The measurements of backscatter differential phase δ in the melting layer at X and S bands

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Introduction and motivation

- The practical utilization of the backscatter differential phase δ, a tell sign for Mie scatterers, is not well explored yet.
- δ bears important information about the dominant size of raindrops and wet snowflakes in the melting layer.
- The magnitude of δ can be utilized as an important calibration parameter for improving microphysical models of the melting layer.
- Thus, analyses of δ, together with horizontal reflectivity Z_H, differential reflectivity Z_{DR}, and cross-correlation coefficient ρ_{hv} within the melting layer measured at X band in Germany and at S band in U.S. have been performed to further explore its informative content for microphysics studies.

Moderate δ at X Band observed in Germany

480 snapshots for 13 different storms observed with the polarimetric X-band radars in Bonn (BoXPol) and Jülich (JuXPol) have been analyzed.

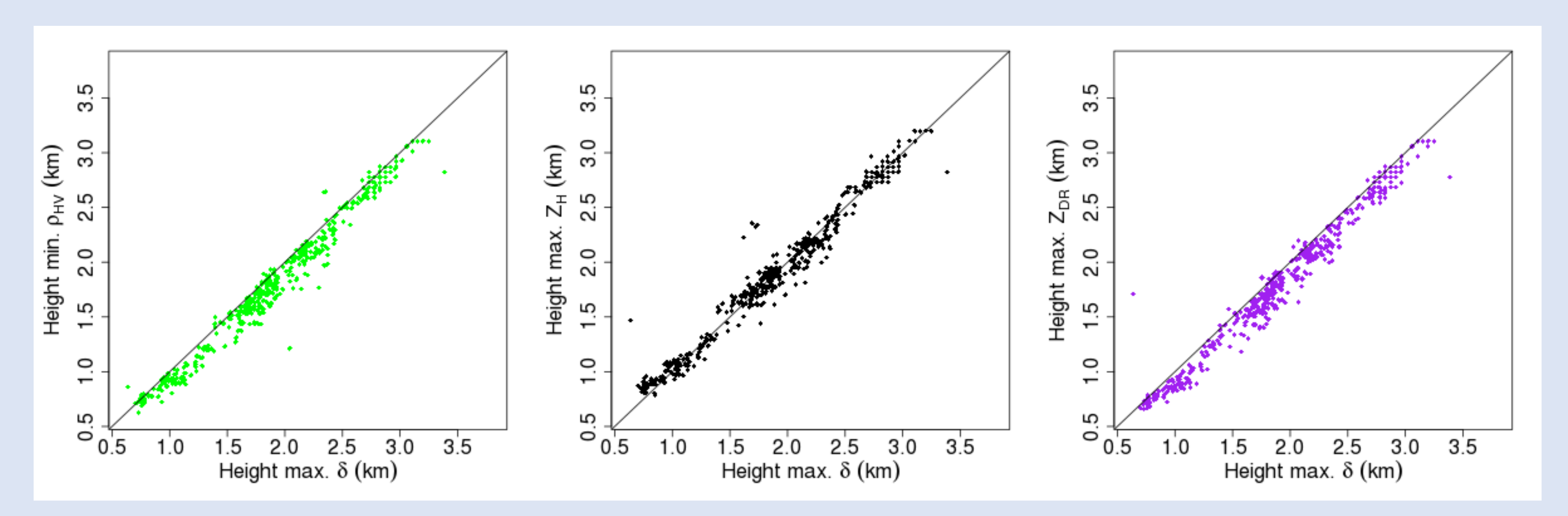

Fig.1 : Relative heights in Z_{DR}, ρ_{HV}, and δ in the melting layer observed with BoXPol and JuxPol.

