<u>Pol</u>arimetric signatures of <u>ice</u> microphysical processes and their interpretation using in-situ observations and cloud modeling (POLICE)

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Objective

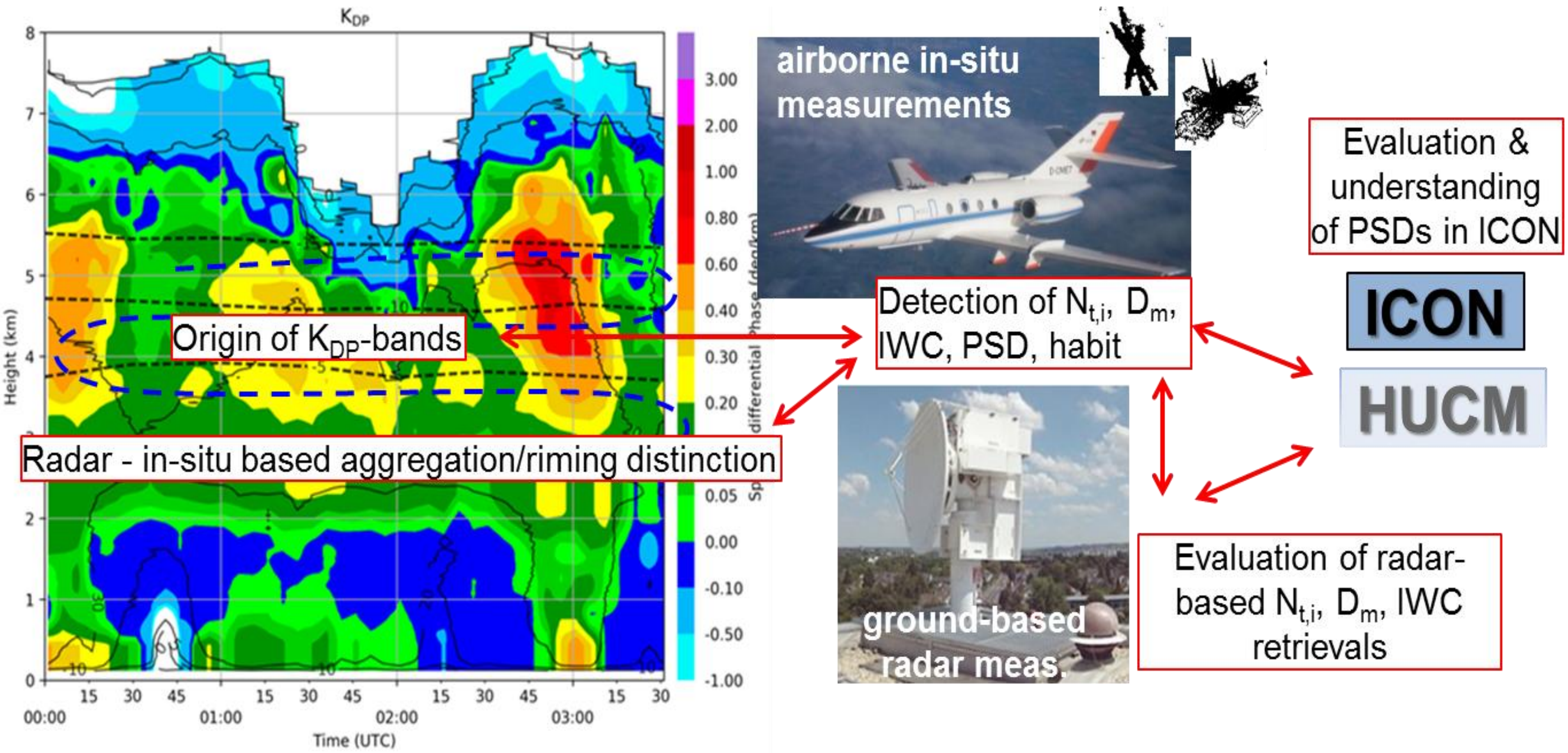
Exploitation of radar polarimetry for quantitative process detection in precipitating clouds and for model evaluation

