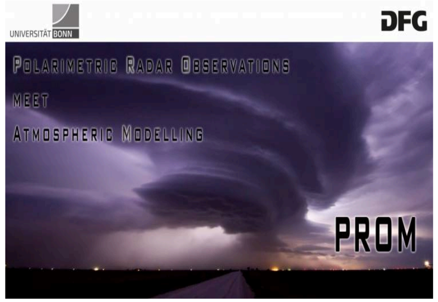

UNIVERSITÄT BONN

Rheinische
Friedrich-Wilhelms-
Universität Bonn

Climate model PArameterizations informed by RAdar (PARA)

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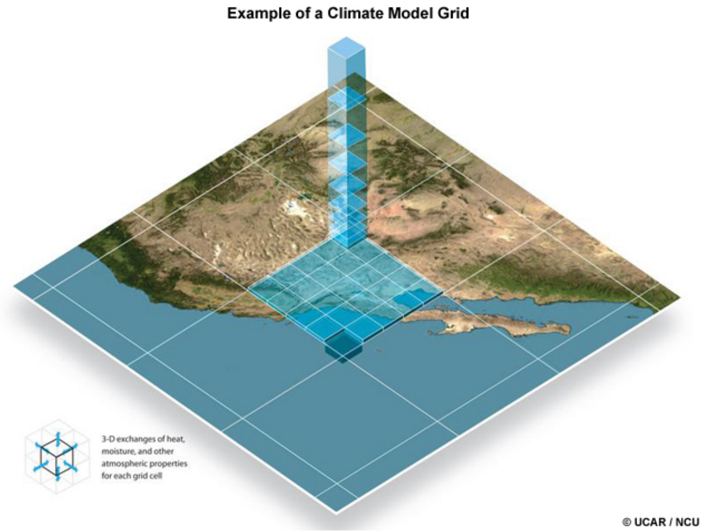
PROM Programme

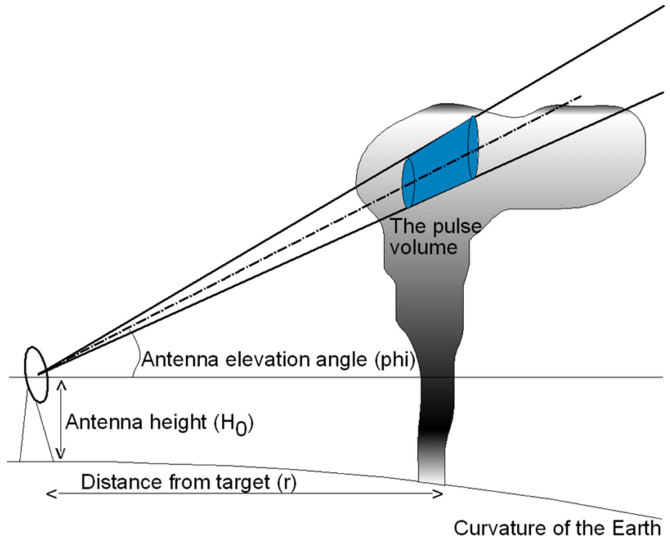
Institute for Geosciences, Department of Meteorology, *Uni Bonn*

Overall motivation of PARA

The overall goal of PARA is to evaluate and improve the representation of microphysical processes in ICON-GCM exploiting high-resolved polarimetric radar observations.



ICON GCM ~ 150km



Radars ~ 0.15 – 1 Km

Work Programme

- The project focuses on the following processes:

  - Spatial sub-grid scale variability of **cloud ice**
  - Aggregation
  - Melting of precipitation
  - Evaporation

***Note*:** The smallest size particle which is assigned to snow in ICON model is 100µm.

Spatial sub-grid scale variability of cloud ice (Uni Bonn)

- Our goal is to provide the mean value and variance of:

❖**Ice Water Content IWC (Ice + Snow + Overall)**

❖**Total number Concentration N_t (Ice + Snow + Overall)**

❖**Mean Volume Diameter D_m (Ice + Snow + Overall)**

as a function of height, using polarimetric radar measurements and applying the most recent ice microphysical retrievals by Ryzhkov et al. (2018) and Bukovcic et al. (2020).

Data and Methodology

Data

Fig. 1) Radar network of DWD, BoXPol and JuXPol radars.

