SPP 2115

Climatology of IWC, Nt and Dm and analysis of variabilities for improved parametrizations using polarimetric retrievals

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photo of Bonn X-band radar by V. Pejcic

Motivation

Creation of a climatology of different ice-microphysical retrievals and polarimetric variables using a large BoXPol dataset

- Statistical investigations (e.g. CFADs and vertical profiles of QVPs (RD-QVPs))
- QVP (RD-QVP) methodology to significantly reduce statistical errors in ice microphysical retrievals through averaging [Ryzhkov et al., 2016]

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- Obtain the "true" spatial variability that can be compared to the ICON-GCM variability at the subgrid-scale and used to improve its parameterizations

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Motivation → Sector Quasi Vertical Profiles (QVPs)

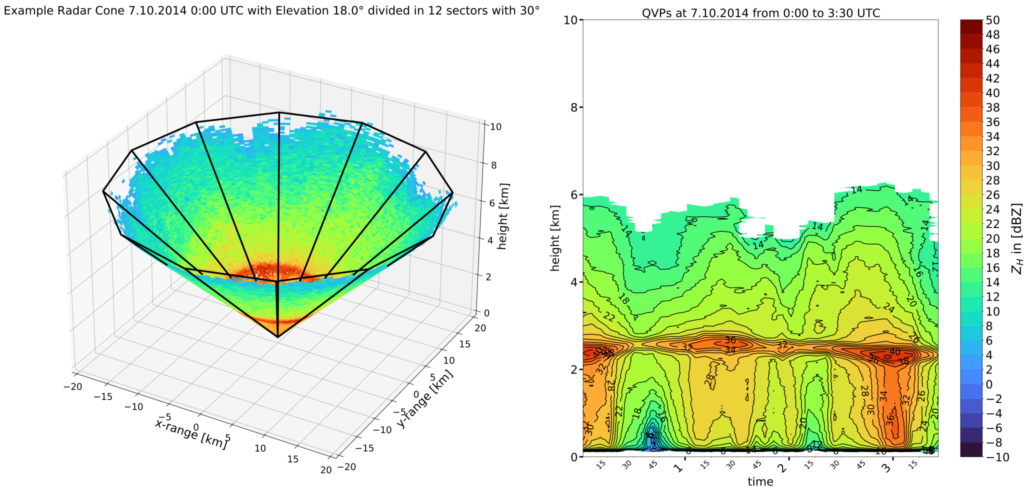

Figure 1: Left: 3D Cone of PPI scan, with black lines representing the separation in 12 sectors with 30°. Right: Classical QVPs as time versus height display

