Climatology of the Vertical Profiles of Polarimetric Radar Variables at X Band in Stratiform Clouds

Silke Trömel[1], Alexander V. Ryzhkov[2], Brandon Hickman[1], Clemens Simmer[1]

[1]*Meteorological Institute, University of Bonn, Germany*

[2]*Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, Norman, Oklahoma, and NOAA/OAR/National Severe Storms Laboratory, Norman, Oklahoma*

Introduction and motivation

- **Statistics of Quasi-Vertical Profiles (QVPs)** using polarimetric X band radar measurements in Bonn, Germany, for 52 stratiform events have been performed. The events last between 1h 20 min. and 12h 30min.

- **1st Application:** Look-up tables with 6 numbers (in red, Fig. 1) characterizing the estimated intrinsic vertical profile of reflectivity for a **new Polarimetric VPR technique**. Correlations among the polarimetric variables are used to narrow down the search for the optimal look-up values.

- **2nd Application:** Gradients in reflectivity Z_H and enhanced specific differential phase K_{DP} in the dendritic growth layer (DGL) indicate precipitation enhancements near the surface with lead times > 30 min. These promising signatures for **nowcasting precipitation** are noisy in PPI scans or reconstructed RHIs but nicely detectable in QVPs.

Quasi-Vertical-Profiles (QVPs)

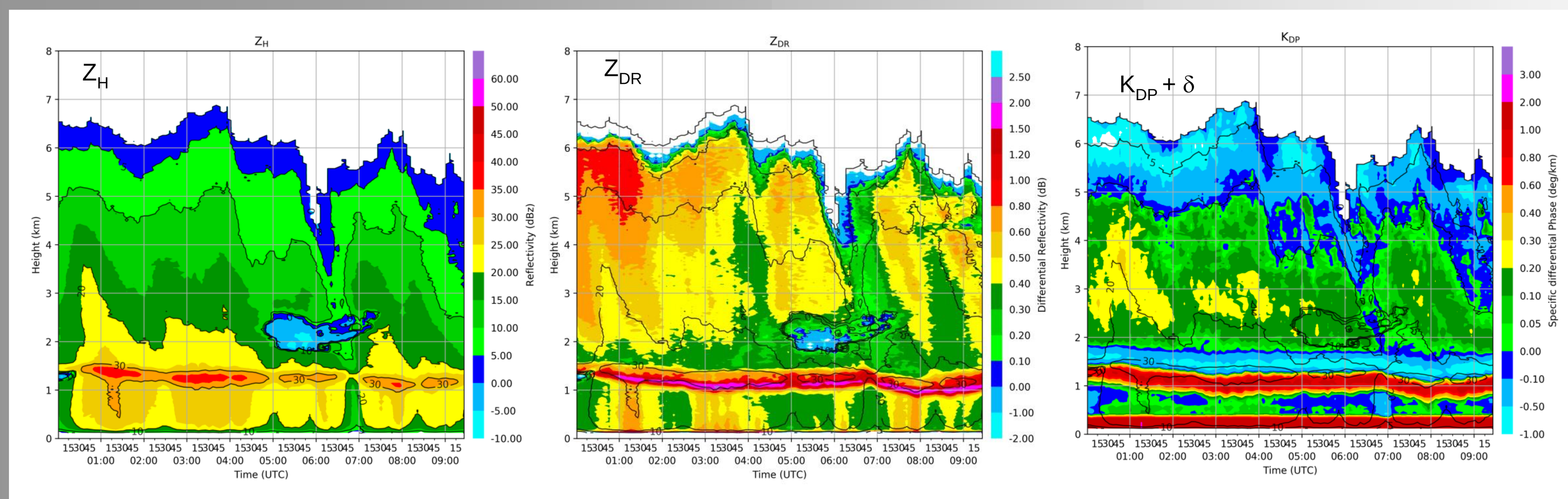

Fig.2 : QVPs observed with the polarimetric X-band radar in Bonn, Germany, on 16 November 2014.