Polarimetric radar data from the:

- Radar network of DWD with C – band weather radars.
- BoXPol X – band radar
- JuXPol X – band radar

Methodology - Ice microphysical retrievals

- This study uses the most recent ice microphysical retrievals by Ryzhkov et al. (2018) and Bukovcic et al. (2020).

1) $D_m\ (mm) =$ = -0.1 + 2.0($\frac{Z_{DP}}{K_{DP}\ \lambda})^{1/2}$
2) IWC ($\frac{\text{gr}}{m^3}$) = 4 x $10^{-3}\ \frac{K_{DP}\ \lambda}{1-Zdr^{-1}}$
3) log(N_t) ($\frac{1}{\text{L}}$) = 0.1Z – 2log(0.2D_m^2) - 1.33

Ryzhkov et al. (2018)

$D_m(mm) =$ *0.7* $(\frac{Z}{K_{DP}\ \lambda})^{1/3}$

IWC$(\frac{\text{gr}}{m^3}) =$ *0.3*$(K_{DP}\ \lambda)^{0.66}\ Z^{0.28}$

log(N_t)($\frac{1}{\text{L}}$) = 0.1Z – 2log(0.2D_m^2) - 1.33

Bukovcic et al. (2020)

Note: σ= 0 and a/b=0.65

Methodology – Statistical Errors

Estimation of the statistical errors of Z_{DR}, Z_H and K_{DP} following **Ryzhkov and Zrnic (2018)** and **Vulpiani et al. (2012).**

Using the Gaussian Error propagation is estimated the resulting error in IWC(K_{DP}, Z) and IWC (Z_{DR}, K_{DP}) for each radar bin.

- Averaging is needed in order to be reduced the statistical error of the retrievals.
- This study uses the Quasi Vertical Profiles(QVP) methodology and the QVP methodology applied in azimuthal sectors.

Methodology – Quasi Vertical Profiles (QVPs)

Azimuthal averaging of the radar data at antenna elevation angles between 10°–20° (representation height-vs-time)

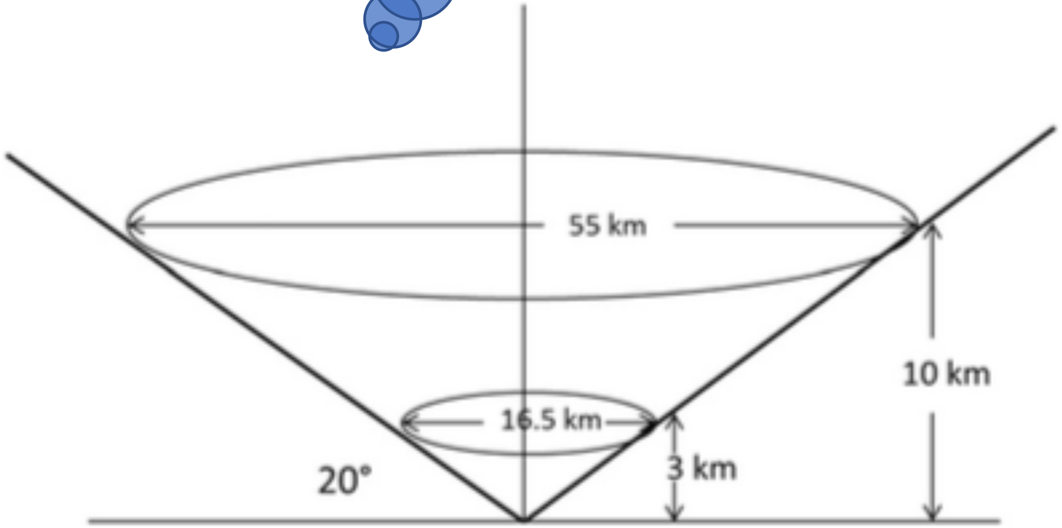


Fig. 2) Quasi Vertical Profile methodology

- Low statistical errors.
- Coarse resolution which cannot provide alone the sub-grid scale ice variability.

Methodology – QVPs applied in azimuthal sectors

+ Provides the horizontal variability in azimuths.
- Higher statistical errors.

Challenge:

➢ The appropriate choice of the sector size.

How?