Workflow

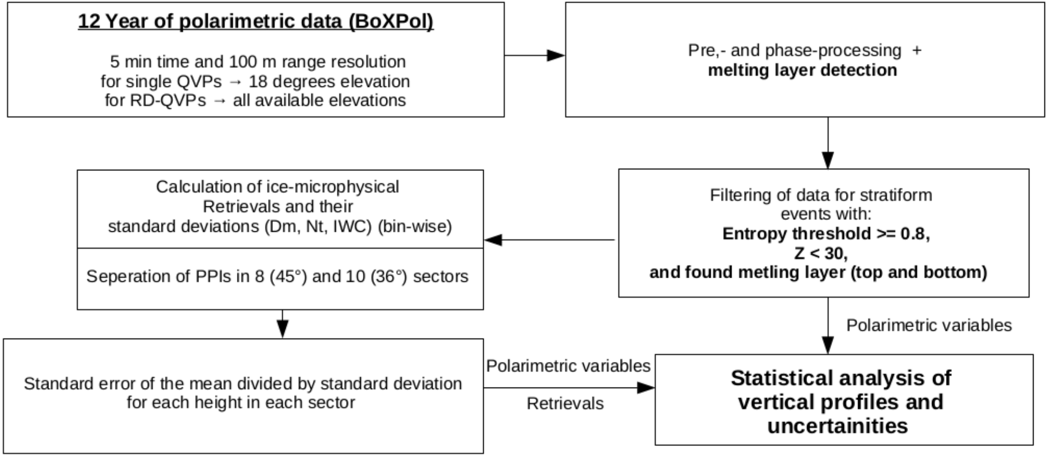

Figure 2: Workflow

Error ratio statistic

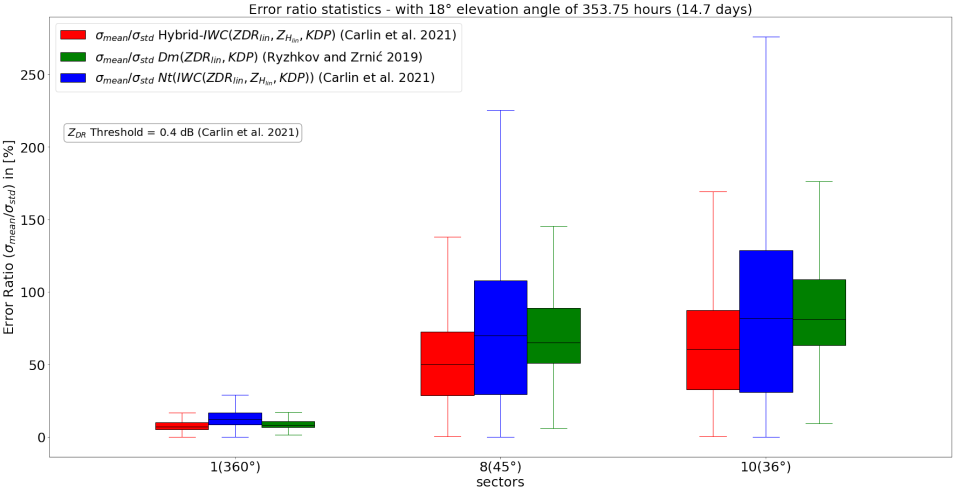

Figure 3: Boxplots representing the values of all time steps and heights of defined error ratio $(\frac{\sigma_{mean}}{\sigma_{std}})_{18}$ for *IWC*, *Dm* and *Nt* retrievals of stratiform events with a total of 353.75 hours (14.7 days)

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Standard Deviation Over Sector (RD-) QVPs → Sub-Grid Scale Variability

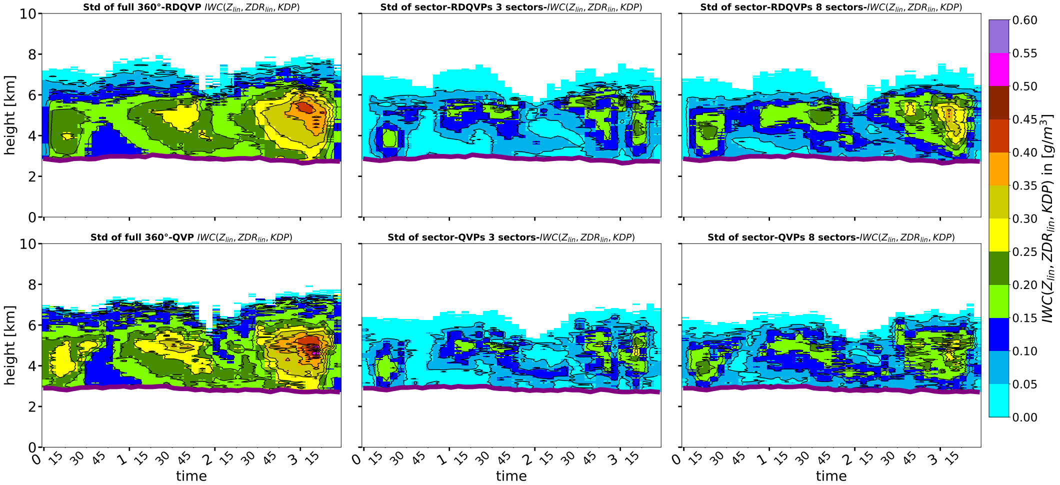

Figure 4: Std of different sized sector QVPs (bottom) , RD-QVPs (top) and over 360° for the $IWC(Z_{H_{lin}}, ZDR_{lin}, KDP)$ retrieval, at 7.10.2014 from 00:00 to 03:30 UTC. The violet thick line represents the top of the melting layer.