Polarimetric variables in the melting layer (ML)

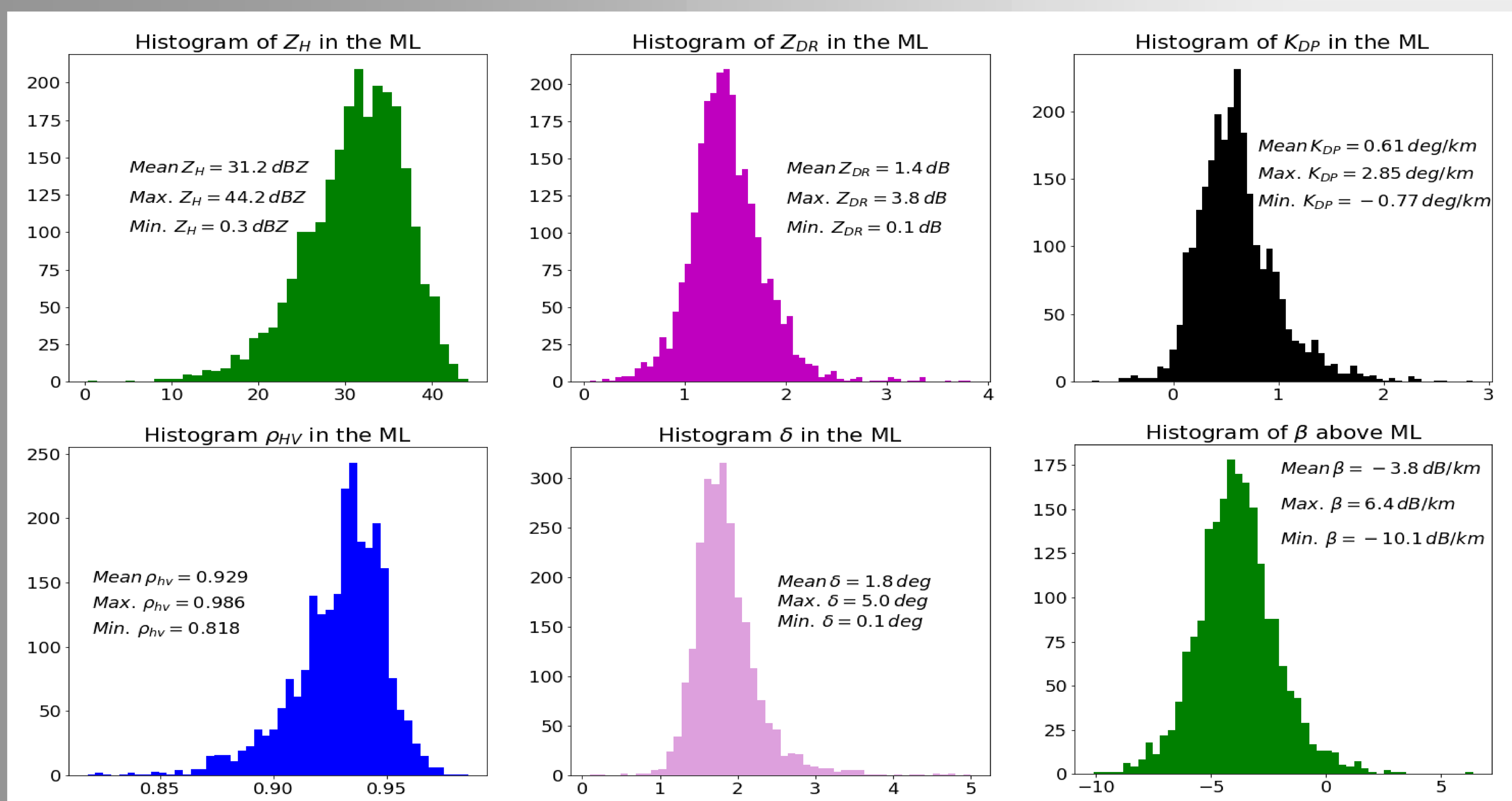

Fig.3: Histograms of the polarimetric variables in the ML and the slope β above the ML at X band based on 52 stratiform events analyzed in terms of QVPs.

