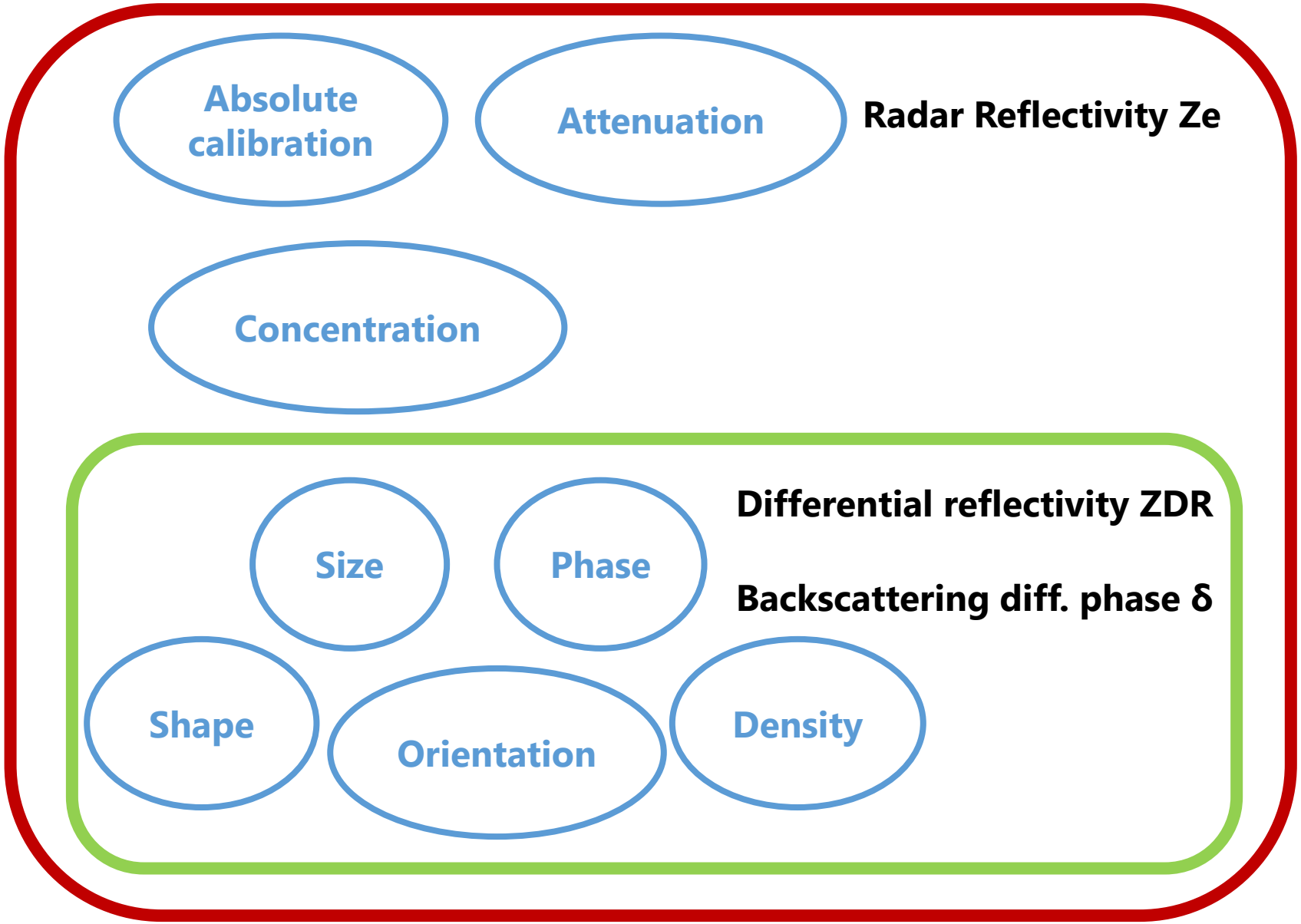
Weather radar (cm-wavelength) polarimetry