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Information Entropy

- Homogeneous conditions are necessary for successful reduction of statistical errors of polarimetric variables/retrievals (stratiform clouds)
- Usage of a normalized version of shannon information Entropy in the range from $(0-1)$

  0: Total heterogeneous conditions

  1: Fully homogeneous conditions

Information Entropy Stratiform Example

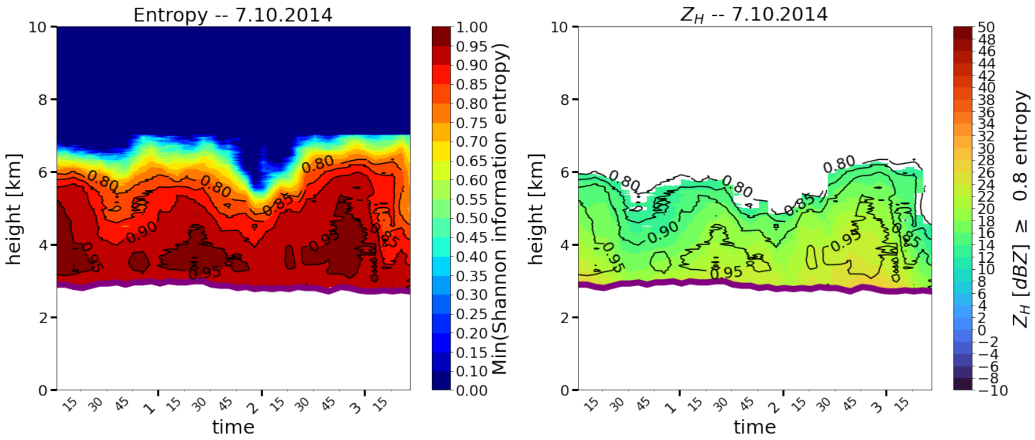

Figure 5: Azimuthal "minimum entropy QVP" (left) and filtered QVP for Z_H (right). The violet thick line represents the top of the melting layer.

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Information Entropy Convective Example

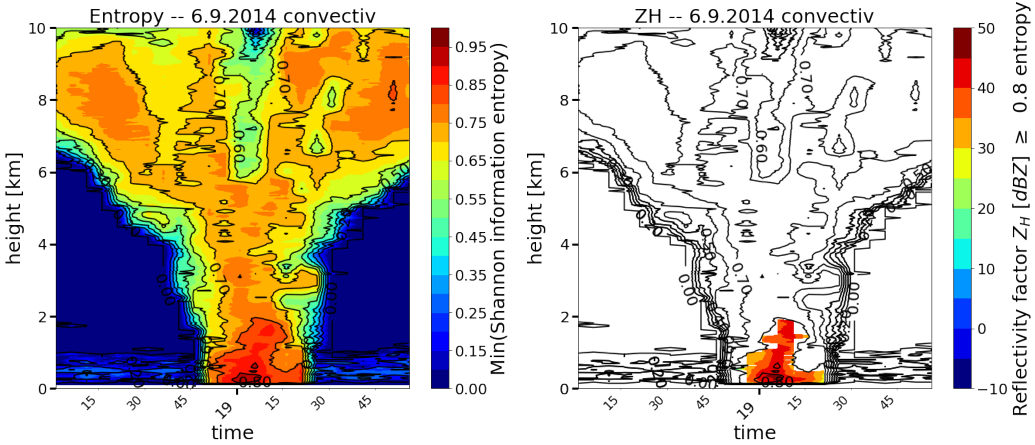

Figure 6: Azimuthal "minimum entropy QVP" (left) and filtered QVP for Z_H (right).