❖ Comparisons between the variability of IWC (of both formulas) in azimuths with the mean error of IWC for different sector sizes

Stdev(IWC) vs Error(IWC)

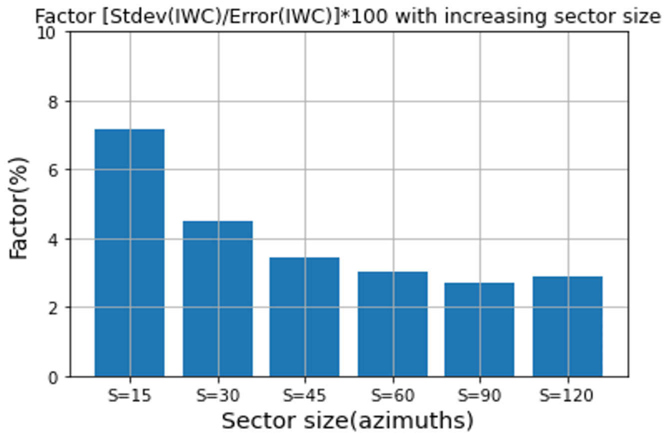
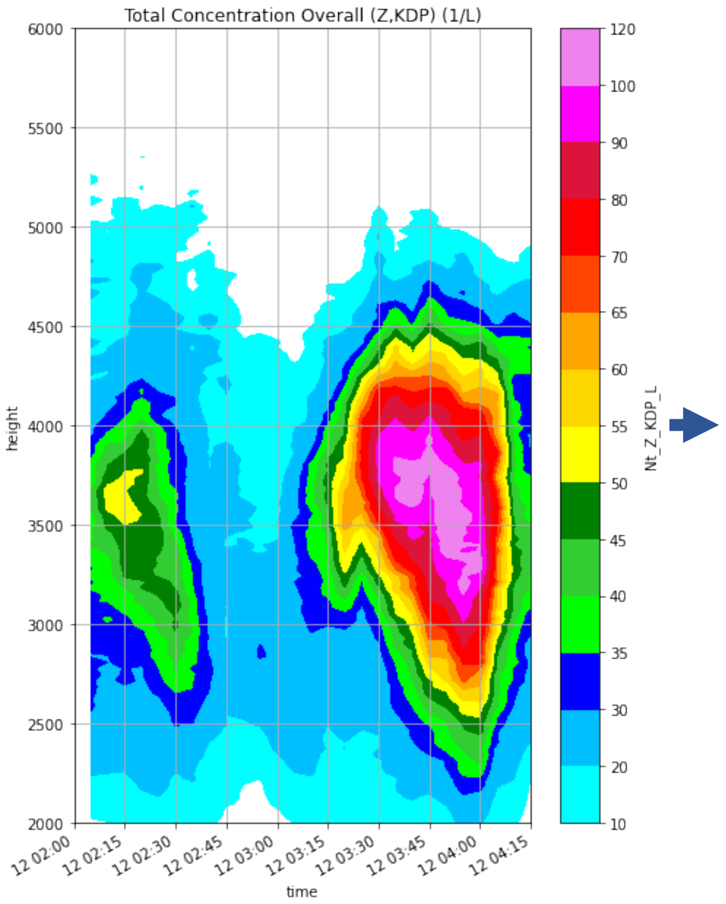


Fig. 3) Variability and error with increasing sector size.