How much power scattered back

Weather radar (cm-wavelength) polarimetry

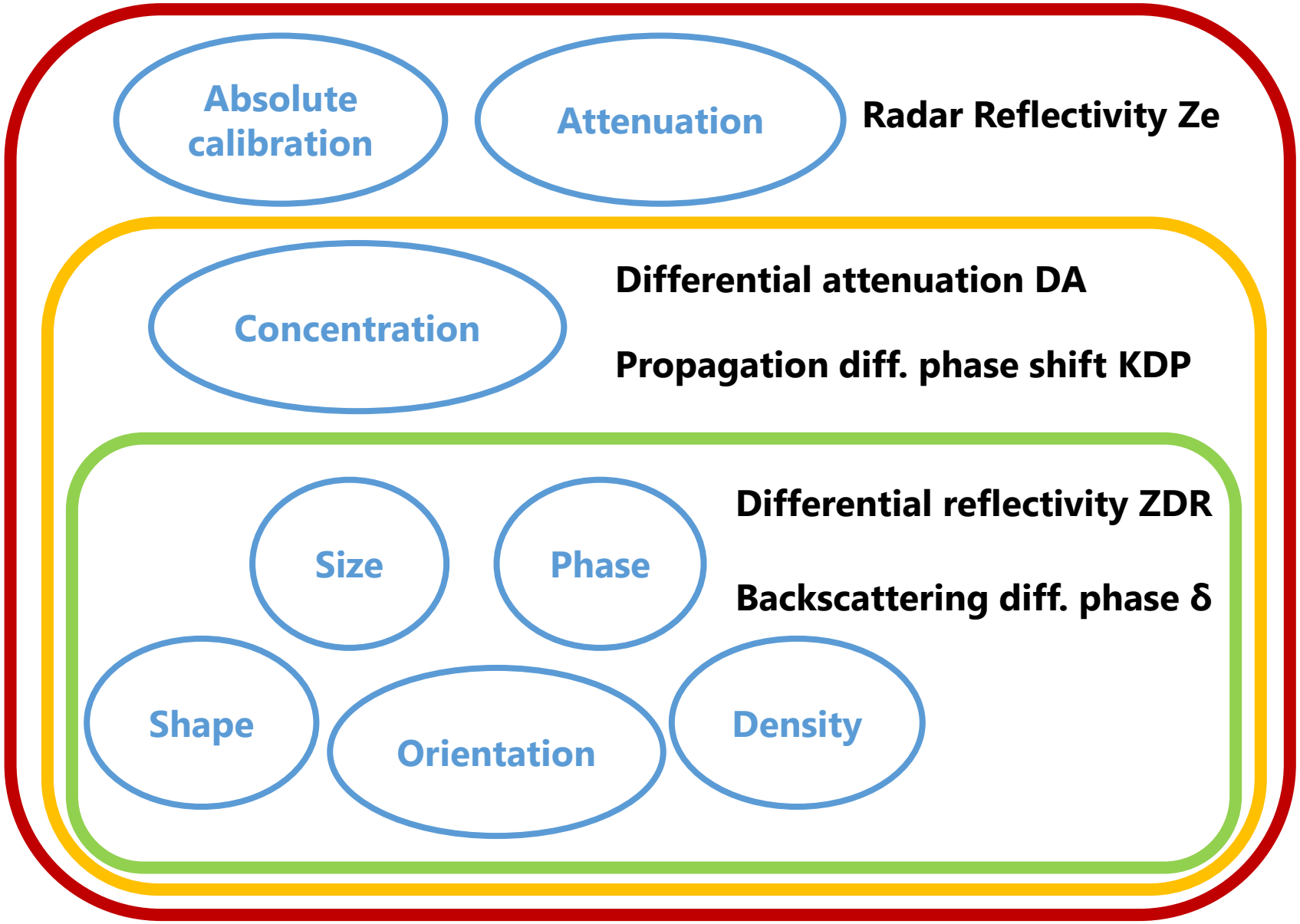


How much power scattered back

Scattering is more efficient at one polarization

Scattering 'center' is closer at one polarization

Weather radar (cm-wavelength) polarimetry



How much power scattered back

One polarization is attenuated more

One polarization propagates faster

Scattering is more efficient at one polarization

Scattering 'center' is closer at one polarization

Variables sensitive to different properties

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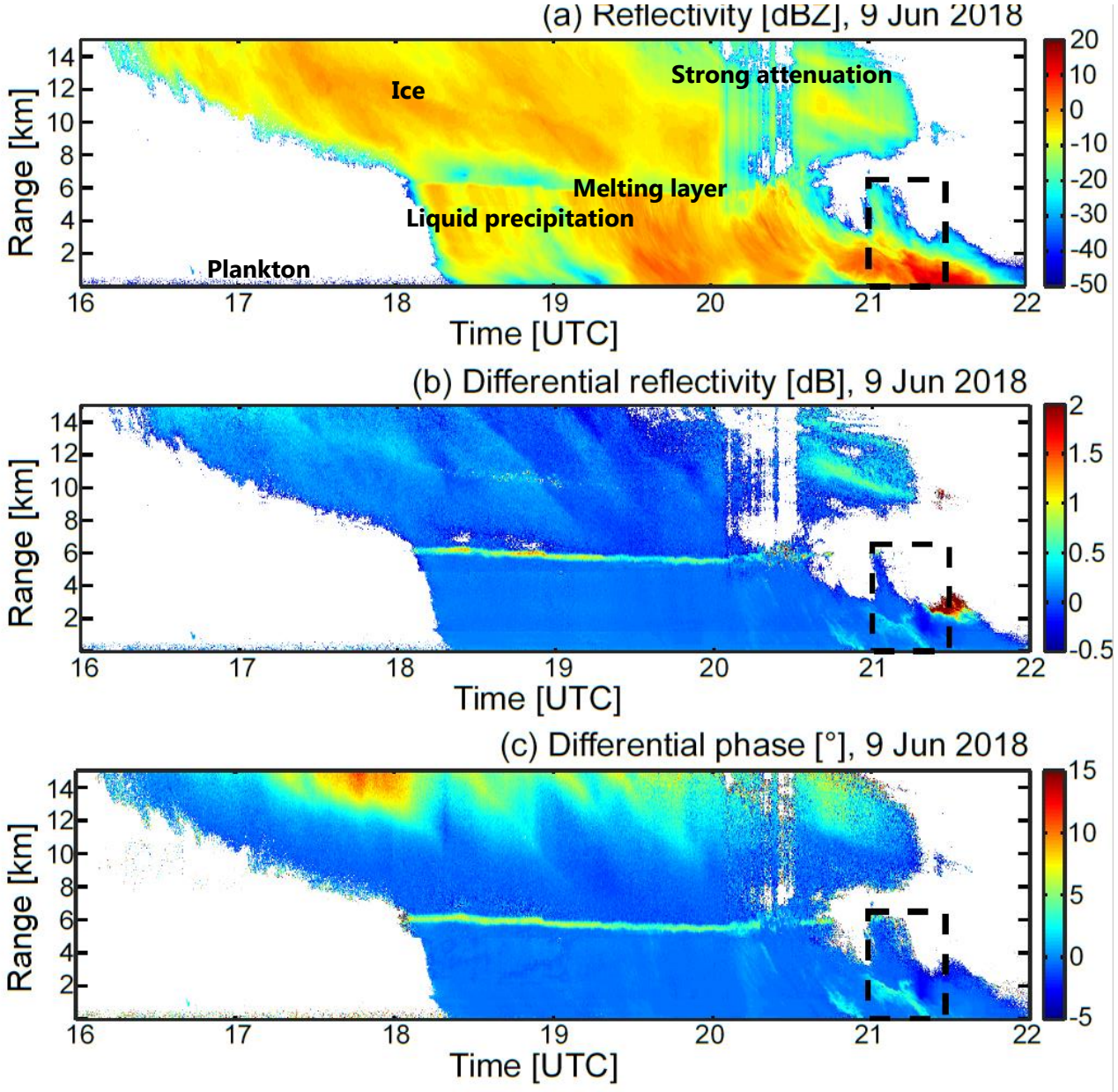
A set used for classification and quantitative estimates

See Kumjian 2013, J. Operational Meteor. For more details

Cloud radar (mm-wavelength) polarimetry

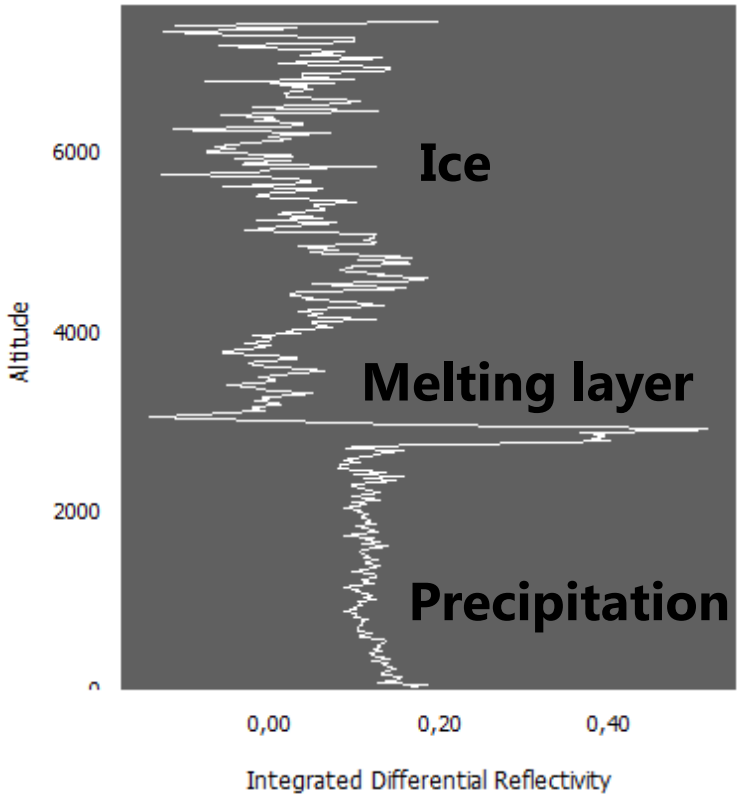


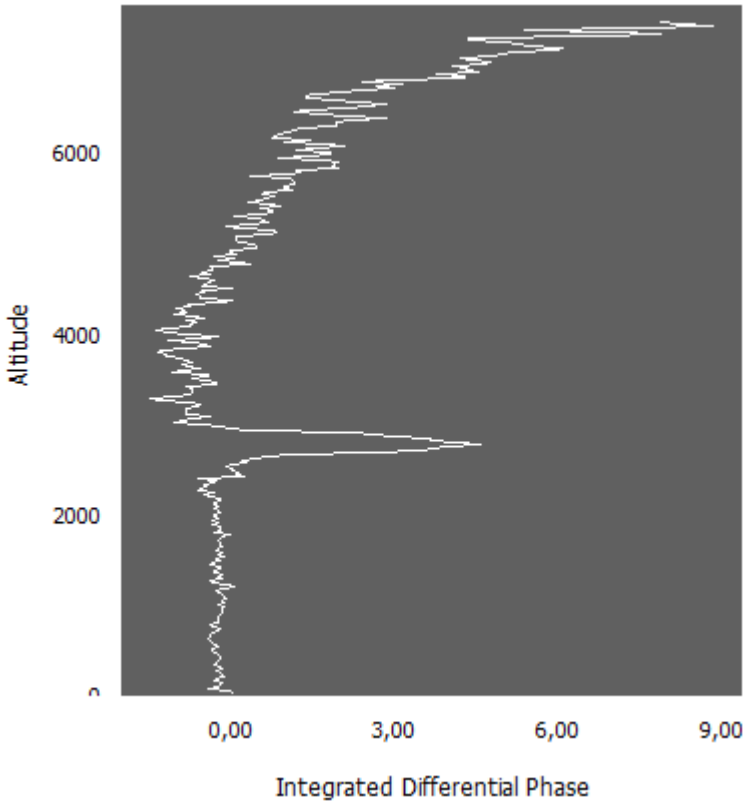
Observations at 30˚ elevation

- 94 GHz scanning radar
- STSR mode (Myagkov et al 2016, AMT)
- Rain event with intensity up to 15 mm/hr
- Backscattering signatures in melting layer
- ZDR in rain <0.2 dB
- PHI in rain up to 3 deg
- KDP signatures in ice area