Contoured frequency by altitude diagrams CFADs

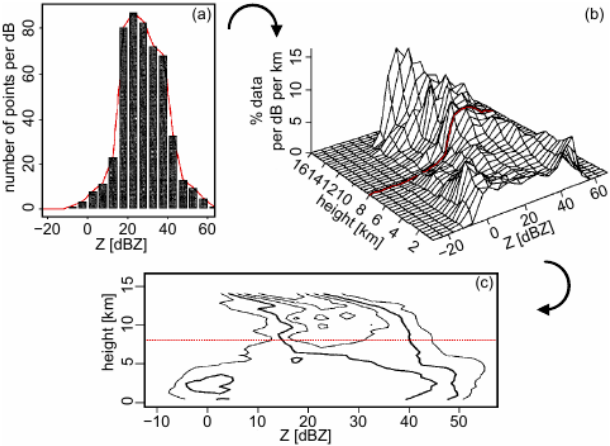

Figure 7: Developing process for CFADs, original after Yuter and Houze Jr. 1995, a) representig a histogram in specific height, b) multiple histograms for all heights and c) the CFADs.

QVPs of reflectivity factor for example date

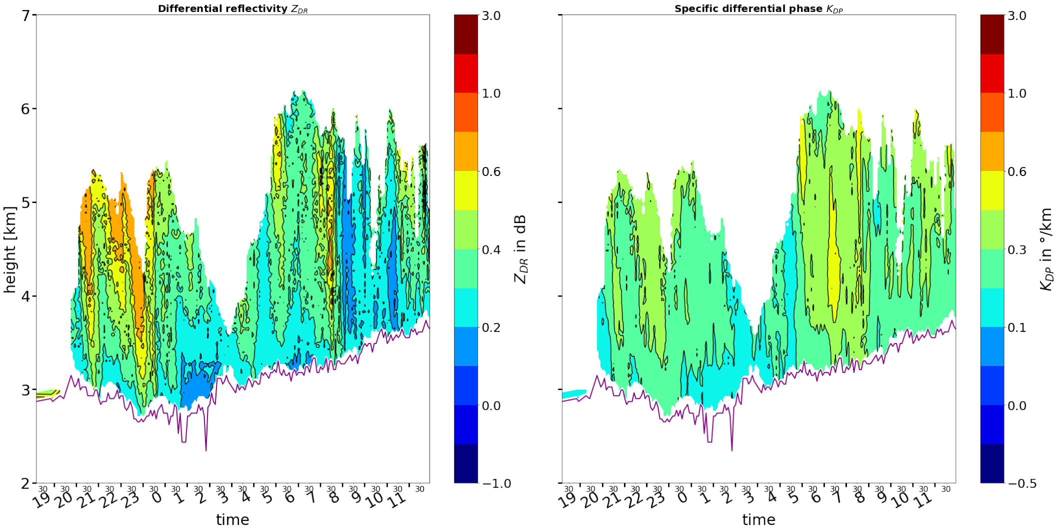

Figure 8: Z_{DR} (left) and K_{DP} (right) QVPs in the time from 2014-07-08 19:00 UTC to 2014-07-09 12:00 UTC.