Polarimetric VPR technique

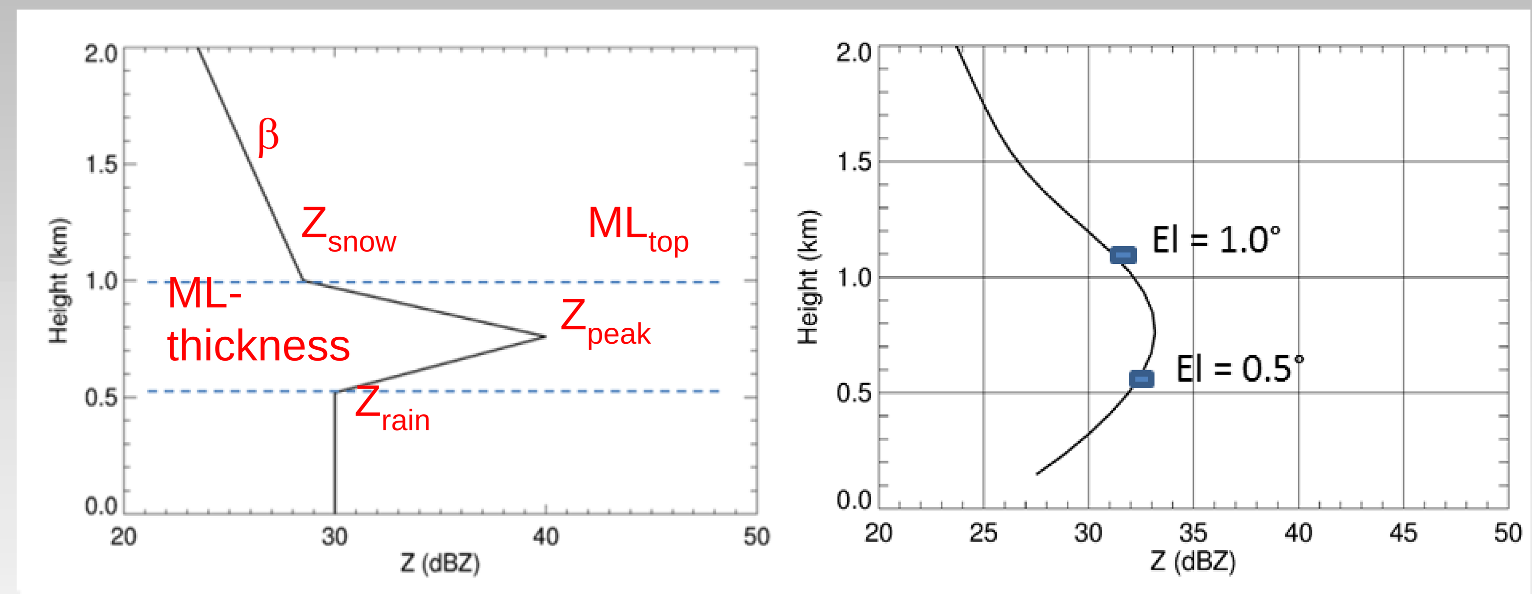

Fig.1 : Schematic of an intrinsic profile of reflectivity Z_H characterized by 6 numbers (left) and corresponding measured Z_H values (blue points). At elevation 0.5° Z_H is about 32.5 dBZ, which is 2.5 dB higher than the "true one" in rain according to the intrinsic profile of Z_H, i.e. 2.5 dB has to be substracted.

