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High resolution estimation of specific differential phase and backscatter differential phase for polarimetric X-band weather radars

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Abstract

Wide interest and considerable effort have been given to estimate the specific differential phase (***Kdp***) and the backscatter differential phase (***δ***) because of their independence to radar miscalibration and attenuation.

In this work, an advanced method to estimate K_{dp} and δ from rain at X-band frequencies is proposed. The method aims to obtain high spatial resolution of K_{dp} and δ estimators while controlling their inherent bias-variance dilemma. In addition, the variance of K_{dp} was mathematically formulated for quality control.

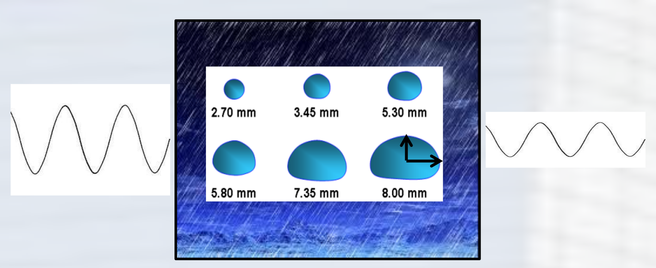
Results have shown that estimated K_{dp} and δ were able to retain the spatial variability of storms, few tens of meters, and produce a variance similar to or less than those of conventional approaches.

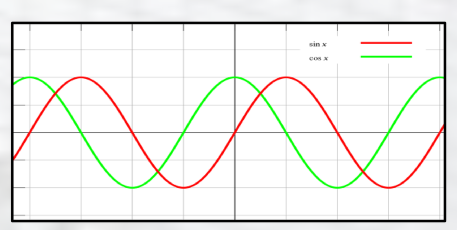
1. Introduction

Differential Phase (Ψ_{dp}) at X-band

(A) **Attenuation** through rain media

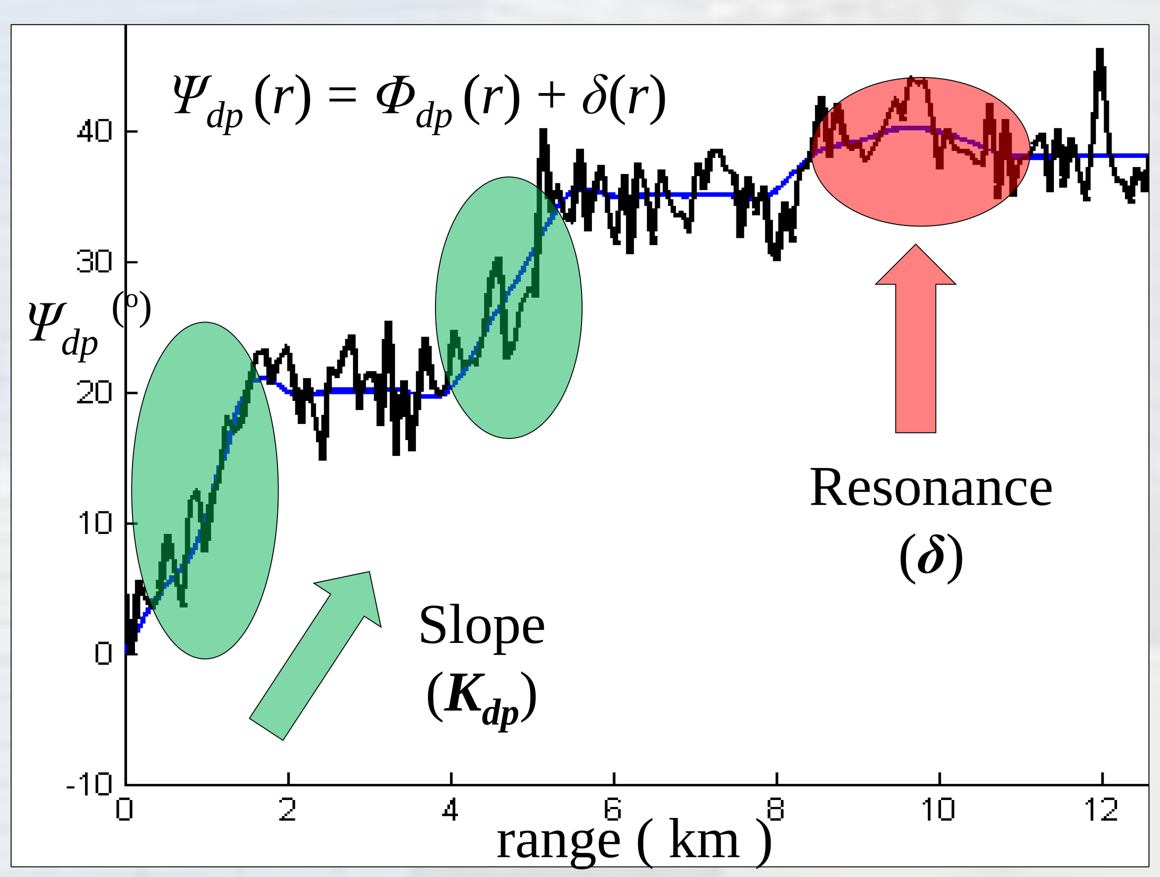
(B) **Phase shift** between H and V ($\Psi_{dp} = \Psi_H - \Psi_V$)