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CFAD of reflectivity factor of one event

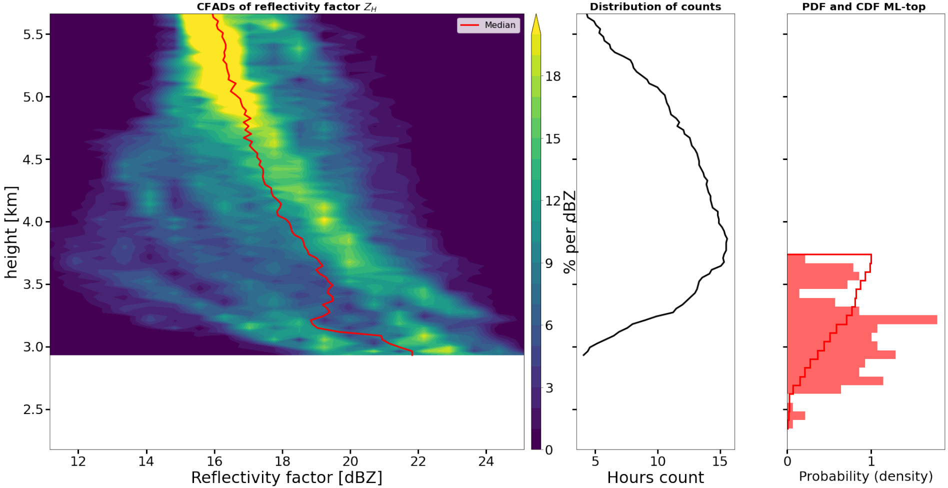

Figure 9: CFAD of Z_H (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from 2014-07-08 19:00 UTC to 2014-07-09 12:00 UTC.

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CFAD of differential reflectivity of one event

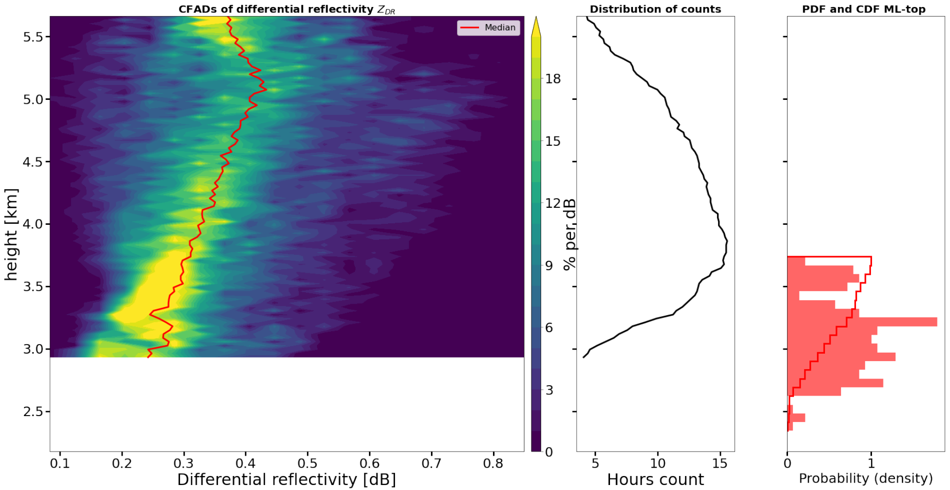

Figure 10: CFAD of Z_{DR} (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from 2014-07-08 19:00 UTC to 2014-07-09 12:00 UTC.

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CFAD of specific differential phase of one event