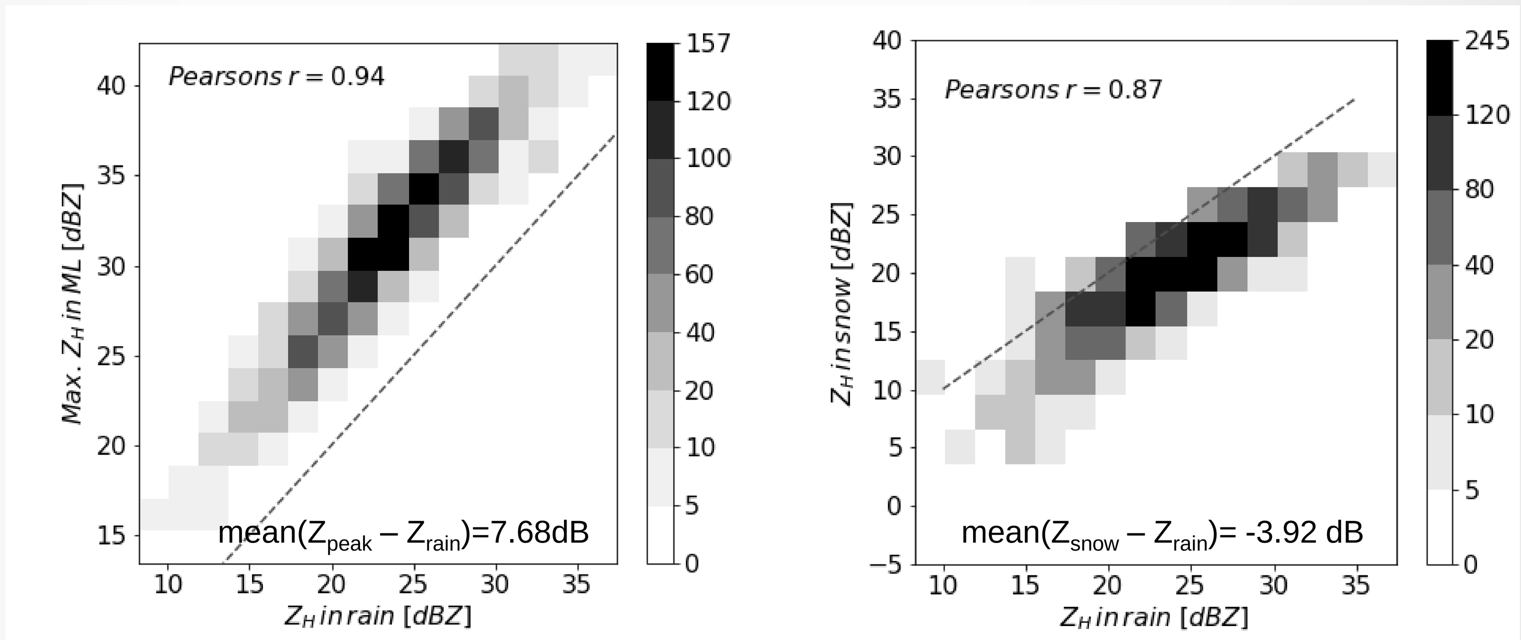

Fig.4 : Scatter density plots based on 52 events comparing the peak reflectivity Z_{peak} with reflectivity Zrain just below the ML (left) and reflectivity in snow Z_{snow} just above the ML with reflectivity in rain Z_{rain} (right).