(C) Range profile of a phase shift is **noisy**

(D) Phase shift has a resonance (**backscatter**) component

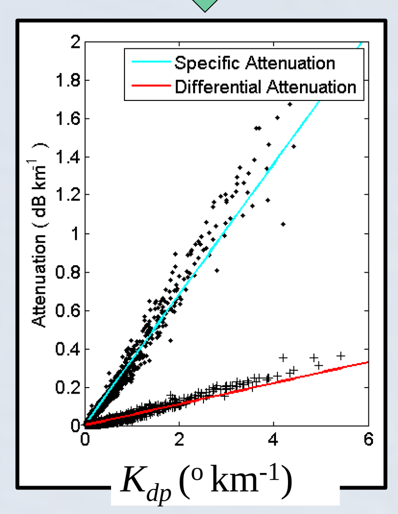


How to reduce noise and resonance effects maintaining the spatial resolution of Ψ_{dp}?

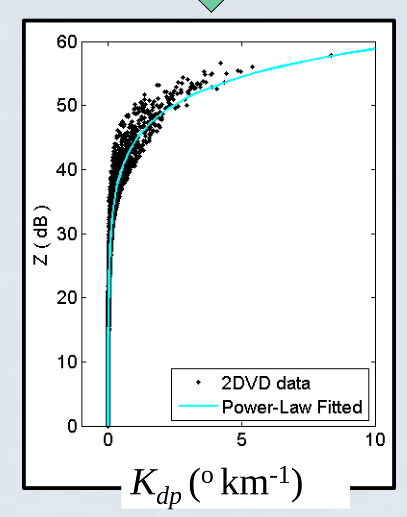
2. Simulated radar variables

Relations between polarimetric radar variables simulated by scattering computation and measured DSD's over 1 year, NL.