Rain

Cloud radar (mm-wavelength) polarimetry



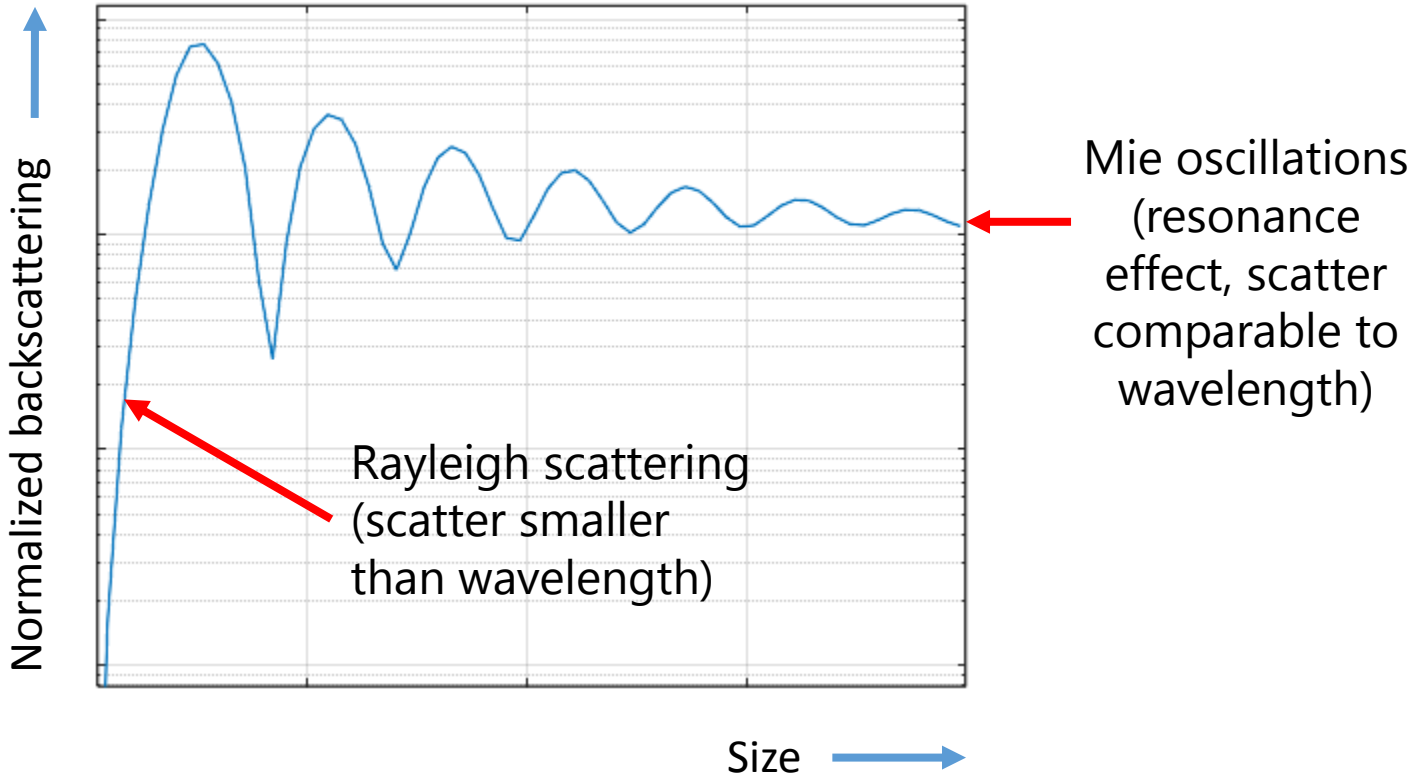


Observations at 30˚ elevation

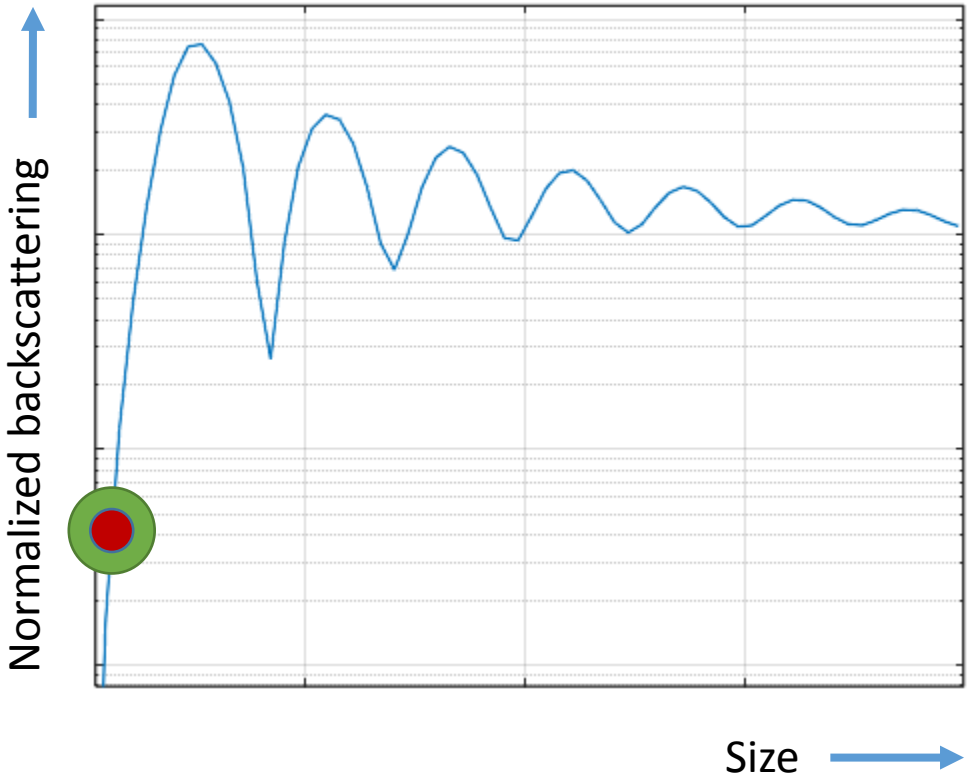
No signatures in integrated polarimetric variables in rain

Are polarimetric observations at 94 GHz in rain useless?