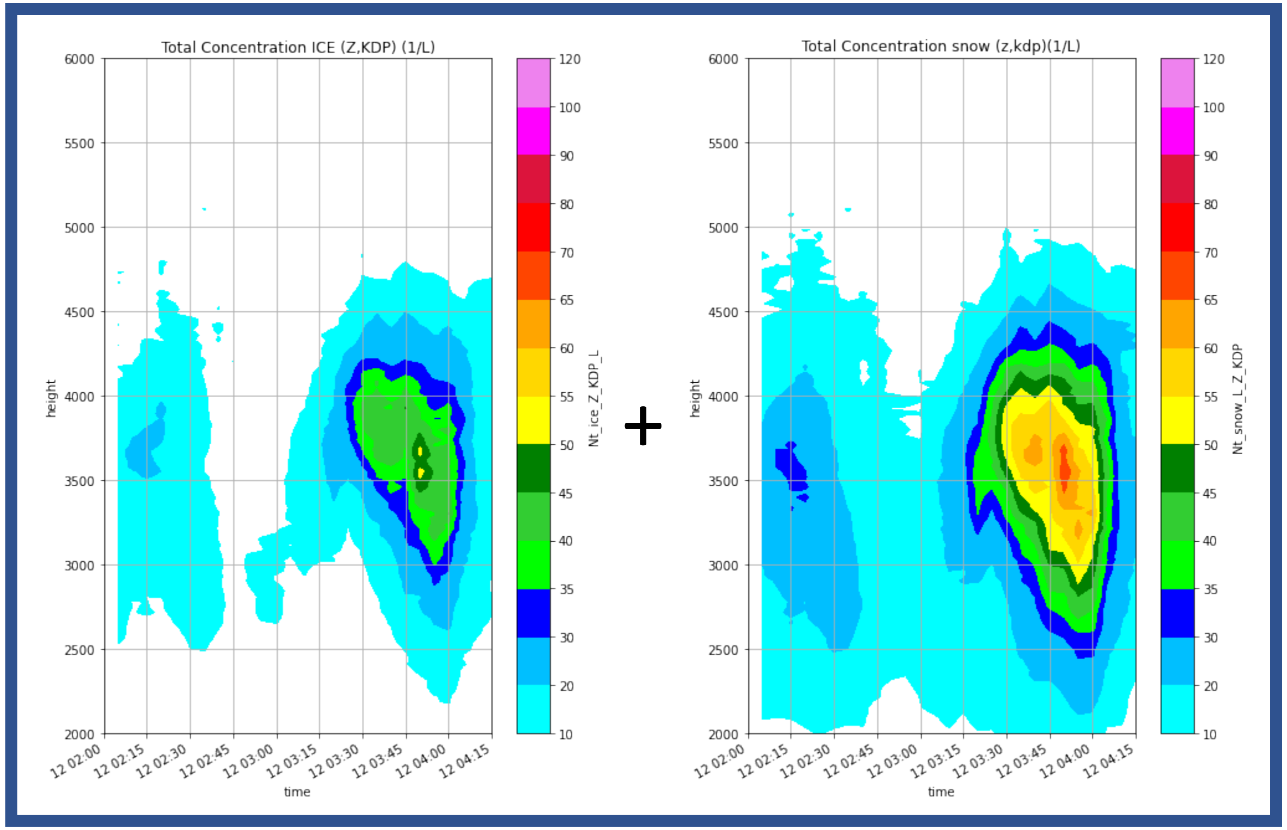
Methodology - Ice and snow component of IWC, $\boldsymbol{D_m}, \boldsymbol{N_t}$

Overall



Ice component

Snow component



- Fitting the exponential size distribution

N(D)=$N_{os}\exp(-\Lambda_s \mathbf{D})$

- $\Lambda_s = \frac{4}{Dm}$
- $N_{os} = \frac{4Nt}{Dm}$

- and estimating the snow and ice component of the retrievals.

Fig. 4) QVPs of Total Concentration for the rain event 12/04/2013 using BoXPol radar and elevation angle 18 degrees.

Results

Results
(snow component)