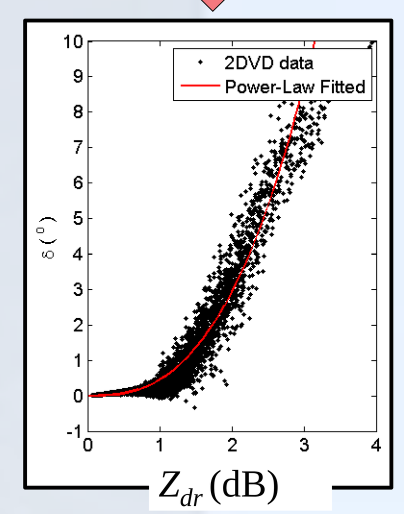
Attenuation vs K_{dp}



Reflectivity vs K_{dp}

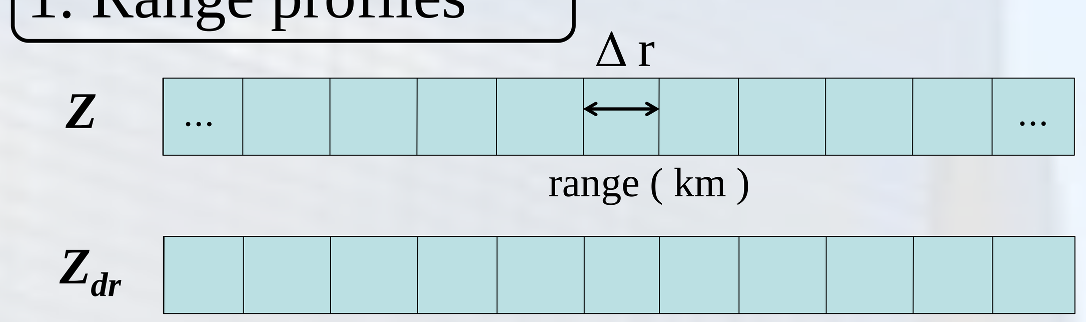


Backscatter vs Z_{dr}

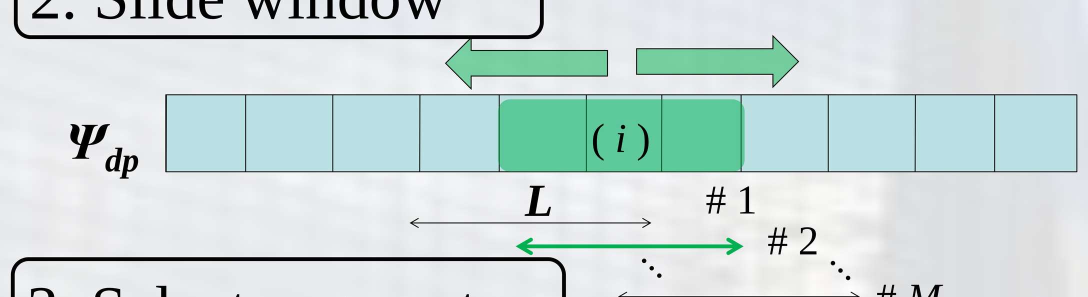


3. The K_{dp} and δ retrieval approach

1. Range profiles

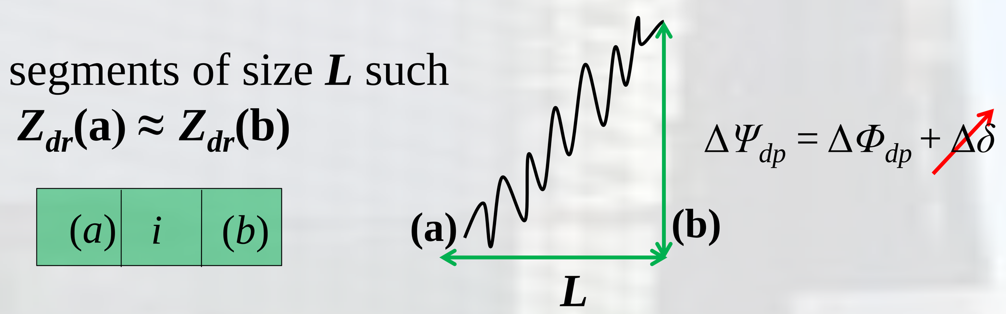