Water particle cross-section at millimeter wavelength



Water particle cross-section at millimeter wavelength



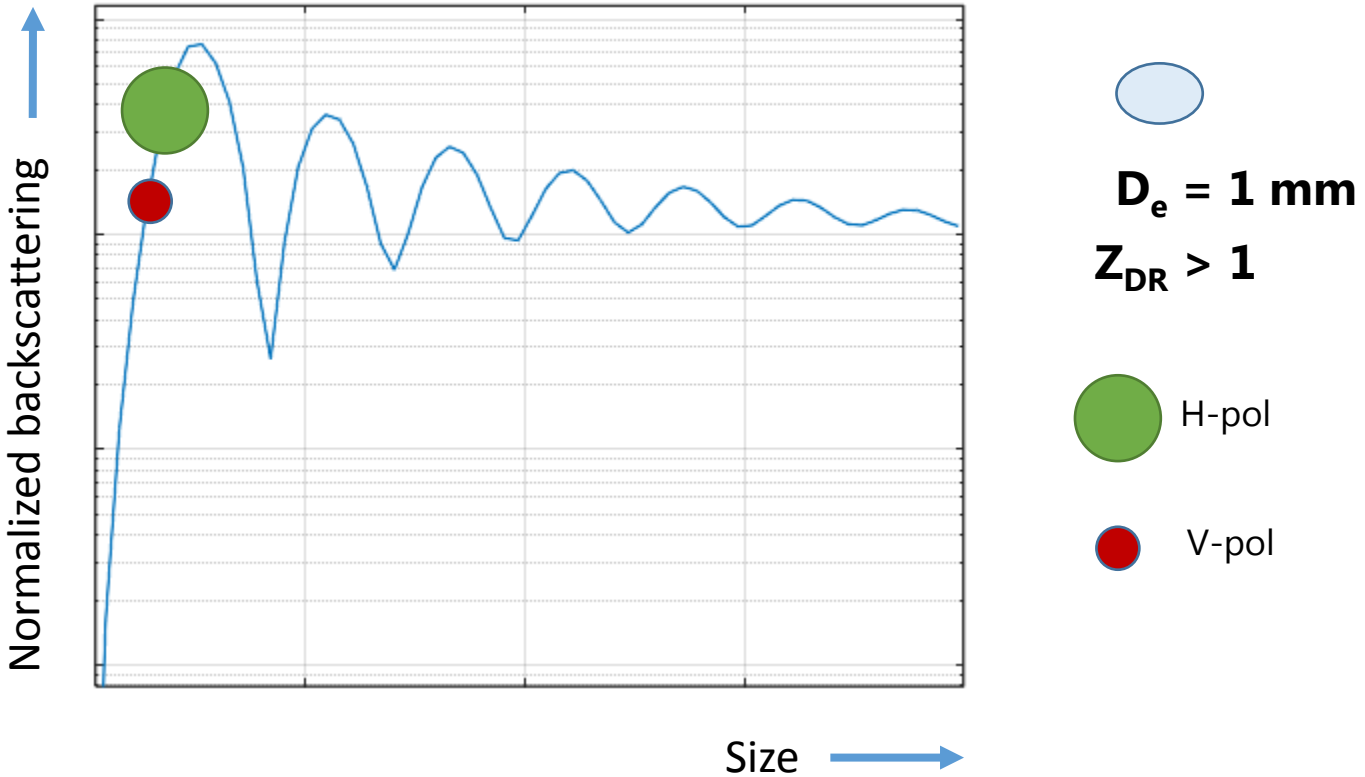
D_e = 0.2 mm

Z_{DR} ~ 1

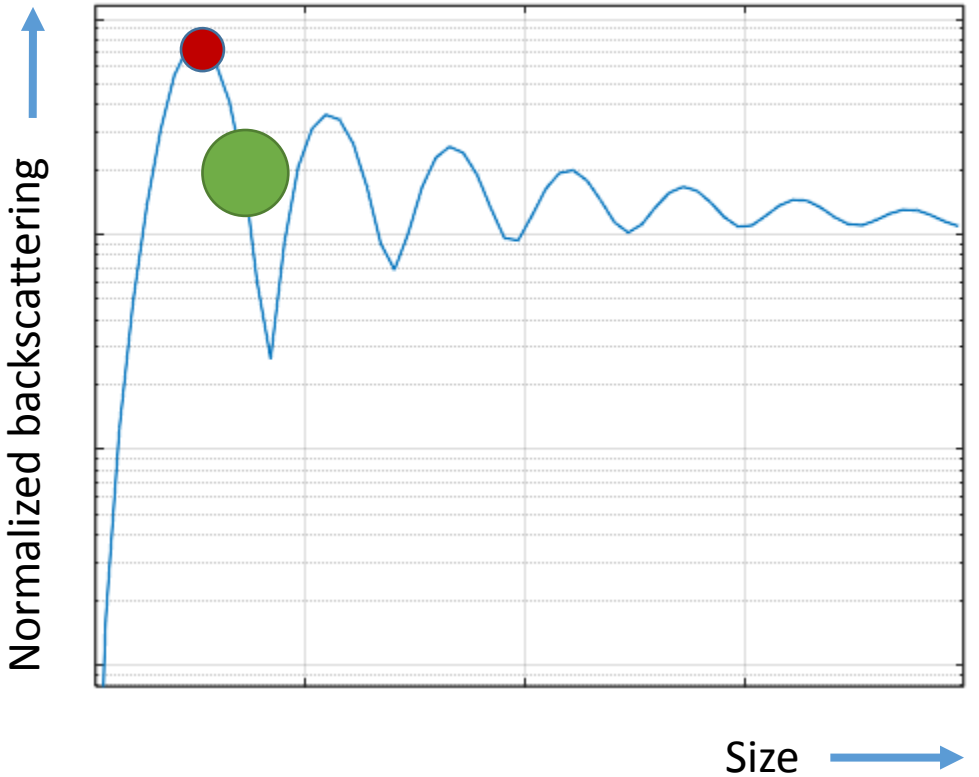
V-pol

H-pol

Water particle cross-section at millimeter wavelength



Water particle cross-section at millimeter wavelength



D_e = 1.8 mm

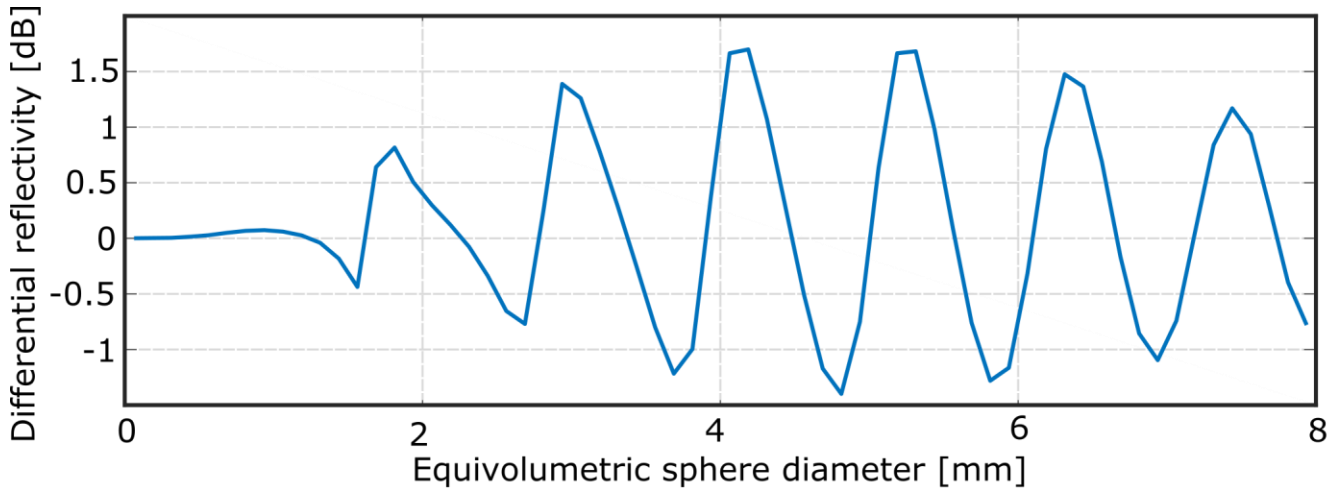
Z_{DR} < 1

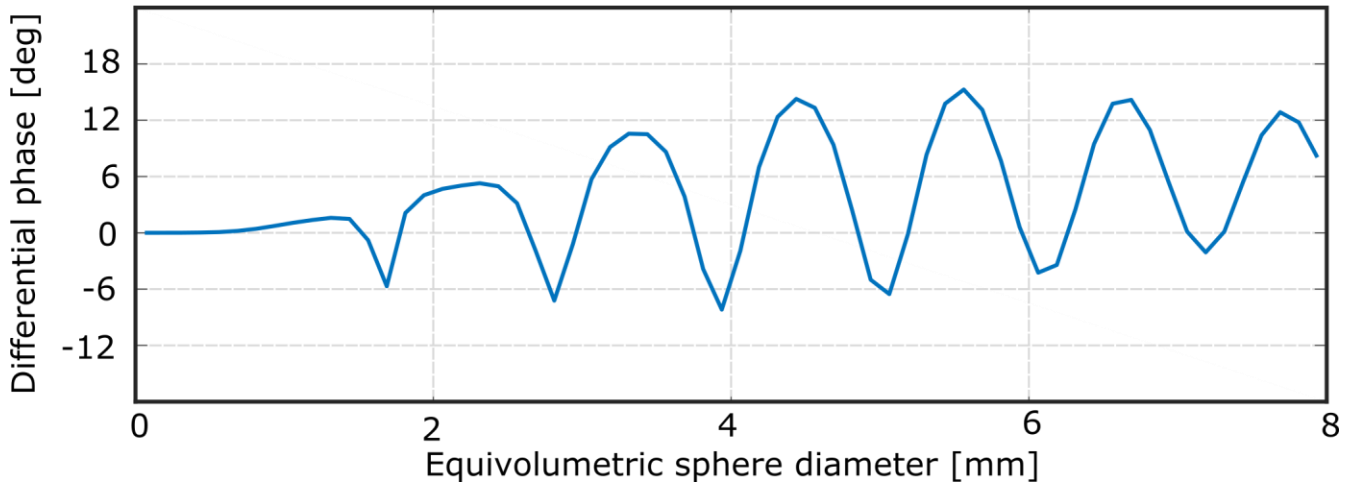
H-pol

V-pol

Polarimetric "oscillations"

Polarimetric oscillations for a water spheroid





Can we observe this oscillatory behavior in drop scattering?

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Known size-terminal velocity relations

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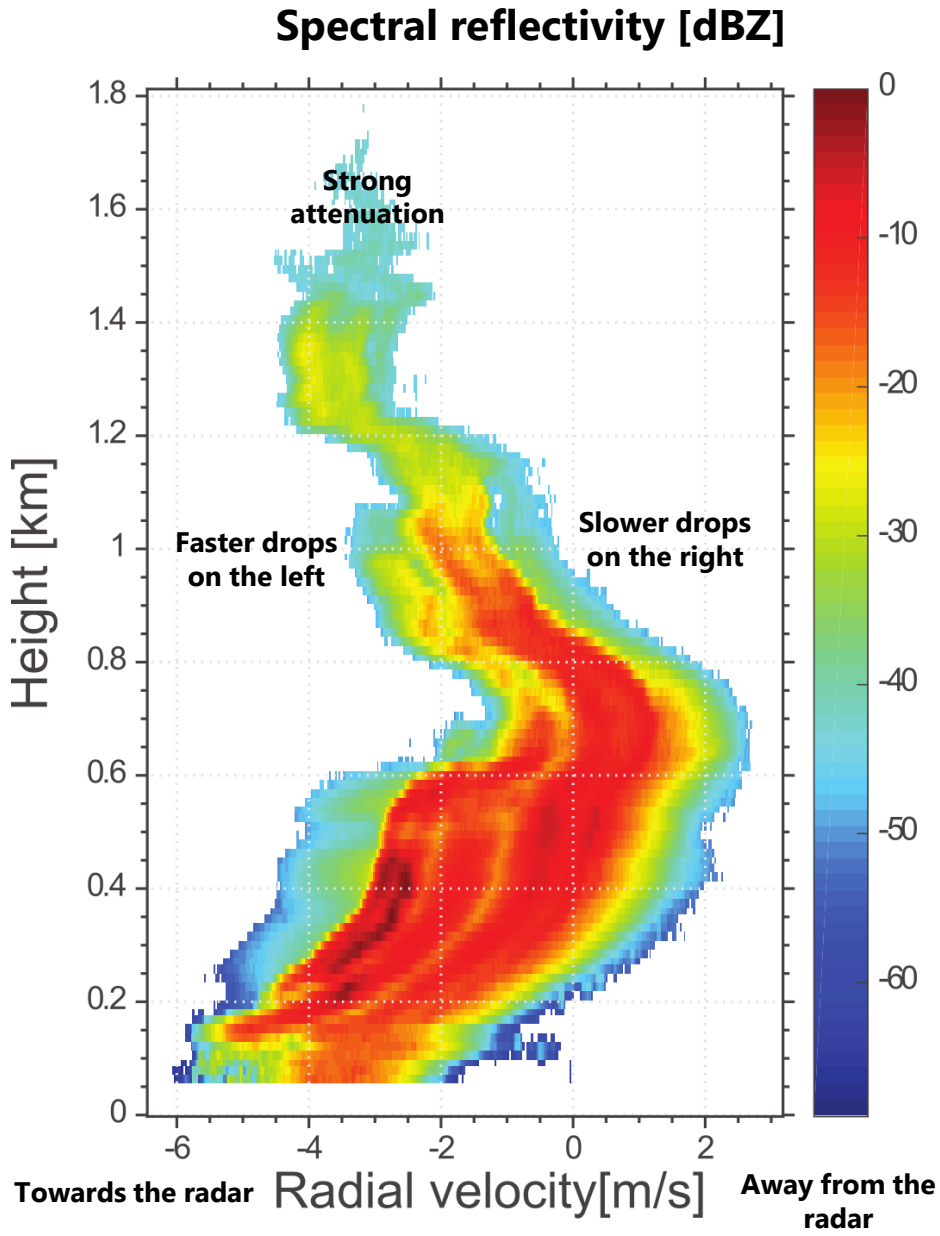
Spectral polarimetry