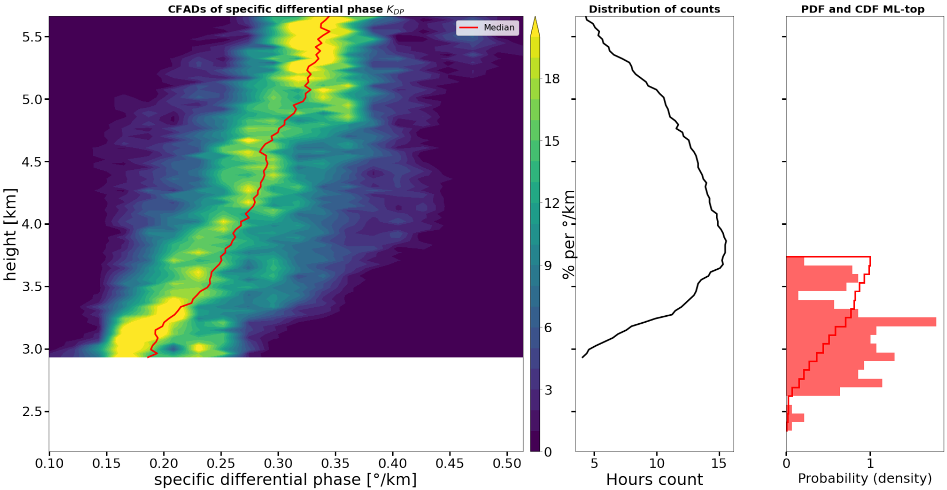

Figure 11: CFAD of K_{DP} (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015.

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CFAD of reflectivity factor summer (2014 and 2015)

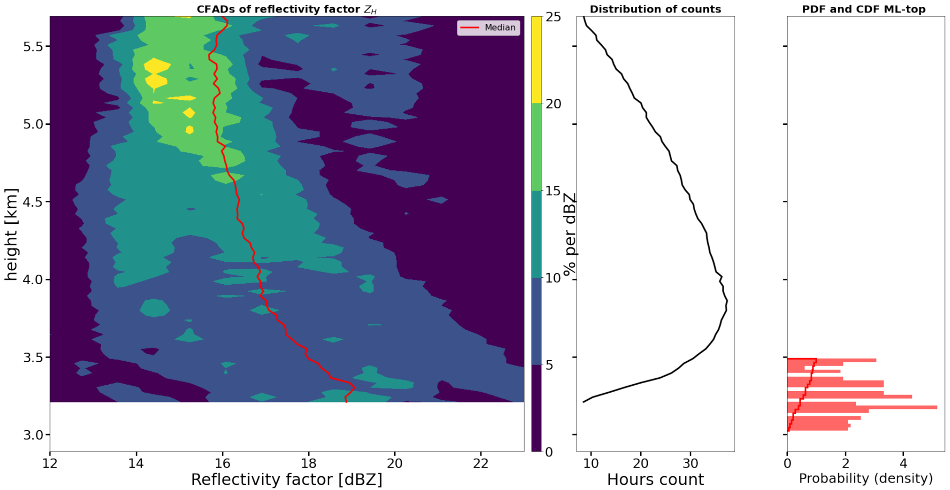

Figure 12: CFAD of Z_H (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015 (in total 41 hours), where ML top between 3 and 3.5 km.

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CFAD of differential reflectivity summer (2014 and 2015)

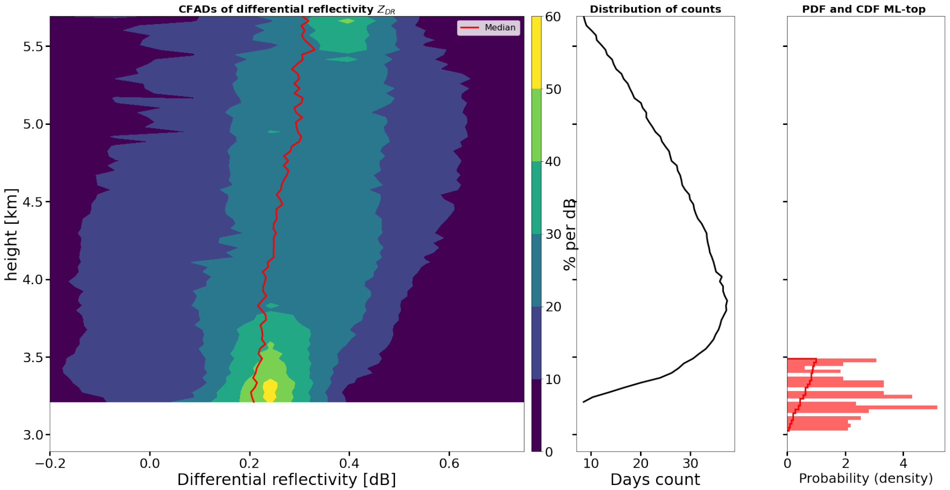

Figure 13: CFAD of Z_{DR} (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015.