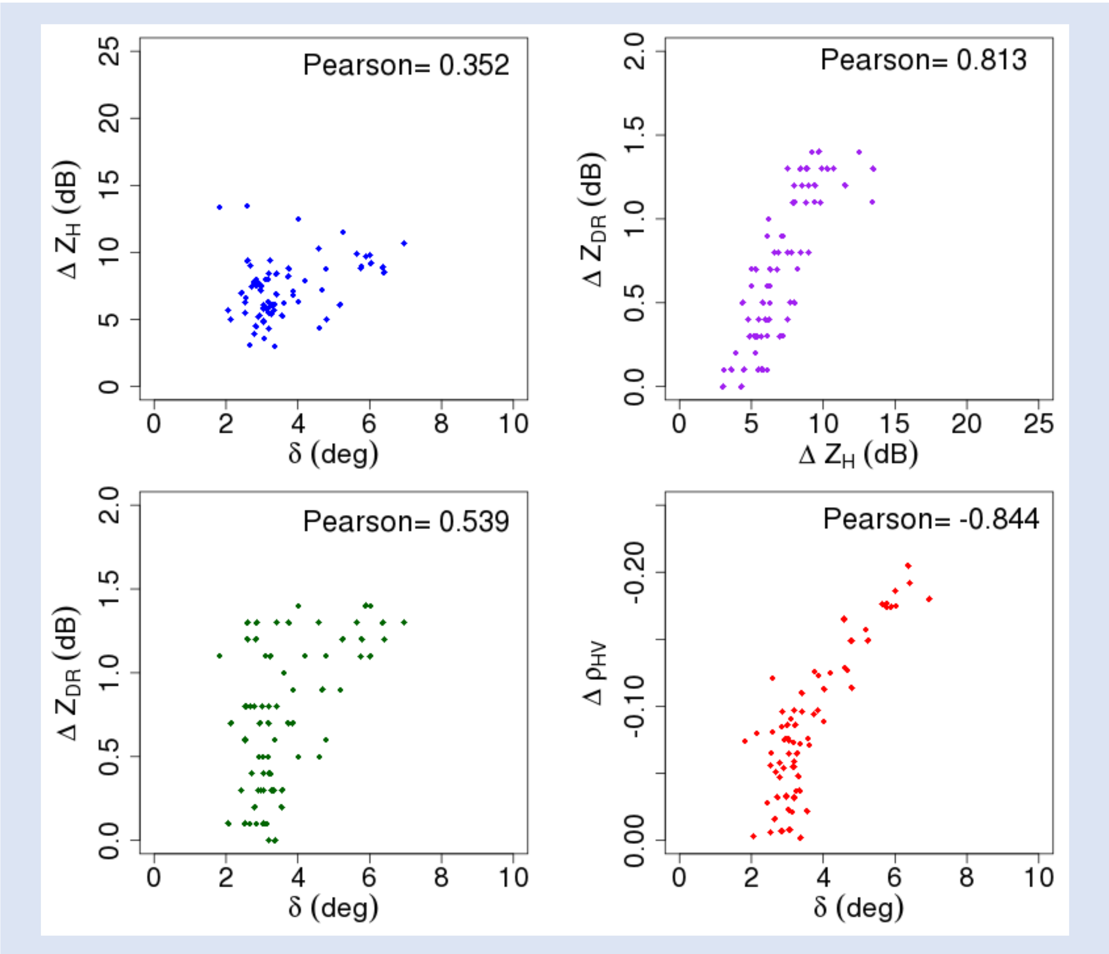

Fig.2: Correlations between anomalies in the melting layer observed on 4 December 2011 from the 7° elevation angle PPI taken by the BoXPol polarimetric radar in Bonn.

Estimating backscatter differential phase δ in the melting layer (ML)

- Measured total differential phase Φ_{DP} routinely exhibits characteristic "bumps" within the ML which may be associated with either δ or with nonuniform beam filling (NBF).
- Estimating δ in the melting layer requires azimuthal averaging of radial profiles of Φ_{DP} at high antenna elevations (>7°).
  - ✓ At higher elevations the forward propagation contribution to the differential phase is reduced leading to increasingly "clean" δ without contamination from K_{DP}. Azimuthal averaging is more efficient at higher elevations.
  - ✓ NBF effects are smaller at higher elevations.
- ➢ The method which provides reliable estimates of δ in the ML was first introduced by Trömel et al. (2013).