Case study, 9 June 2018, 21:20 UTC

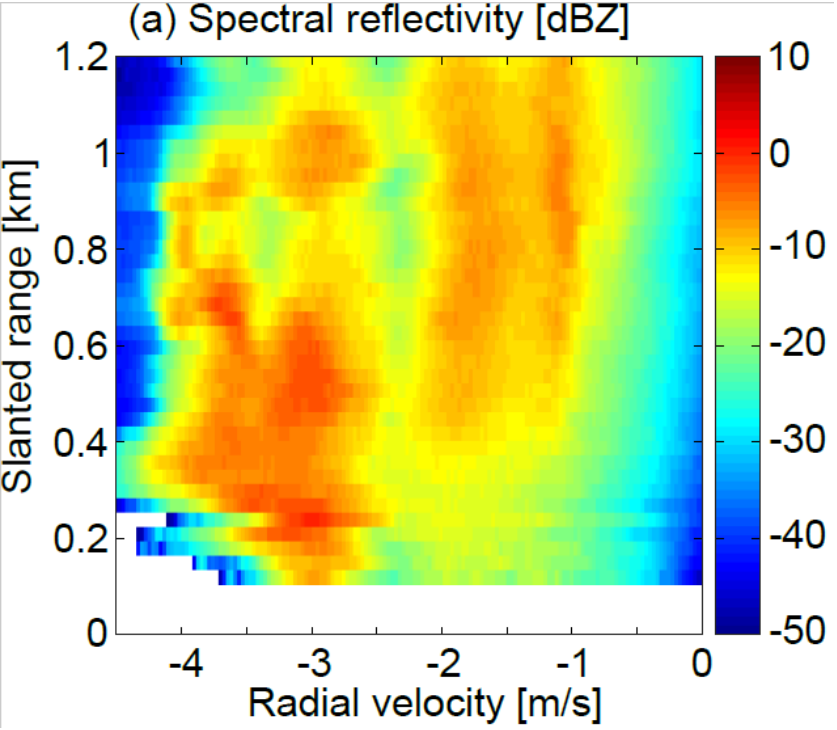


Observations at 30˚ elevation

- Observations at low elevation angles are strongly influenced by air motions

Case study, 9 June 2018, 21:20 UTC

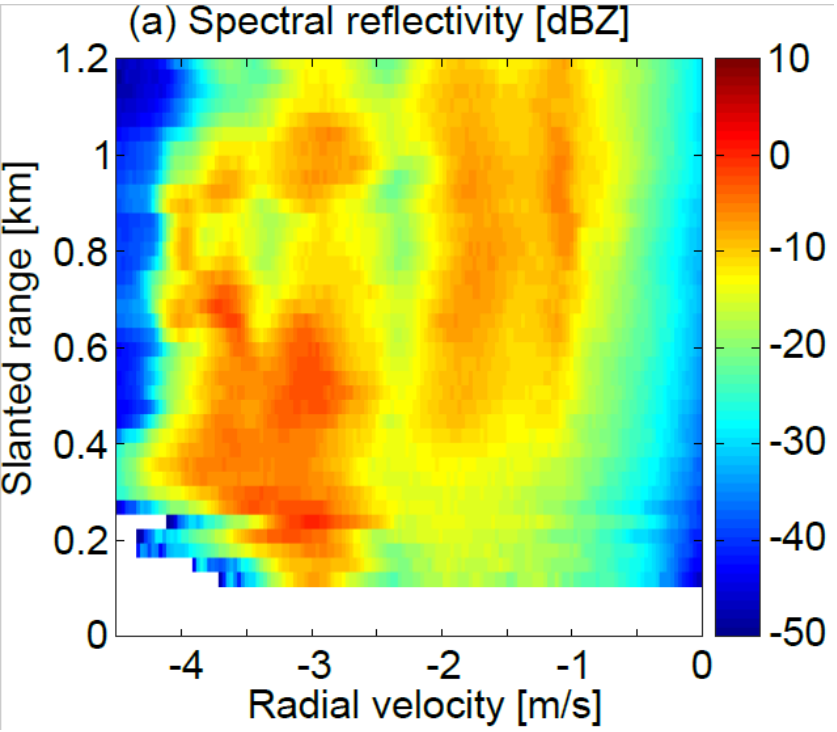
Rough mitigation of wind effects

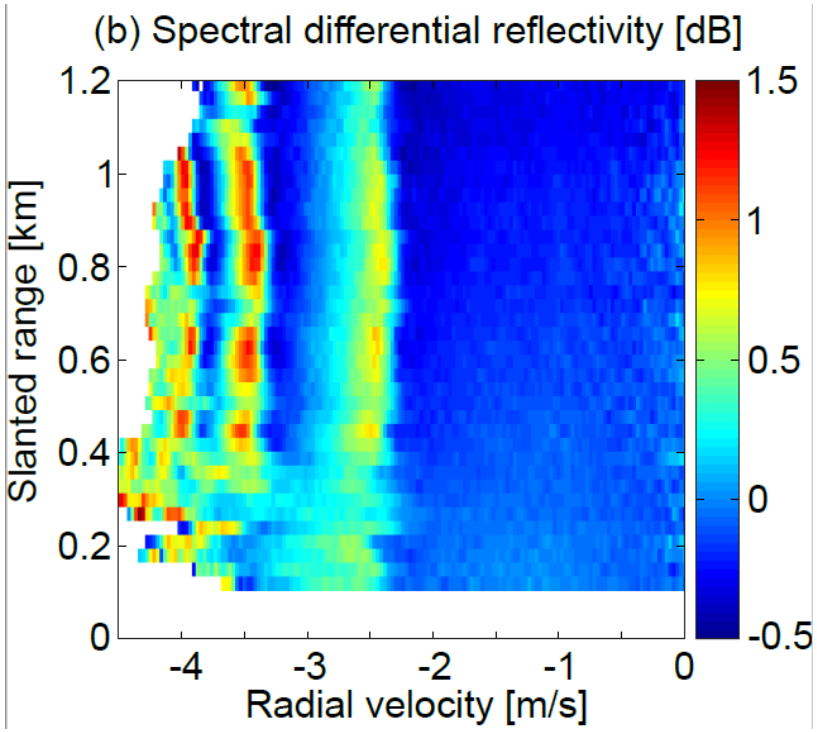


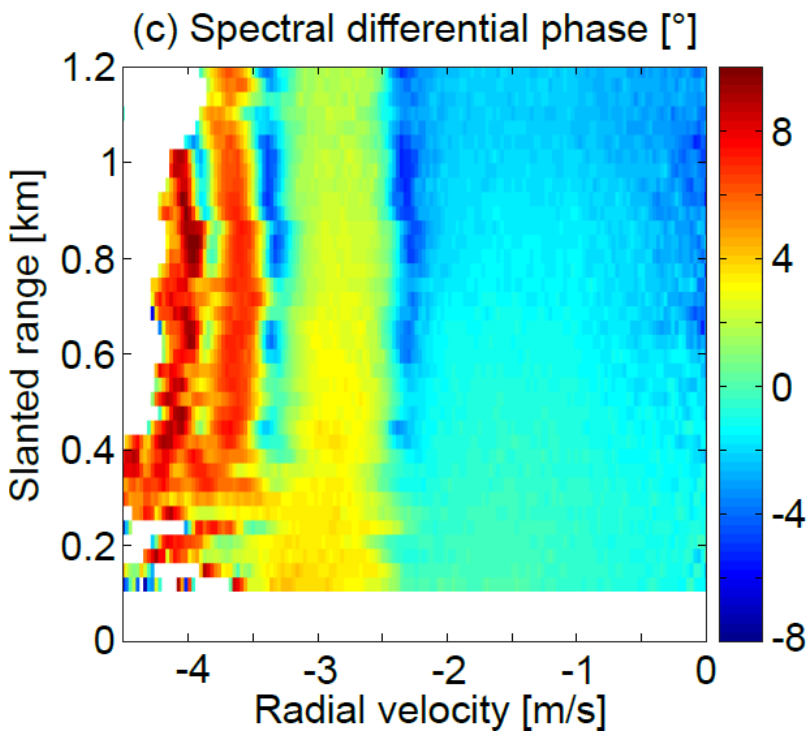
Observations at
30˚ elevation

Case study, 9 June 2018, 21:20 UTC

Rough mitigation of wind effects



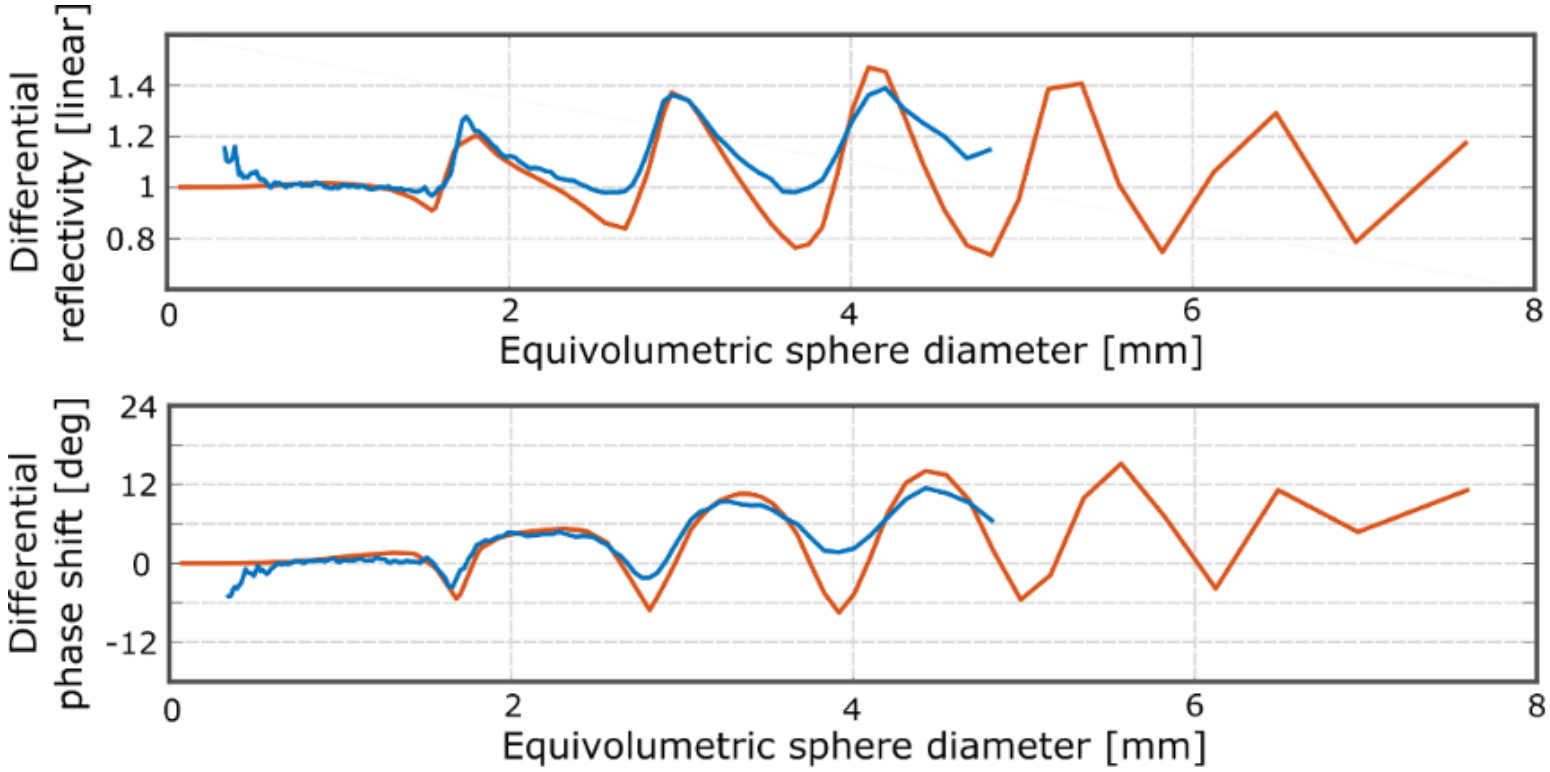