2. Slide window



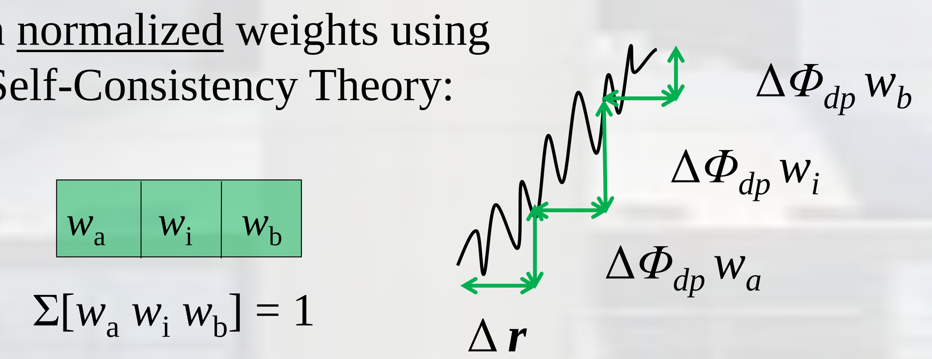
3. Select segments

Choose segments of size L such Z_{dr}(a) ≈ Z_{dr}(b)

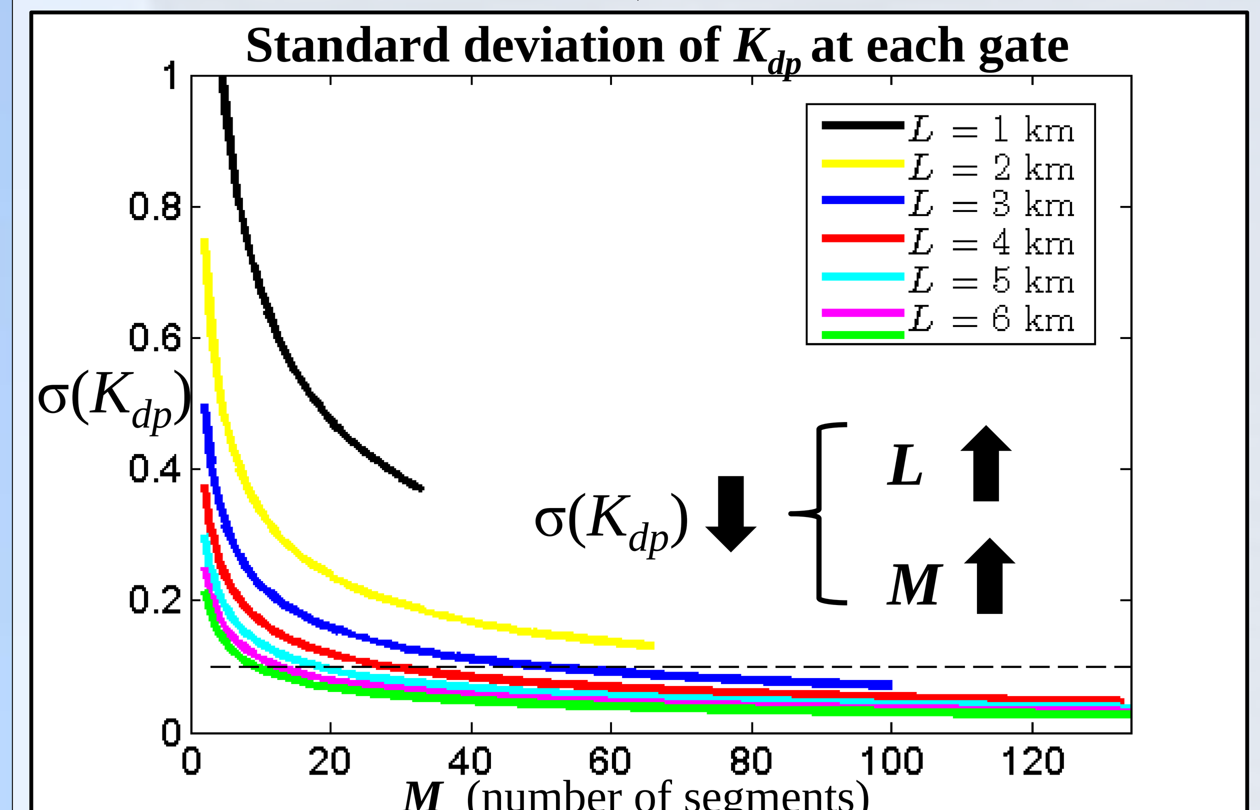


4. Weighted smoothing

Obtain normalized weights using the Self-Consistency Theory:

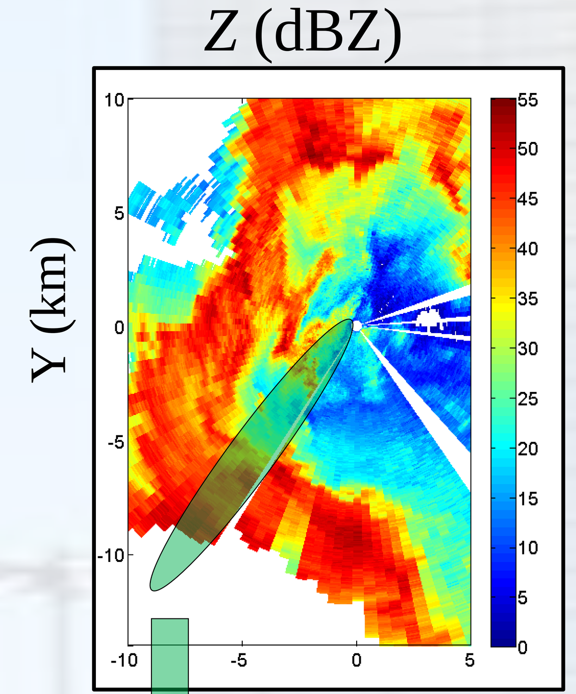


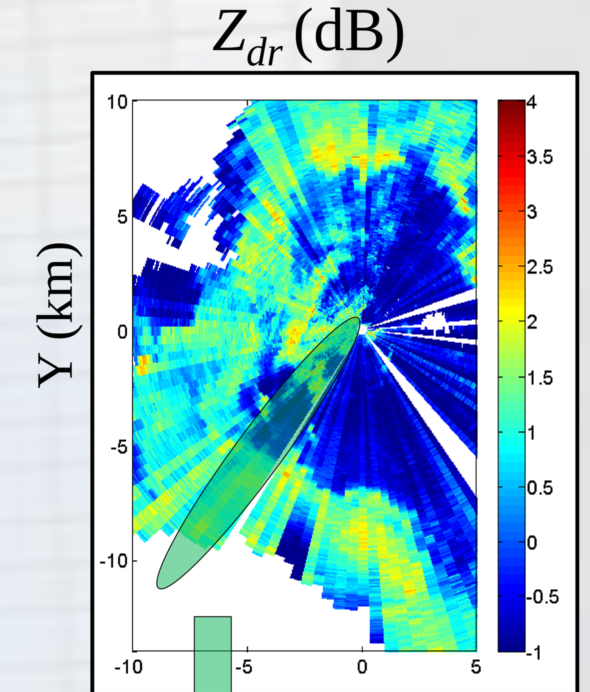
Expected precision of K_{dp}



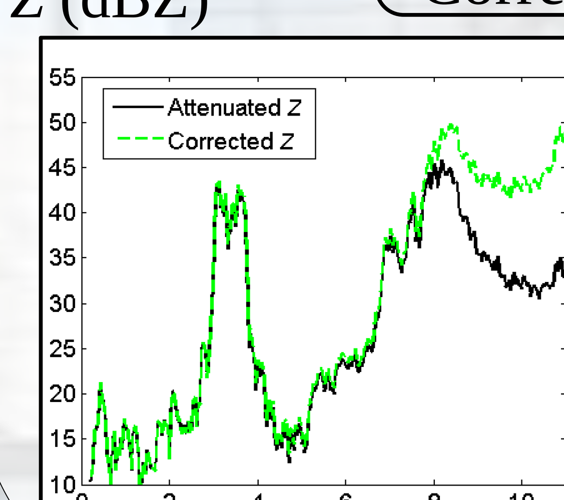
4. Results

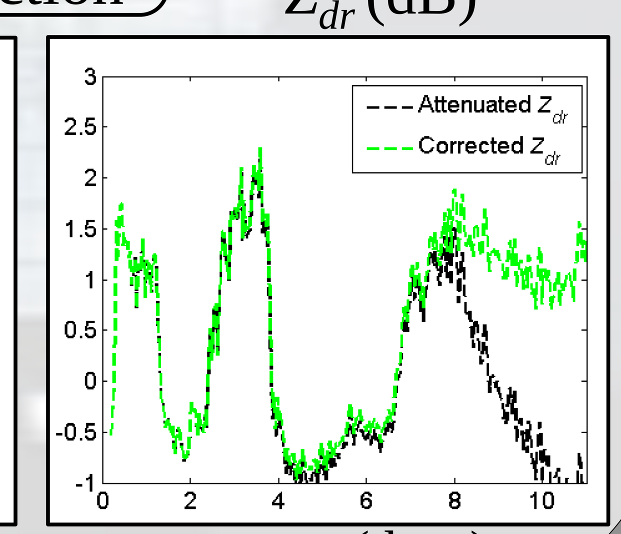
Squall line storm on September 10 2011, 19:50 UTC. Δ r = 30 m and L = 4 km