Observations of dendritic growth

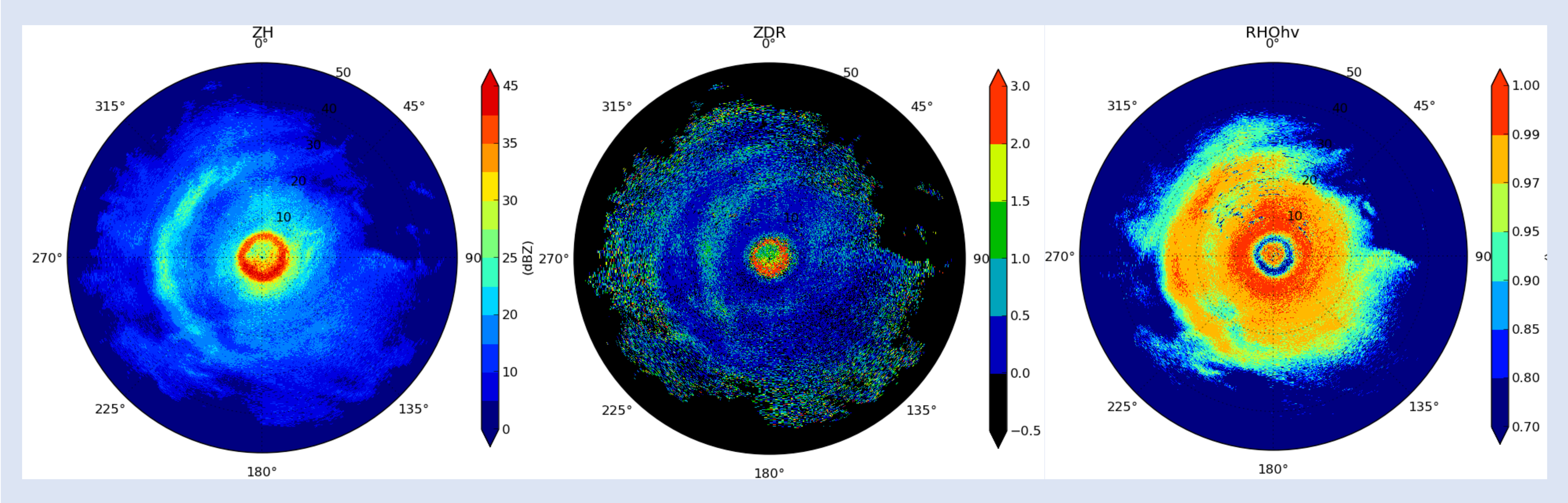

Fig.3 : PPIs of ZH, Z_{DR}, ρ_{HV} observed with BoXPol on December 4, 2011, 21:41UTC at elevation 8.1°.

Results

- Backscatter differential phase δ within the ML is a reliably measurable parameter which exhibits high variability.
- Contrary to expectation, much higher δ has been observed at S band compared to X band (Fig.4,5).
  - ➢ Maximal δ(X-band) = 8.5°, whereas maximal δ(S-band) = 40.° Part of this can be attributed to climate difference between the U.S. and Germany.
  - ➢ Theoretical simulations which assume spheroidal shape of melting snowflakes in the absence of aggregation within the ML yield much lower values of δ than observed in the experiments, especially at S band.
- As expected, correlation between δ and ΔZ_H in the ML is not significant because δ does not depend on particle concentration.
- Strong correlation between δ and $\Delta\rho_{HV}$ is observed in only one case (4 December 2011, see Fig. 2), which is in contrast with expectations.
- The height level of δ maximum is generally below the ρhv minimum and the Z_{DR} maximum, whereas the relation to the Z_H maximum is not as clear. This is in full agreement with polarimetric theory of the melting layer (Fig.1).
- Larger δ should be associated with larger size aggregates above the ML. No correlation between δ and the depth of the cloud identified so far. However, some link may exist between the appearance of the zone of intense dendritic growth aloft and δ within the ML (see Fig.3).
- The δ signature definitely contains very important microphysical information which has to be further explored.

Huge δ at S band observed in the US

The data for 7 storms observed with the WSR-88D S-band radars in the US were analyzed. All days show well pronounced δ ranging from 18 to 40°.