Observations at
30˚ elevation

Polarimetric oscillations!

Comparison of model and observations



Model
Obs.

Good agreement

Applications

Data processing:

Separation of backscattering and propagation effects

Absolute radar calibration (manuscript in preparation with S. Kneifel)

Microphysics:

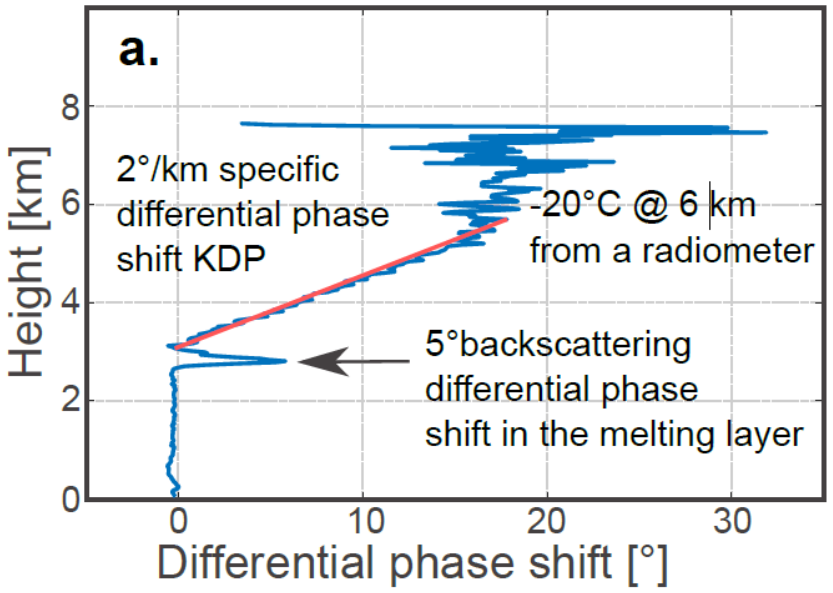
DSD profiling (at relatively low elevations)

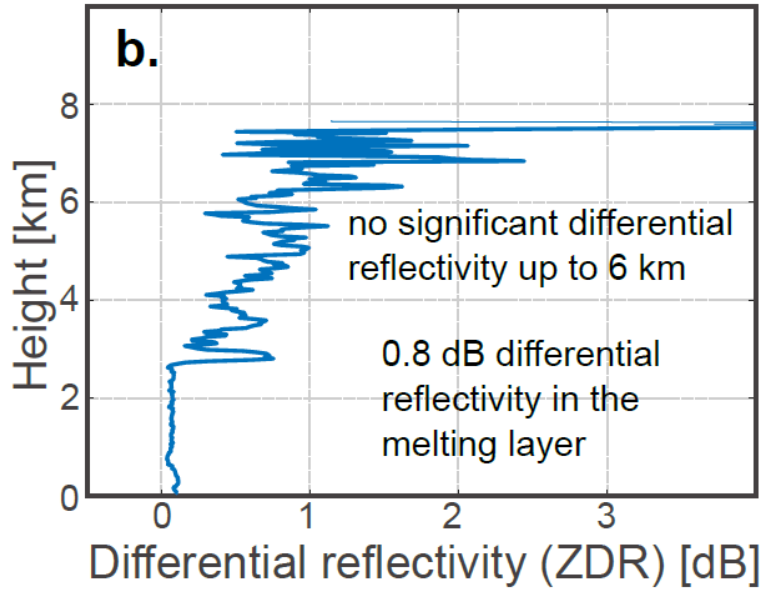
Rain microphysical processes (similar to F. Tridon and C. Williams)