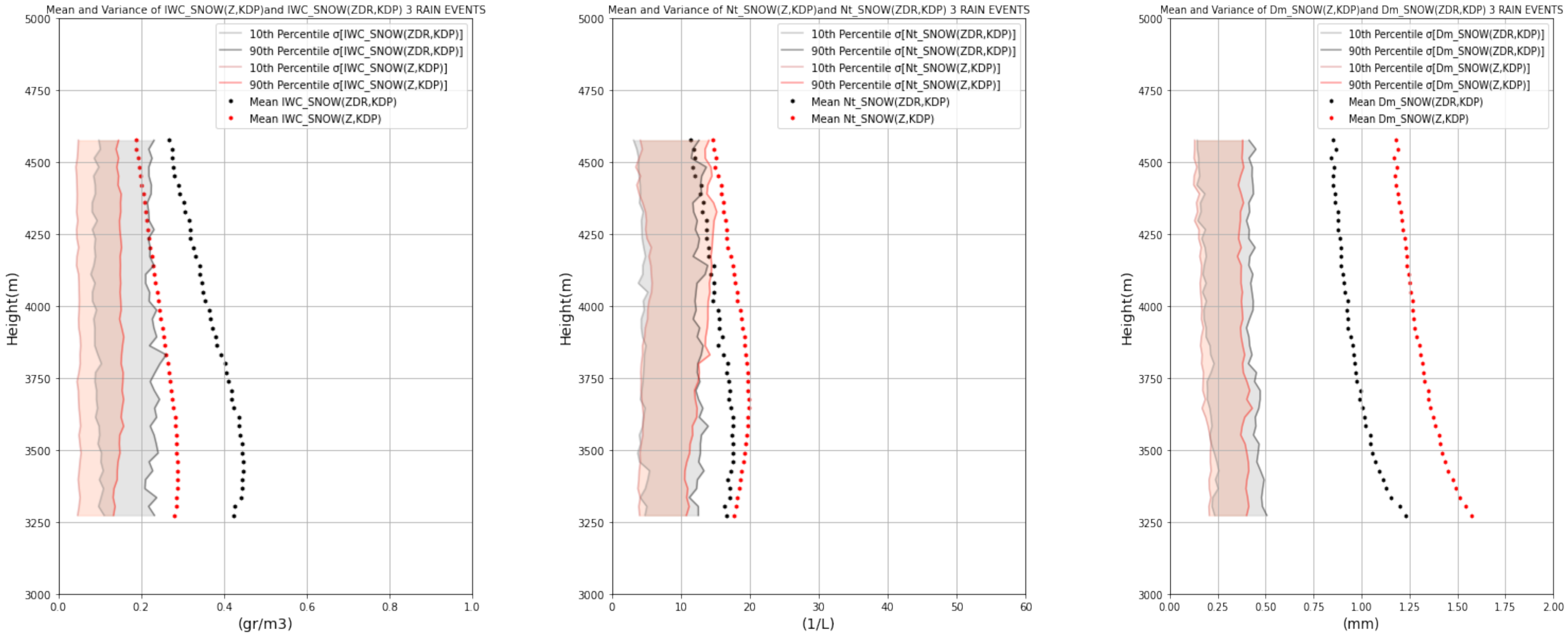
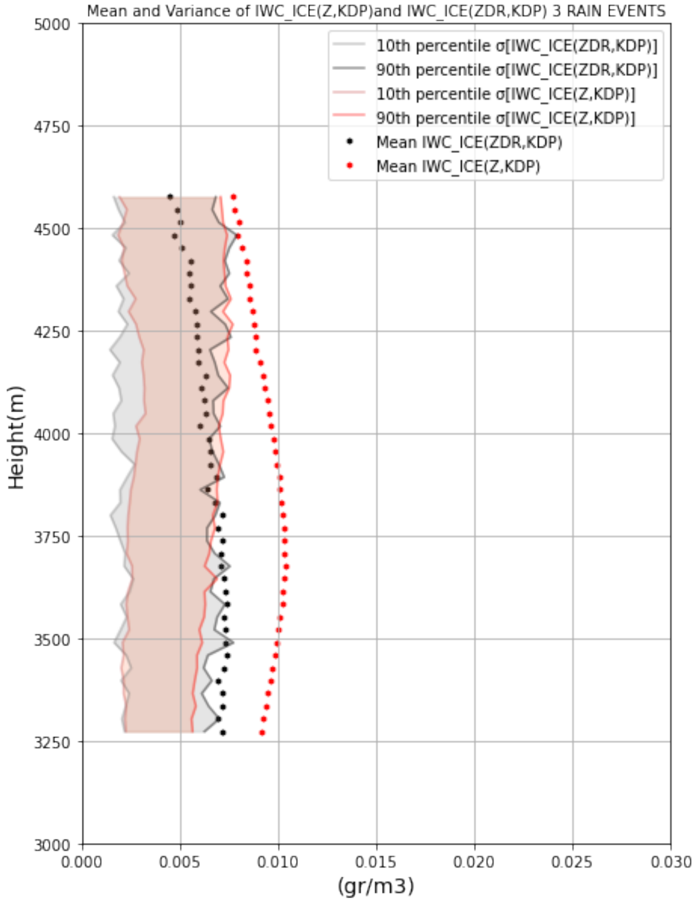
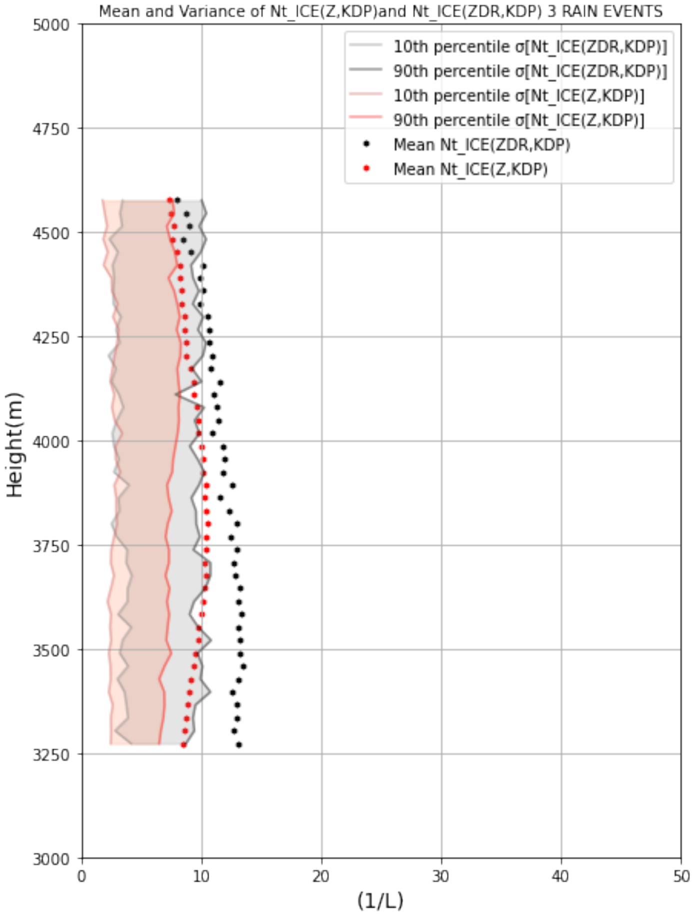