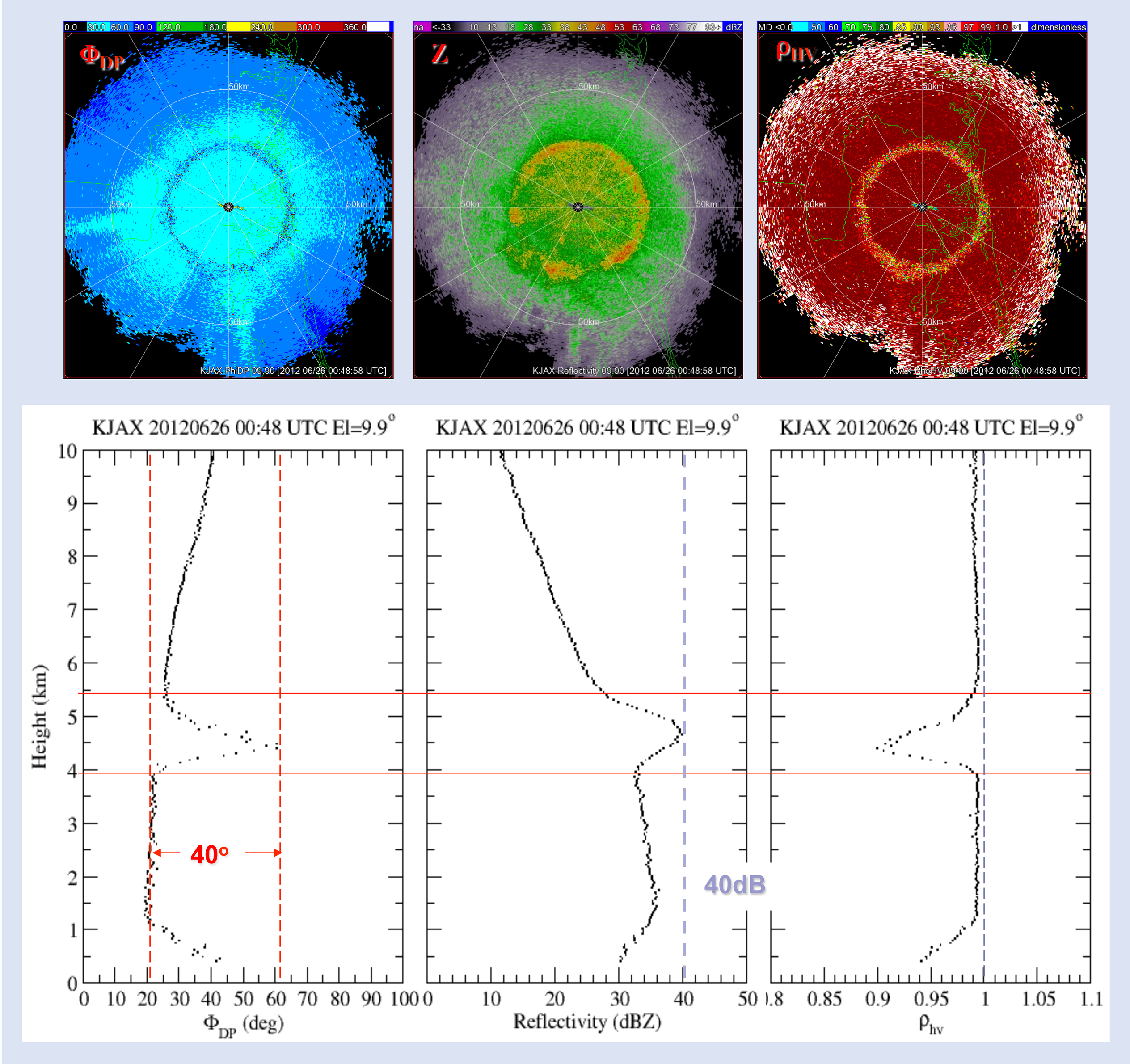

Fig. 4: PPIs and quasi-vertical profiles of Z_{DR}, ρ_{HV}, and δ in the melting layer observed with KJAX radar in Jacksonville, Florida, at 9.9° elevation on 26 June 2012.