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CFAD of specific differential phase summer (2014 and 2015)

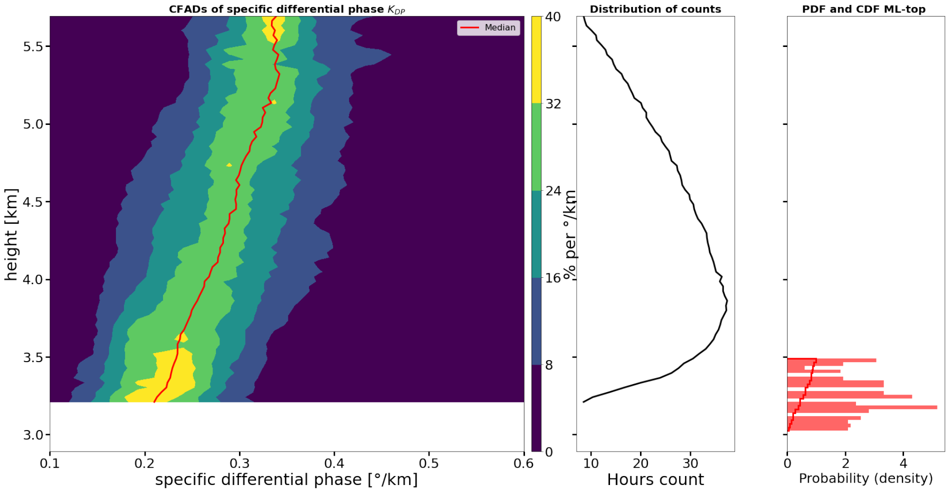

Figure 14: CFAD of K_{DP} (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015.

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CFAD ice water content summer (2014 and 2015)

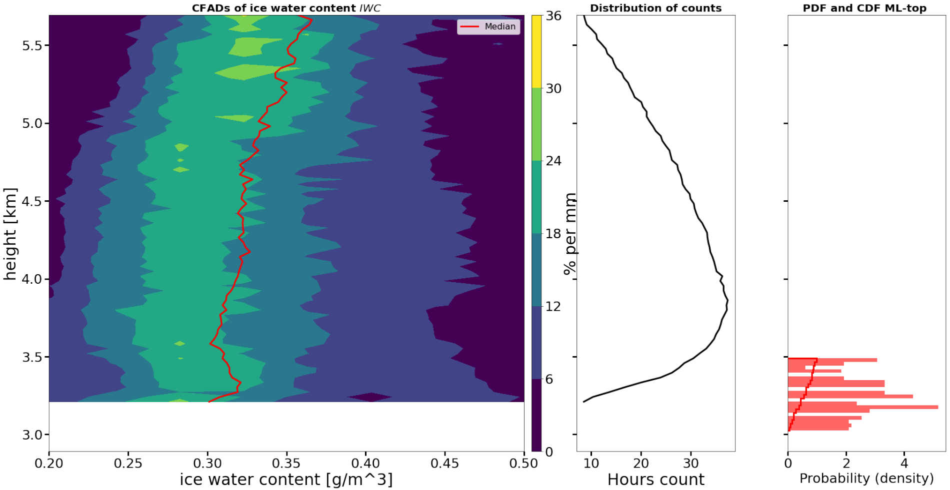

Figure 15: CFAD of IWC (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015.