Ice

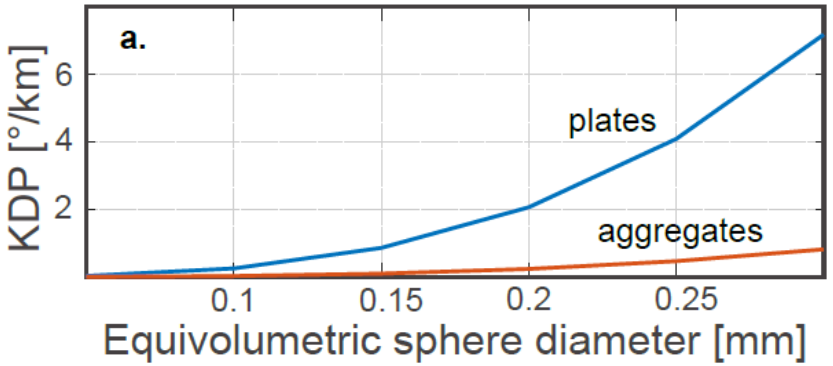
KDP signatures in ice area

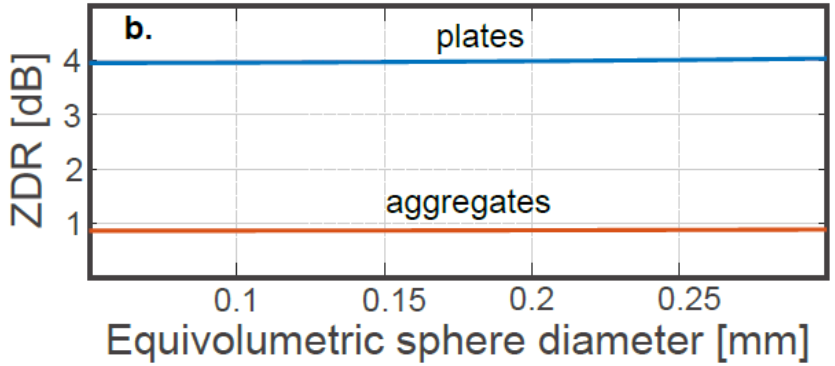
Observations





Model

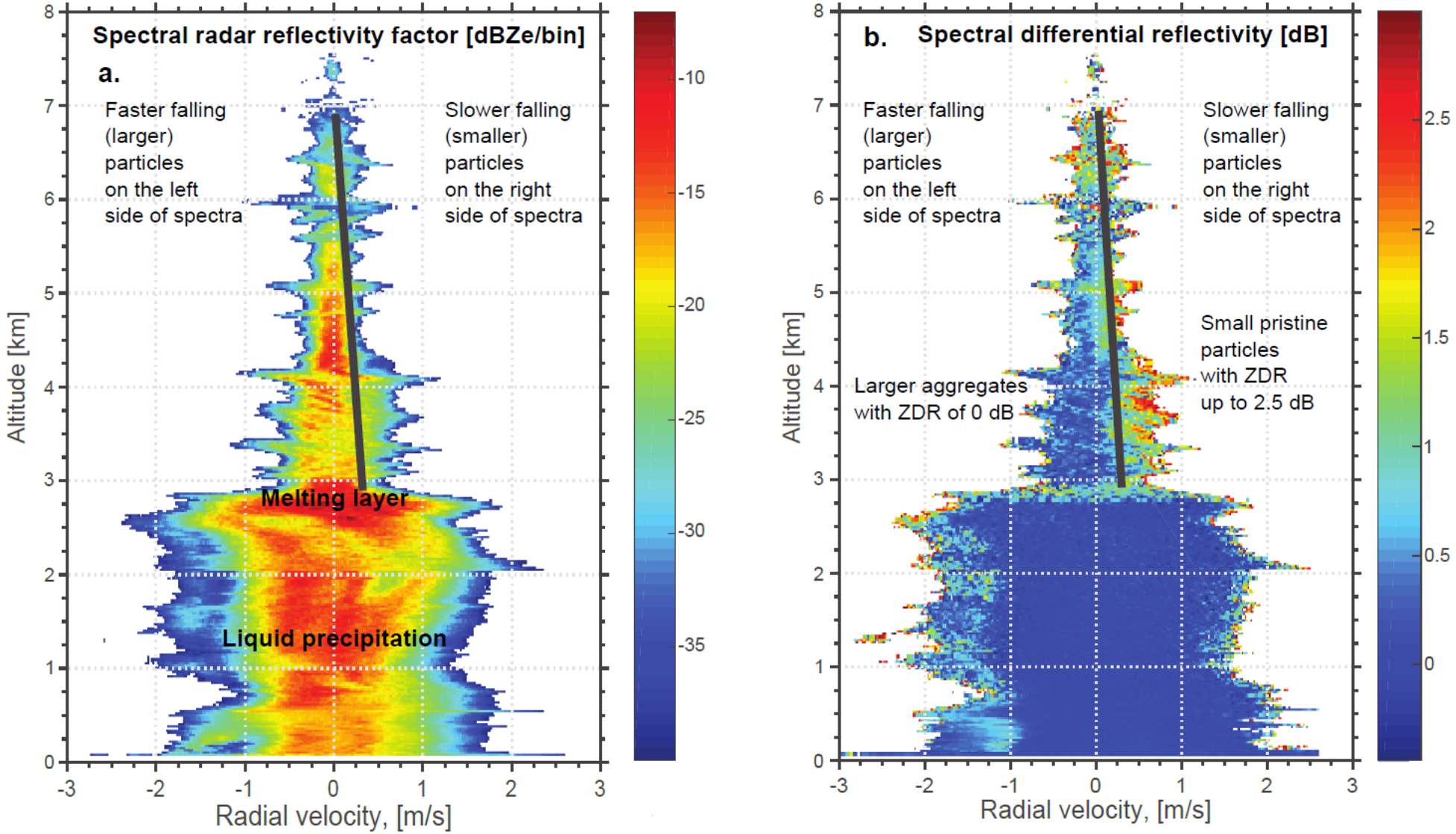




Observations at 30° elevation

Single particle type cannot explain the observations

Spectral observations



Spectral polarimetry resolves different types of particles in a volume

Applications of spectral polarimetry

Data processing:

- Separation of backscattering and propagation effects
- Absolute radar calibration (manuscript in preparation with S. Kneifel)

Rain:

- DSD profiling (at relatively low elevations)
- Rain microphysical processes (similar to F. Tridon and C. Williams)

Ice:

- Detection of secondary ice production
- Detailed quantitative characterization of ‘pristine’ ice particles (incl. shape, size, concentration)

For more details contact alexander.myagkov@radiometer-physics.de

Supplementary slides

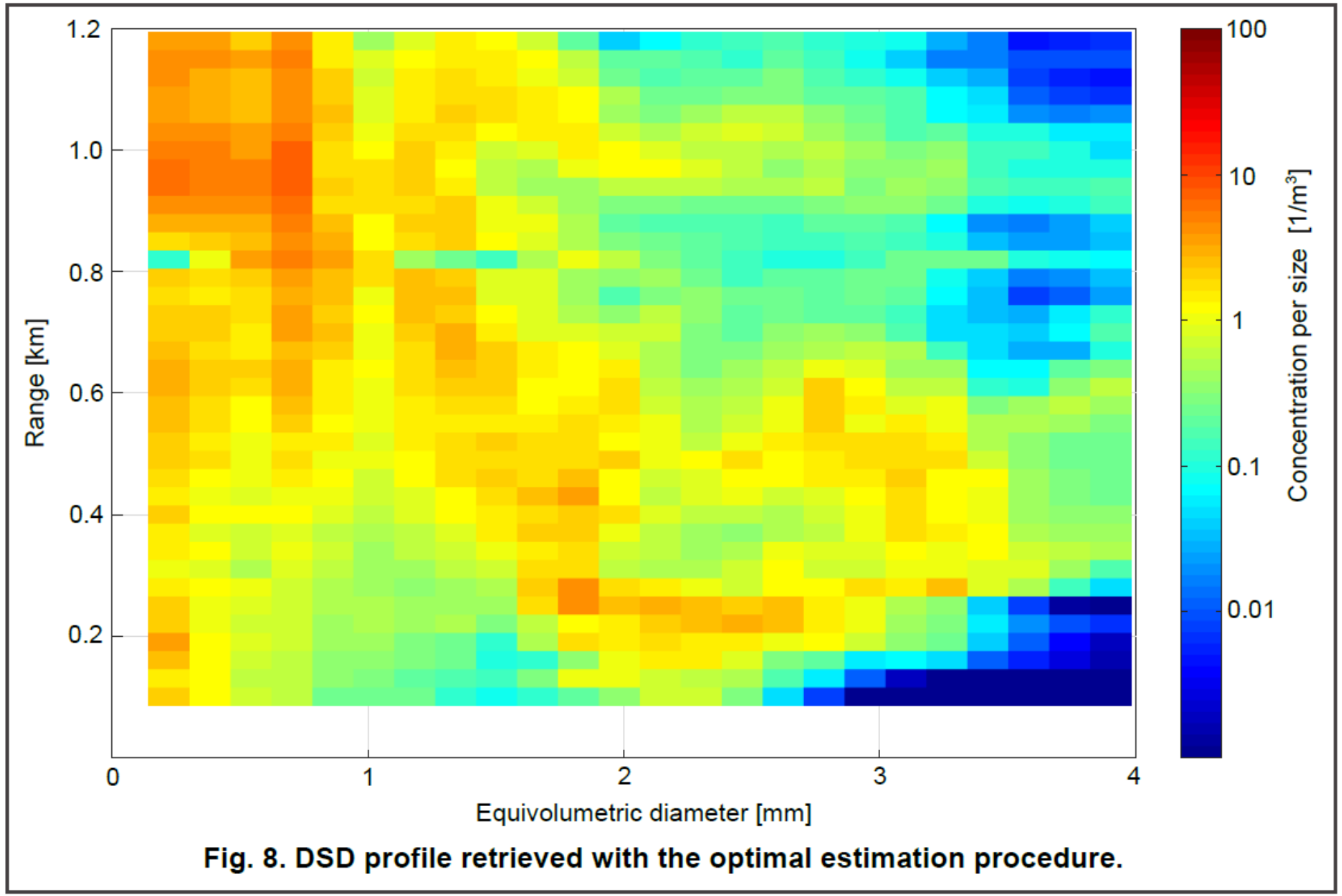


Fig. 8. DSD profile retrieved with the optimal estimation procedure.