Major Goals

Exploit existing and new in-situ measurements in the DGL and below to:

1) Evaluate hypotheses on the origin of enhanced K_{DP} in DGL;
2) Quantify multiple indicators to discriminate between aggregation and riming;
3) Evaluate the most recent polarimetric ice microphysical retrievals;
4) Evaluate the representation of particle type and size distribution in ICON-LAM;
5) Make use of spectral bin modelling (SBM) to identify processes resonsible for deficiencies regarding the representation of ice particle size distributions in ICON-LAM.

Major Goals


KDP
Height (km)
Time (UTC)
00:00
01:00
02:00
03:00
airborne in-situ measurements
Origin of K_{DP}-bands
Detection of $N_{t,i}$, D_m, IWC, PSD, habit
Radar - in-situ based aggregation/riming distinction
ground-based radar meas.
Evaluation & understanding of PSDs in ICON
ICON
HUCM
Evaluation of radar-based $N_{t,i}$, D_m, IWC retrievals

State-of-the-art of polarimetric fingerprints

Perform literature review on:

- Latest understanding of K_{DP}-bands and polarimetric fingerprints of microphysical processes
- Radar data processing
- Quasi-Vertical-Profile vs. Columnar Vertical Profile methodology

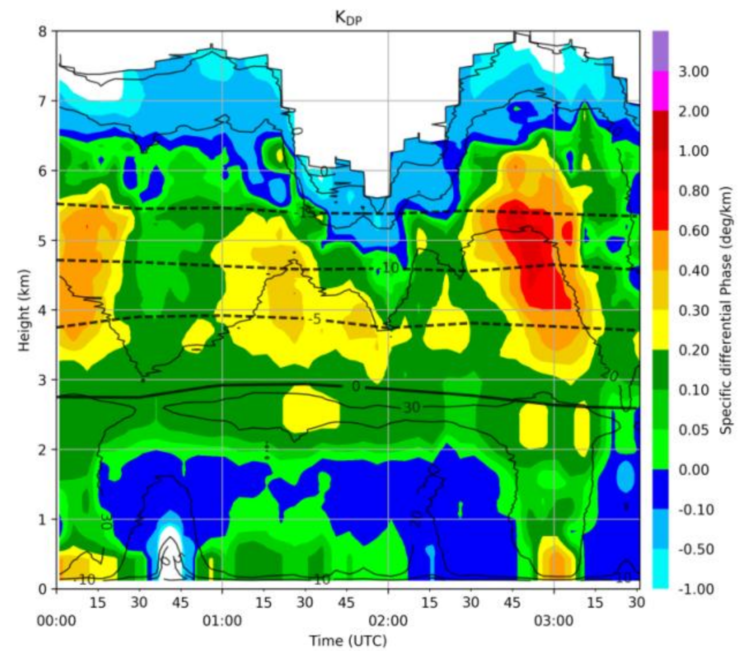
What causes K_{DP}-bands in DGL?

Competing hypotheses:

- dendrites/and or hexagonal plates with very small aspect ratio
- snowflakes with irregular shapes in high concentrations
- more isotropic ice particles with nearly spherical shapes

Workplan:

- Compare QVPs generated with BoXPol measurements, with in-situ measurements



Evaluation of ice-microphysical retrievals

Hypotheses:

– Accuracy of most recent polarimetric ice microphysical retrievals (N_t, D_m, IWC) meet requirements for data assimilation and model evaluation/improvement

Ryzhkov et al. (2018):

$D_m = -0.1 + 2.0\eta$ with $\eta = \left(\frac{Z_{DP}}{K_{DP}\lambda}\right)^{1/2}$ and $Z_{DP} = z_H - z_V$,