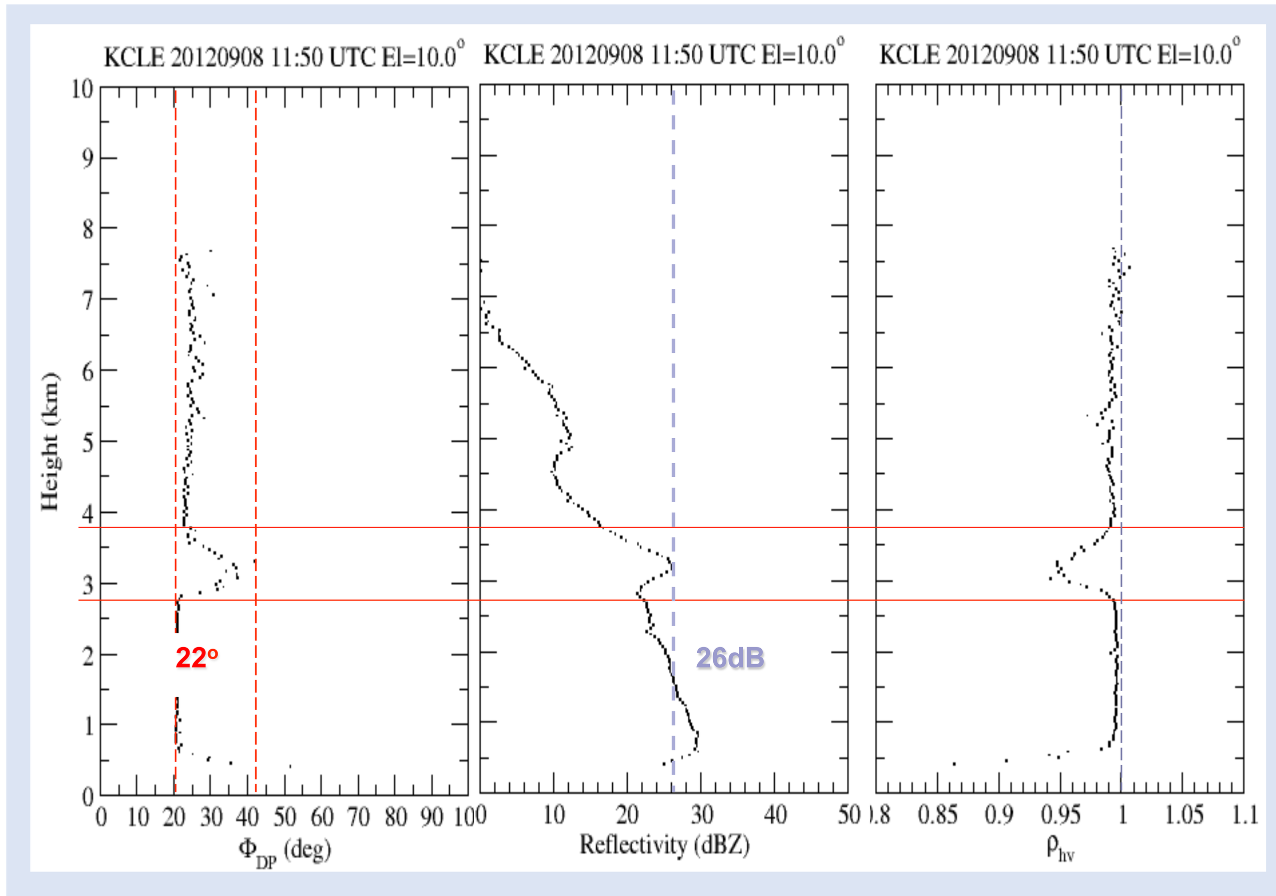

Fig. 5: PPIs and quasi-vertical profiles of Z_{DR}, ρ_{HV}, and δ in the melting layer observed with KCLE radar in Cleveland, Ohio, at 10° elevation on 8 September 2012.