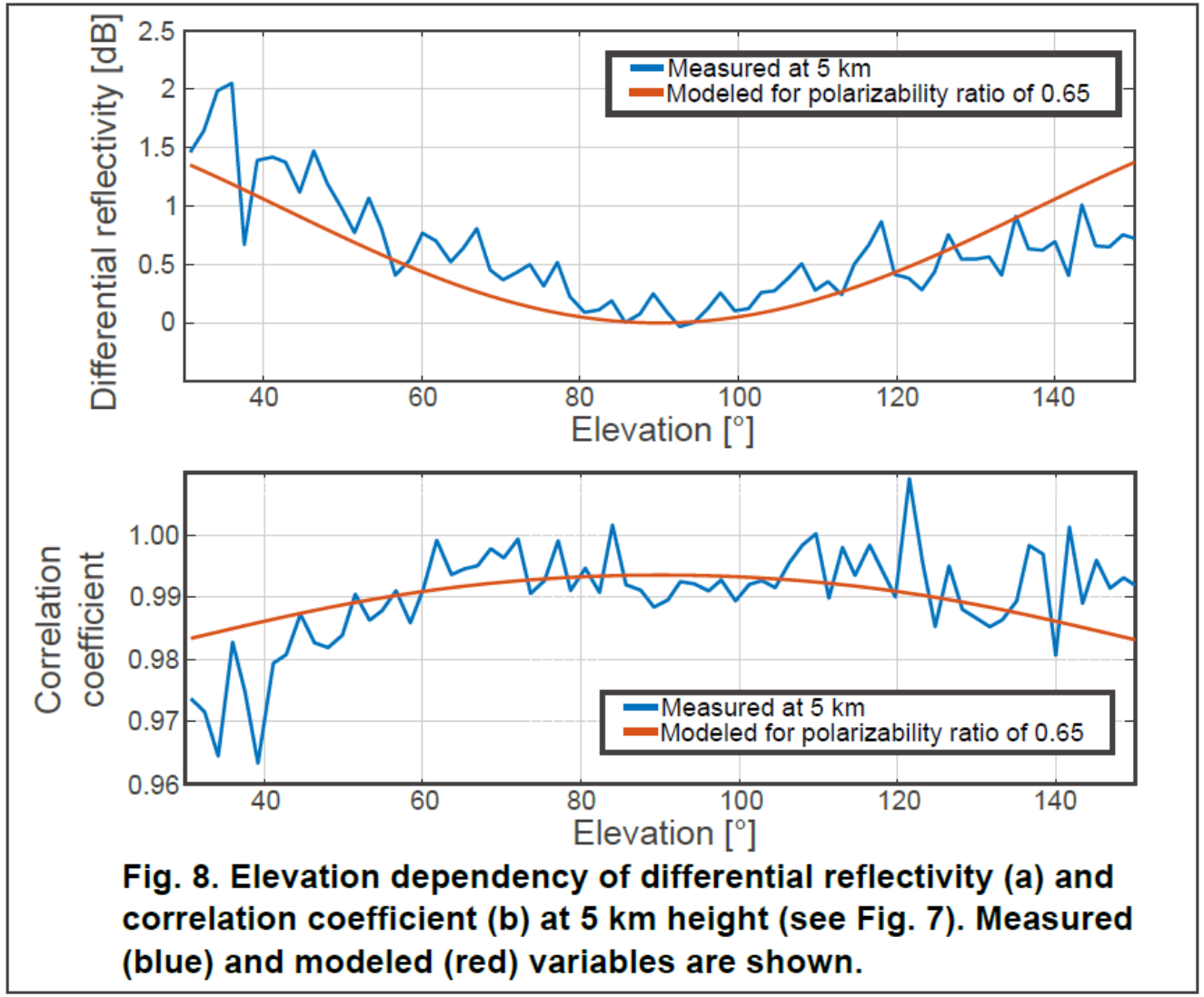


Fig. 8. Elevation dependency of differential reflectivity (a) and correlation coefficient (b) at 5 km height (see Fig. 7). Measured (blue) and modeled (red) variables are shown.

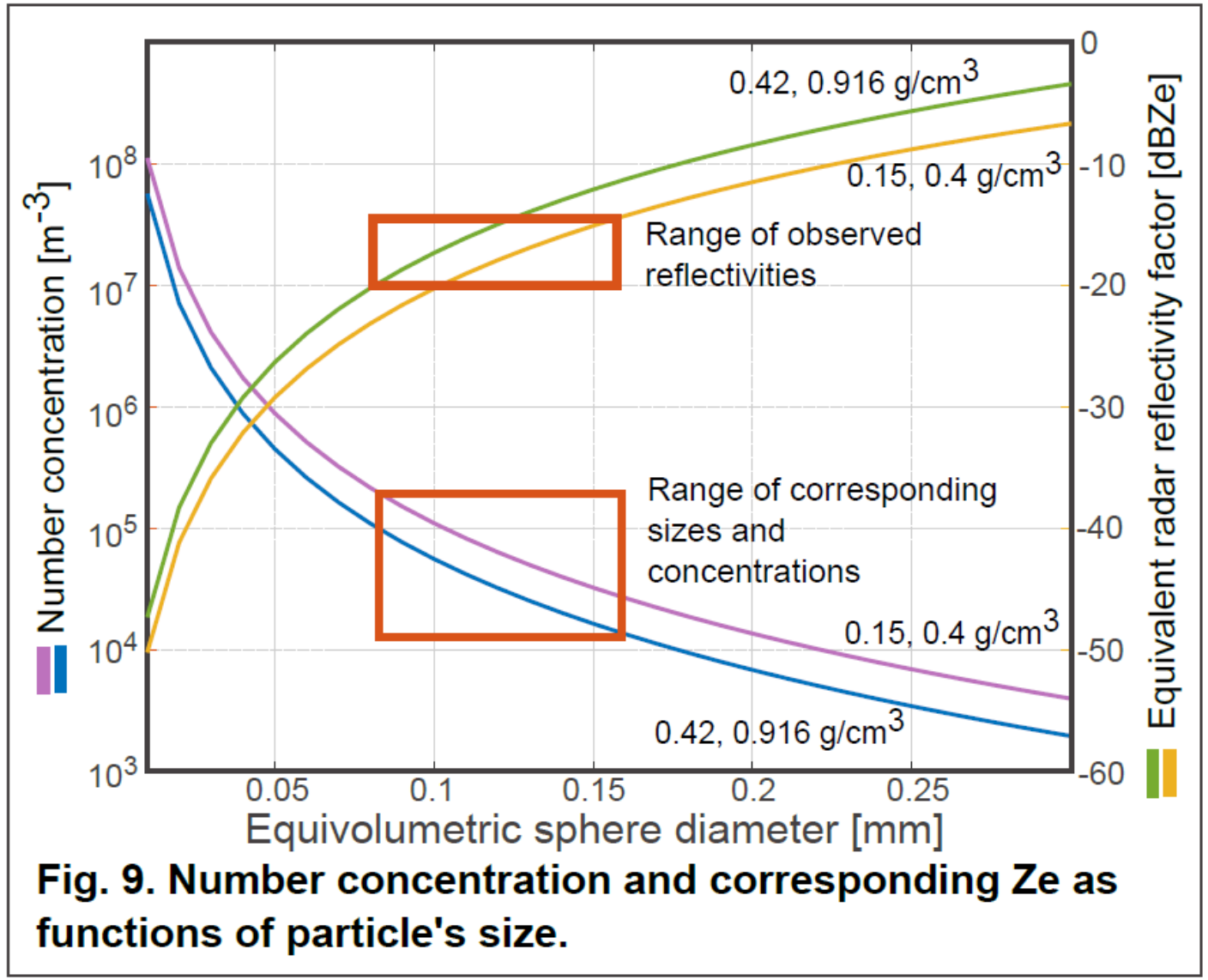


Fig. 9. Number concentration and corresponding Ze as functions of particle's size.