$\log N_t = 0.1 Z_H - 2\log\gamma - 1.33$ with $\gamma \approx 0.78\eta^2$

$IWC \approx 4.0 10^{-3} \frac{K_{DP}\lambda}{1-Z_{dr}{}^{-1}}$ with $Z_{dr} = 10^{0.1 Z_{DR}}$

Bukovčić et al. (2018):

$IWC(K_{DP}, z_H) = 0.71\ K_{DP}^{0.65} z_H^{0.28}$

Murphy et al. (2018):

$D_m = -0.17 + 1.41r + 0.715r^2$ with $r = \left[\frac{z_{DP}}{K_{DP}\lambda}\right]^{1/3}$

$\log(N_{t,i}) = 0.16 + 0.1 Z_H - 4.16\log(D_m)$

$\log(IWC) = -1.96 + \log(N_{t,i}) + 2.08\log(D_m)$

Hogan et al. (2006):

$\log IWC(Z_H) = 0.06 \cdot Z_H - 0.0197 \cdot T - 1.7$

DLR

Evaluation of ice-microphysical retrievals

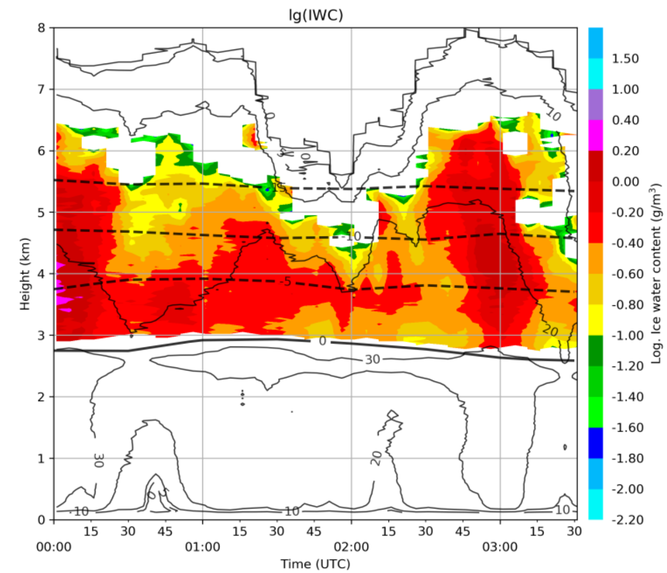
Hypotheses:

– Accuracy of most recent polarimetric ice microphysical retrievals (N_t, D_m, IWC) meet requirements for data assimilation and model evaluation/improvement

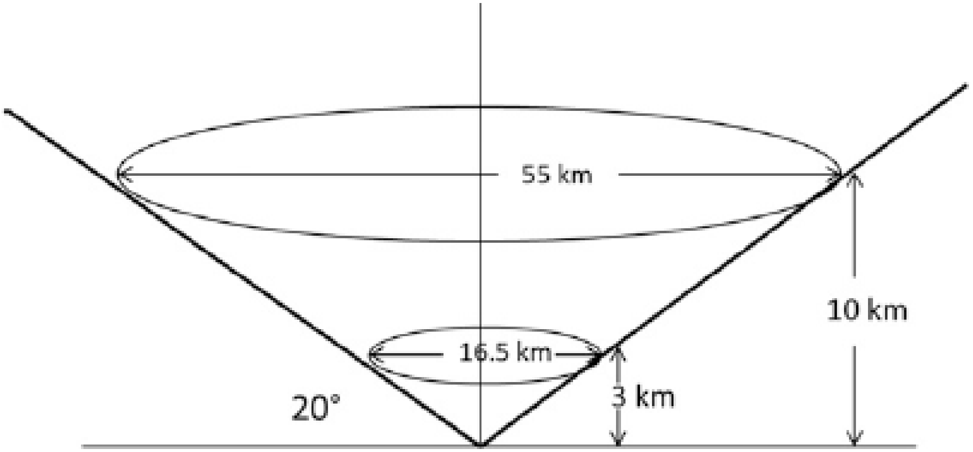
Workplan:

– Accuracy assessment of ice microphysical retrievals by Ryzhkov (2018), Bukovčić et al. (2018), Murphy et al. (2018), and Hogan et al. (2006).