Fig. 5) Height profiles of IWC(snow), Nt(snow) and Dm(snow) for the rain events 12/04/2013, 07/10/2014 and 16/11/2014 using BoXPol radar and elevation angle 18 degrees.

Results
(ice component)





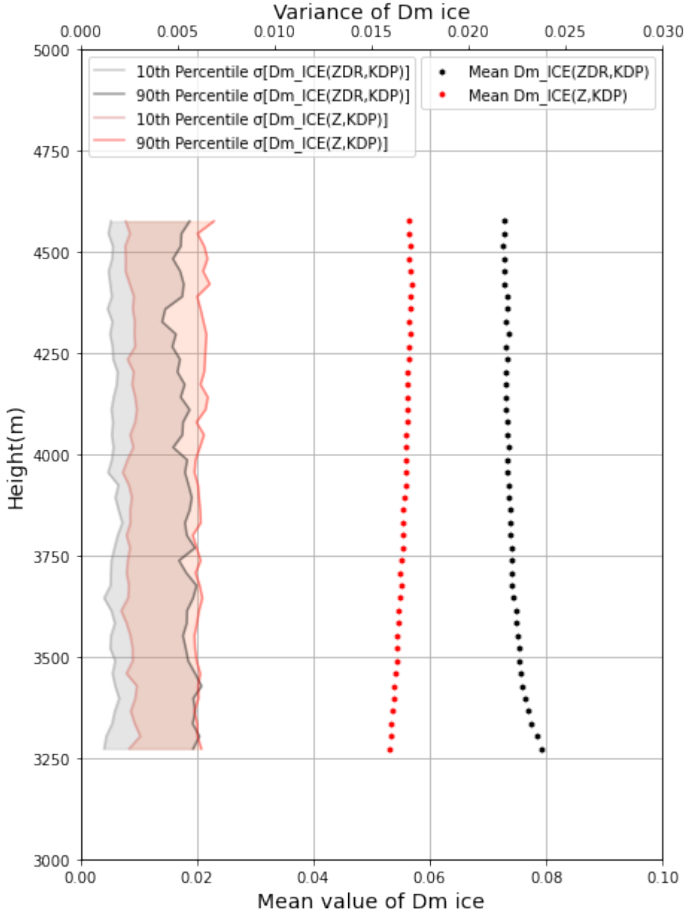


Fig. 6) Height profiles of IWC(ice), Nt(ice) and Dm(ice) for the rain events 12/04/2013, 07/10/2014 and 16/11/2014 using BoXPol radar and elevation angle 18 degrees.

Summary

1

Aim of WP1

Mean value and variance of IWC,Dm,Nt for ice snow and overall particles.

2

The problem

- Distinction ice and snow.
- Noisy measurements.

3

The solution

- Exponential distribution.
- QVP methodology.
- QVP methodology applied in azimuthal sectors.

4

Results

For the studied cases so far, the range of values is identified with in situ measurements (Orikasa et al. 2012, Sean et al. 2007, Hou et al. 2014)

5

Future work

- More cases.
- Study of the snow formation with aggregation