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Polarimetric X-Band weather radar: high-resolution rainfall estimation

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Abstract

Weather observations are conventionally performed by C-band weather radars with spatial and temporal resolution of 1 km and 5 min, respectively. However, in recent years, C-band weather radars have been upgraded from single to dual-polarimetric to improve the quality of their measurements. Still, these spatial and temporal resolutions might be undesirable for the detection of localized heavy rainfall which might be necessary to model fast rainfall-runoff processes in urbanized areas. Therefore, X-band weather radars have been introduced to increase the resolution of rainfall rate (*R*) estimation. For example, in the USA, a network of dual-polarimetric X-band radars has been used to estimate rainfall rates of severe storms at high-resolution (Wang and Chandrasekar, 2010). In Western Europe, the RainGain project includes a network of X-band radars to obtain high-resolution rainfall rates to cope with urban flooding (http://www.raingain.edu).

For dual-polarimetric radars, several rainfall rate estimators have been based on the specific differential phase (K_{dp}) because of its independence to radar miscalibration and attenuation. However, typical estimations of K_{dp} require a substantial amount of smoothing processes. In this work, a new method to estimate K_{dp} for X-band frequencies is introduced. The method is a modified version of the one given by Otto and Russchenberg (2011) in order to control its inherent bias-variance dilemma. In addition, the variance of the K_{dp} estimator was mathematically formulated for a quality control scheme. For moderate and convective storms, the estimation of rainfall rate was given by a R–K_{dp} power-law relation.

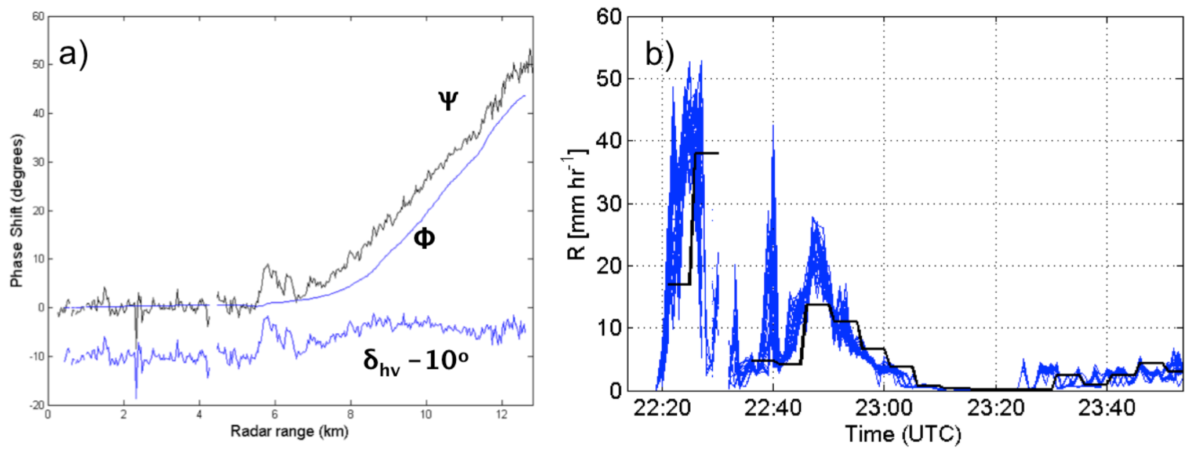

Fig 1: a) Propagation differential phase, Φ_{dp}, constructed from the new estimation of K_{dp}. b) Rainfall rate intensities by IDRA (blue lines) and simulated C-band (black line).

The new method was applied to a storm event observed by the dual-polarimetric X-band weather radar, IDRA hereafter, in the Netherlands on June 28 2011. To show the performance of the K_{dp} estimator, the propagation differential phase (Φ_{dp}) was successfully reconstructed as shown in Fig 1a). Moreover, the impact of spatial and temporal resolutions on the variability of rainfall rates is shown in Fig 1b). Estimated rainfall rates at 30 m and 1 min resolutions using IDRA were averaged and under-sampled at 1 km and 5 min, respectively, to simulate rainfall rates from C-band radars. Results have shown that the estimated K_{dp} and rainfall rate were able to retain the spatial variability of the storm at scales of tens of meters. Furthermore, they were able to produce a variance similar to or less than those of conventional methods. It is foreseen that the proposed method for dual-polarimetric X-band weather radars will improve the quality of radar-based rainfall estimations in real-time as recommended by the urban-hydrology community.

Acknowledgements

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