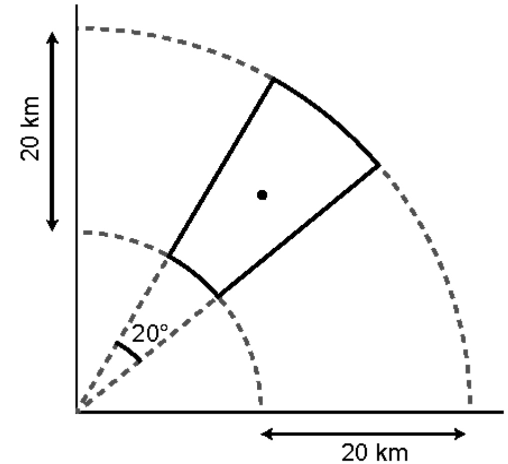
– Application to Quasi Vertical Profiles (QVPs) or more localized Columnar Vertical Profiles (CVPs) following the flight tracks.



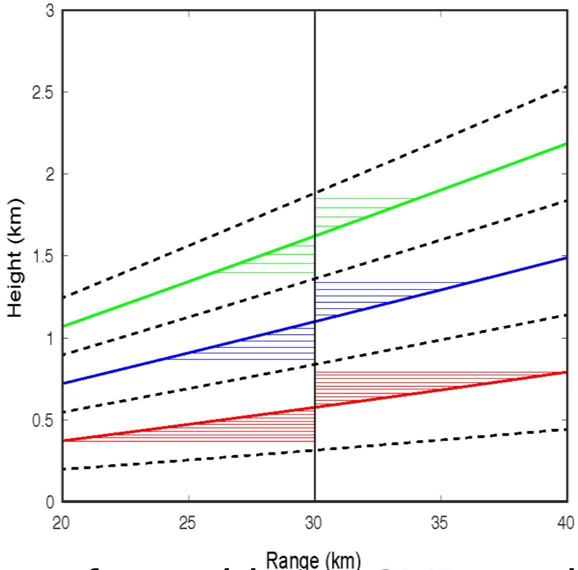
QVPs versus CVPs



Conical volume representing azimuthally averaged quasi-vertical profiles (QVPs)