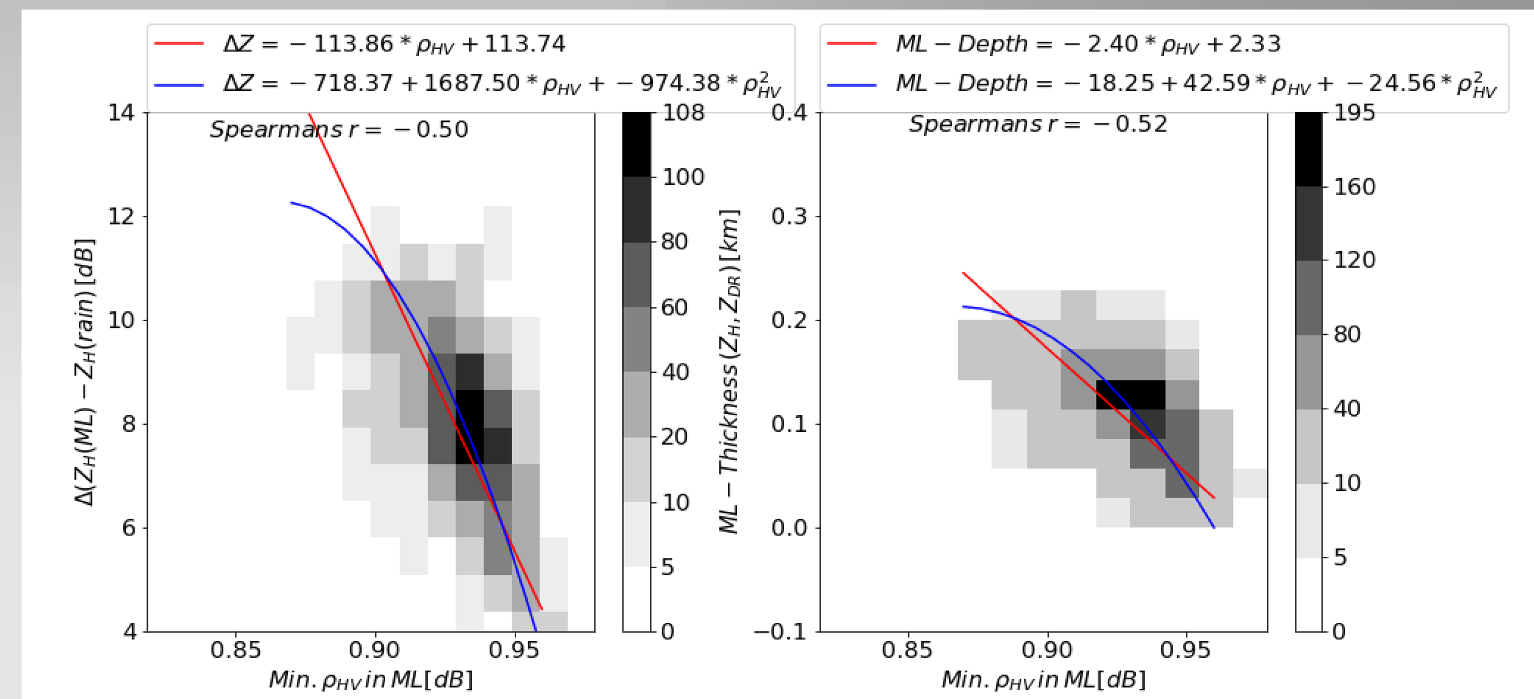

Fig.5 : Scatter density plots based on 52 events comparing ($Z_{peak} - Z_{rain}$) with cross-correlations coefficient ρ_{HV} in the ML (left) and the difference in the heights of the Z_H and Z_{DR} maxima (proportional to ML-thickness) with ρ_{HV} (right).

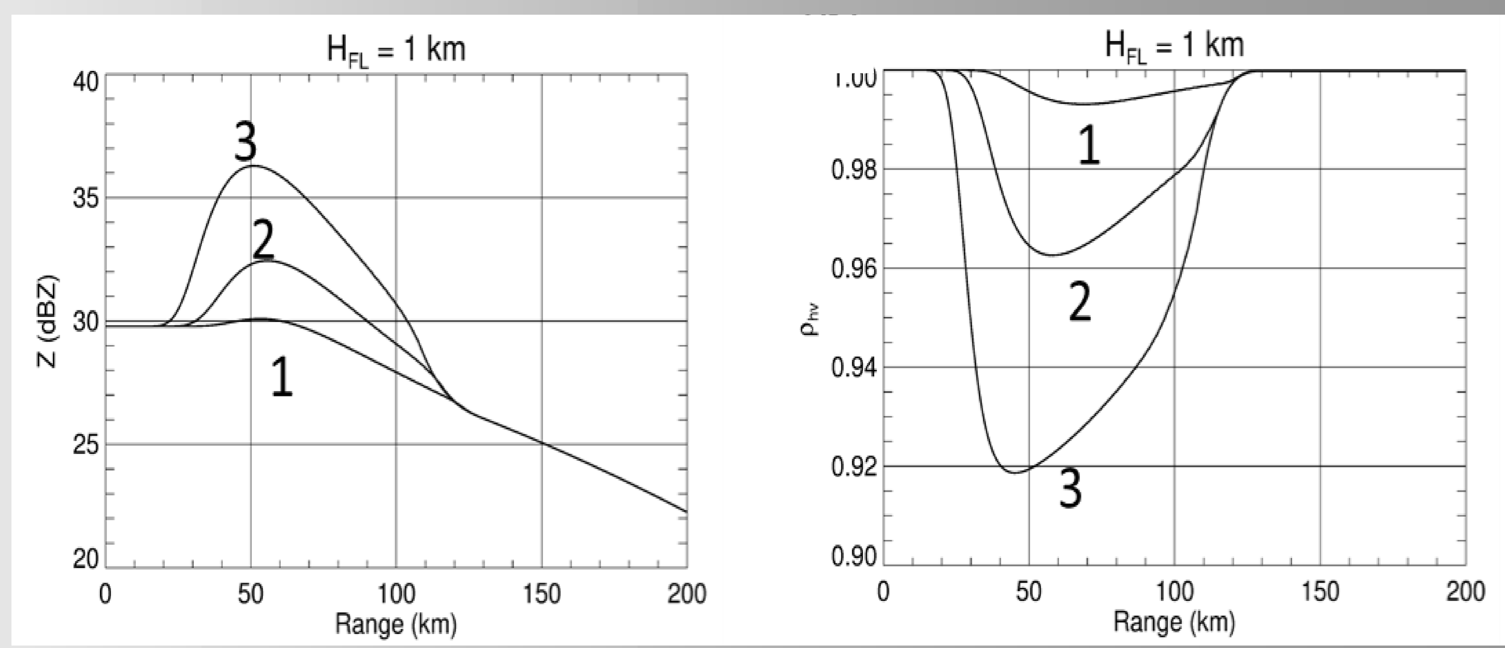

Fig.6 : Radial profiles of Z_H and ρ_{HV} for different values of ΔZ= ($Z_{peak} - Z_{rain}$) and ΔH=ML-thickness. Index "1" corresponds to ΔZ = 4 dB and ΔH = 0.2 km, index "2" – to ΔZ = 8 dB and ΔH = 0.4 km, and index "3" – to ΔZ = 12 dB and ΔH = 0.6 km.