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CFAD mean volume diameter summer (2014 and 2015)

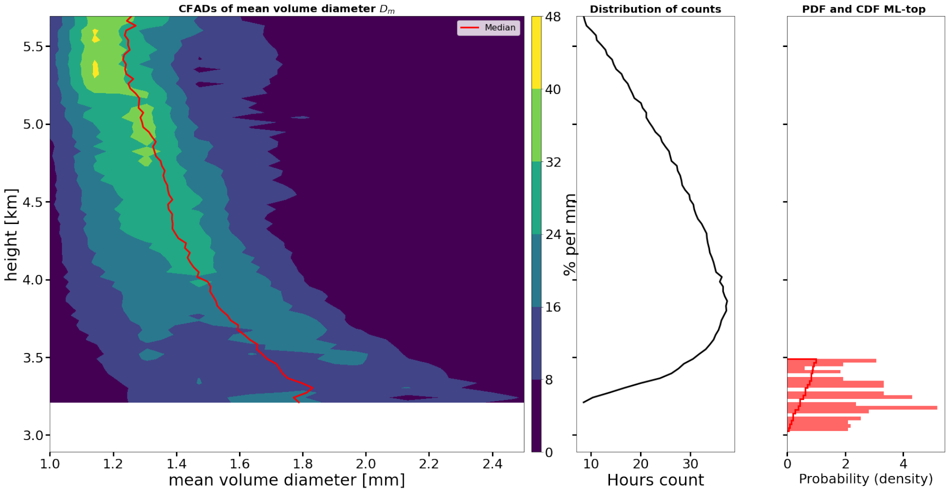

Figure 16: CFAD of Dm (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015.

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CFAD number concentration summer (2014 and 2015)

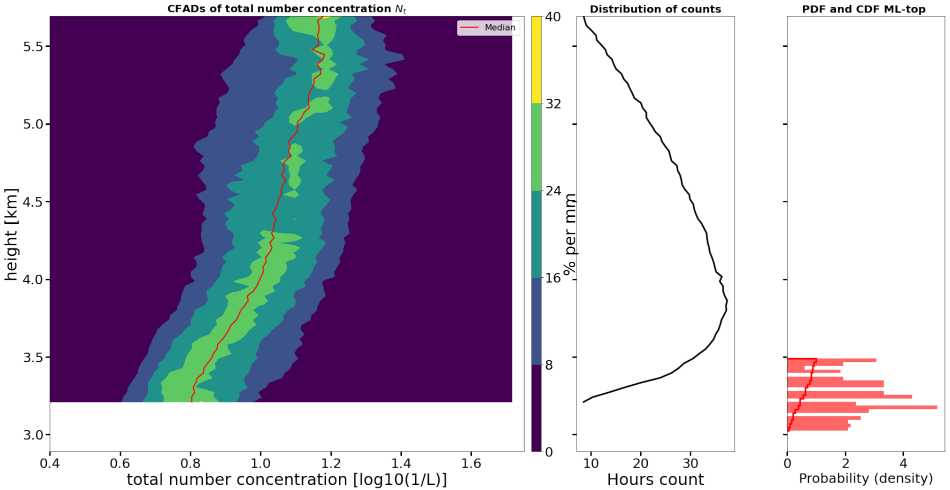

Figure 17: CFAD of log10(Nt) (left), valid hours count for each height (middle) and CDF, PDF of melting layer top height (right) from summer (june, july, august) 2014 to 2015.

Important Key Aspects

- Usage of **8 sector QVPs**, reduces the statistical error of the best performing retrievals to an **error ratio of less than around** $50 - 80\%$

  $\rightarrow$ Effectively separate statistical error from spatial variability using sector (RD-)QVPs while maintaining PPI intrinsic subgrid scale variability as best as possible
- It is consequently possible to compare and improve the subgrid-scale variability of the IWC from ICON-GCM using robust noise-adjusted variabilities of IWC retrievals
- Shannon information entropy is very convenient to check events for stratiform conditions rather than having to estimate them "by eye"
- Statistical analysis using CFADs seems to be promising for analyzing vertical profiles

  besides, there is also the possibility to detect systematic differences between synthetically generated variables (NWP models) and retrievals
- In near future the dataset will be merged with ERA5 reanalysis data

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