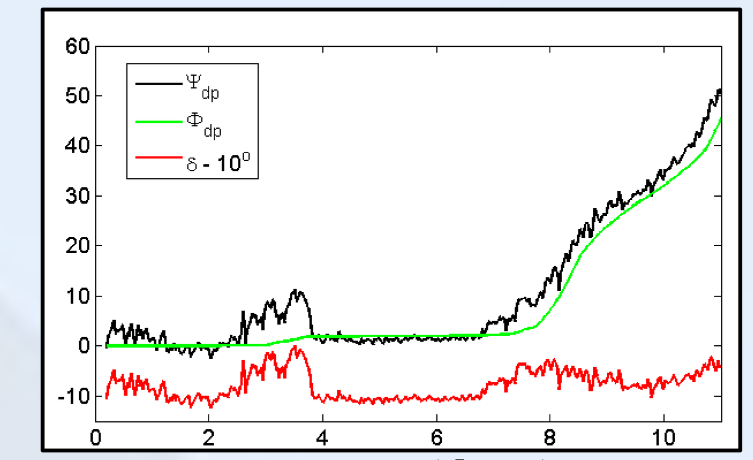


Attenuation Correction



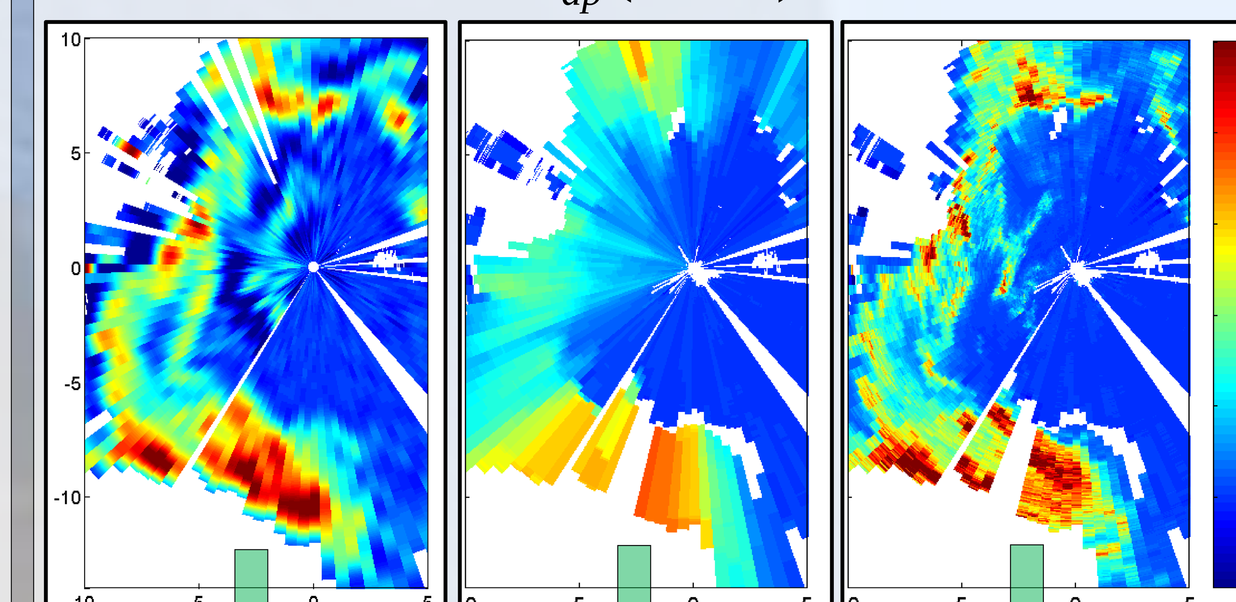


Phase Estimation: Φ, δ (°)

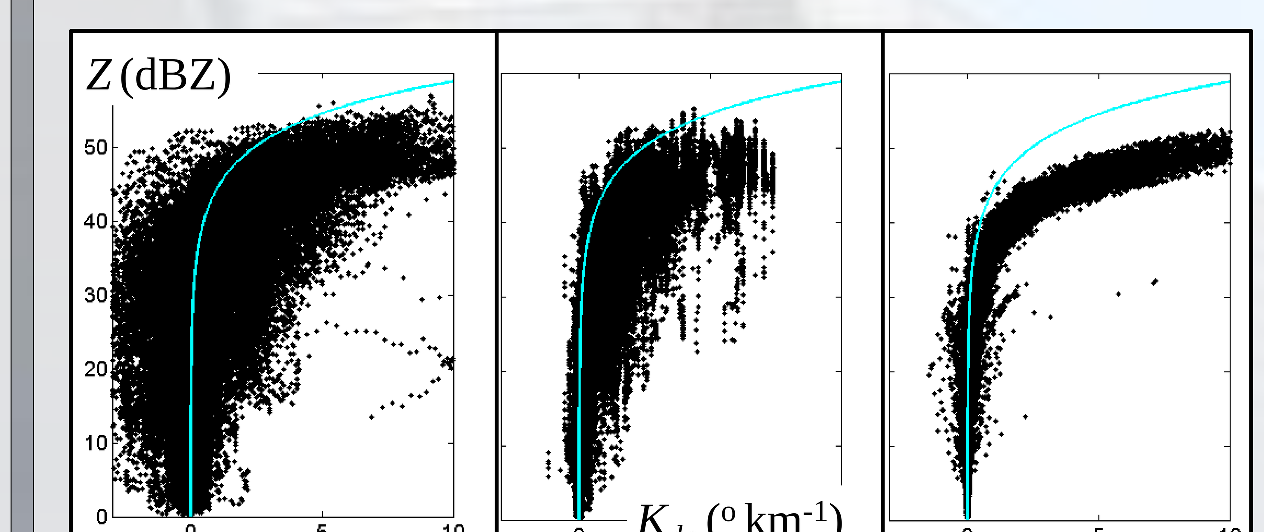


K_{dp} estimation: Evaluation of 3 methods

(1) Iterative Filtering Method | (2) Smoothing | (3) Weighted Smoothing



Consistency between K_{dp} and Reflectivity



Conclusion

- A new approach to retrieve K_{dp} and δ was introduced.
- For K_{dp}, high resolution (30 m) and low standard deviation (0.25 ° km⁻¹) were achieved.
- It is foreseen that the proposed method will improve the quality of radar-based rainfall estimation and therefore benefit urban-hydrology and weather-forecast users.

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