Nowcasting precipitation exploiting signatures in DGL

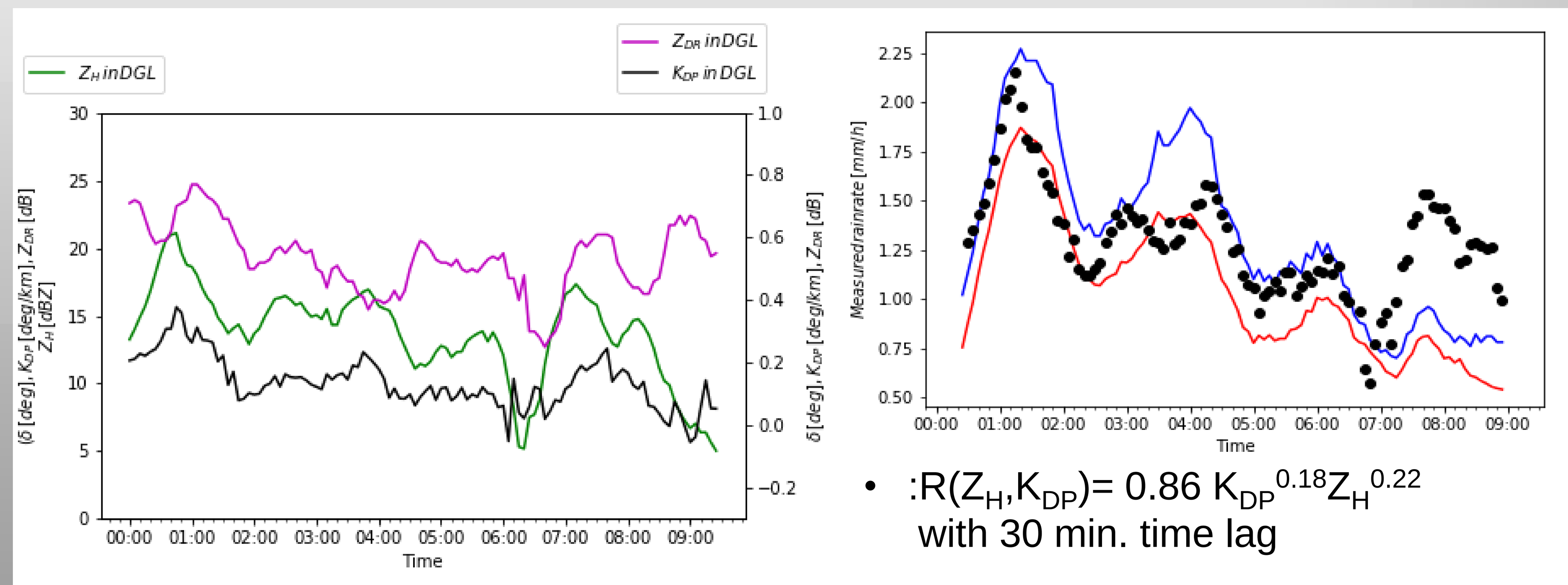

Fig.7: Temporal evolution for Z_H, K_{DP} and Z_{DR} in the DGL for 16 November 2014 (left, compare Fig. 2). Mean measured hourly rain rates during that event based on 2 (blue line) and 5 (red line) rain gauges near the surface together with the fitted rain retrieval R(Z_H, K_{DP}) exploiting the signatures in the DGL (right panel, black dots) taking 30 min. lag time into account. The Pearson correlation coefficient between Z_H in the DGL and near the surface is maximal at this lag and amounts to 0.86.

Conclusions

- The final polarimetric VPR allows to pick an appropriate intrinsic profile of Z_H from the lookup table depending on (1) the height of the ML and (2) the measured variables Z_H, Z_{DR}, and ρ_{HV}. Since ρ_{hv} correlates well with ΔZ = ($Z_{peak} - Z_{rain}$) and ΔH=ML-thickness (see Fig. 5), one can pick up an appropriate Z_H-profile based on ρ_{hv} and estimate the bias of Z_H attributed to the bright band contamination at every distance from the radar (see Fig. 6). At longer distances from the radar the range dependency of Z_H is determined by the slope β. The slope and the corresponding negative bias of Z_H can be obtained from the difference of Z_H at two successive antenna elevations (e.g., 0.5º and 1.0º).

- The use of Z_H and K_{DP} in the DGL is promising for nowcasting precipitation (Fig.7) but blobs of snow generated above can be advected away from the radar location. Their trajectory to the surface using wind information has to be calculated.