Plan view of an arbitrary CVP section

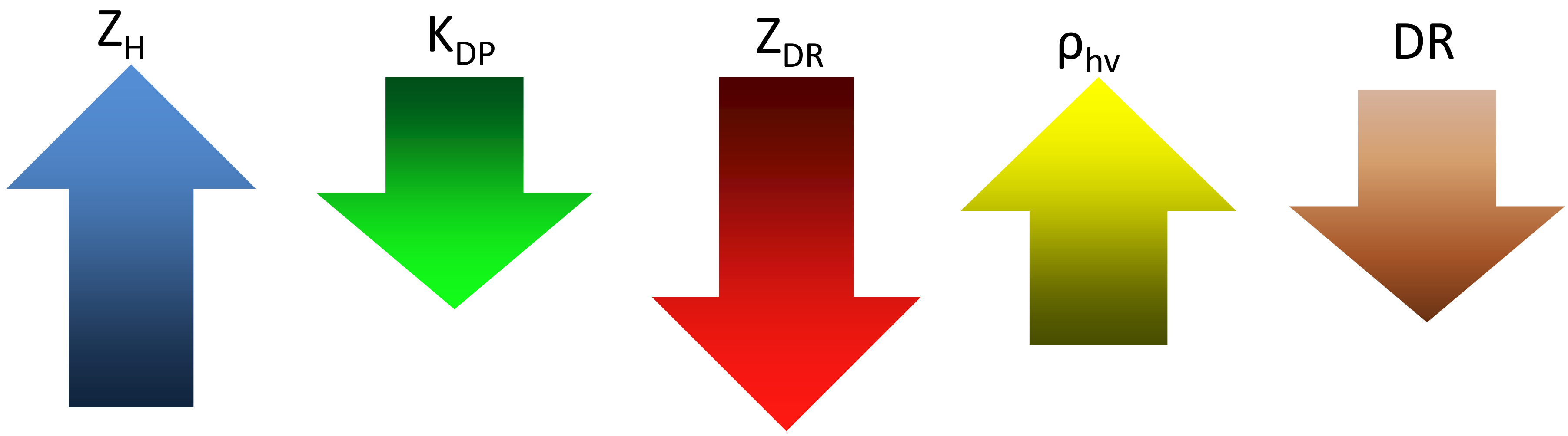


Range-height view of an arbitrary CVP section

Radar algorithm development

Hypotheses:

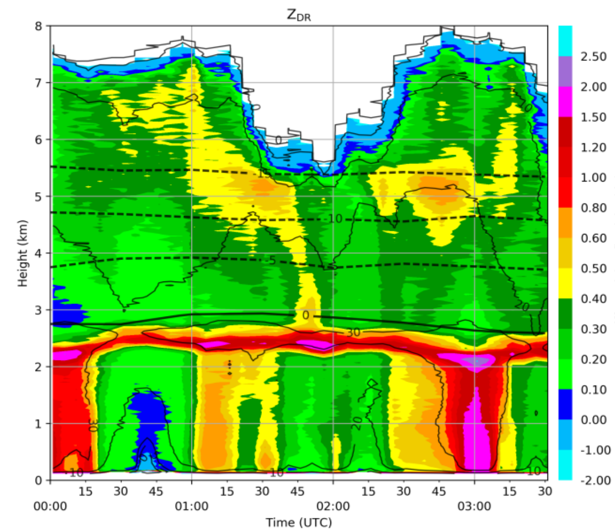
– It is possible to distinguish between dominating aggregation and riming processes based on polarimetric weather radar measurements only



Workplan:

– Evaluate and quantify indicators using in-situ measurements, esp. reduce uncertainties in expected range of decrease in Z_{DR} and DR.

Indicators to distinguish between aggregation and riming



1. Decrease in Z_{DR} above the ML
2. More pronounced decrease in depolarization ratio DR above the ML
3. Sagging of the ML
4. QVPs of Doppler velocity and birdbath scans point to updrafts
5. Spectral fall velocities from vertically pointing Doppler radar
6. Dual wavelength ratios: DWR(X, Ka)>4 dB for aggregates; DWR(X, Ka)<3 dB and DWR(Ka, W)>3 dB for rimed particles

ICON-LAM model evaluation wrt. the representation of particle type and distribution in DGL and below

Hypotheses:

– In-situ measurements combined with quality-assessed ice microphysical retrievals provide insights in the representation of hydrometeor type and distribution in ICON-LAM

Workplan:

– Identify comparable cloud sequences in QVPs/CVPs monitored by measurements and modelled by ICON-LAM
– Compare modelled hydrometeor types, concentration and sizes with in-situ measurements

Comparison between spectral bin model, bulk model and retrieved microphysical parameters.

Hypotheses:

- Coupling of the Hebrew University Cloud Model (HUCM) with polarimetric radar measurements uncovers the processes responsible for a potential misrepresentation of hydrometeor type and distribution

Workplan:

- Comparison between Contour Frequency by Altitude Diagrams (CFADs) of N_t, D_m, IWC retrieved from radar and simulated from both HUCM and ICON-LAM at different heights
- Refinement of processes in HUCM will continue until a reasonable match between radar retrievals and model simulations is achieved

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Questions?

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