Abstract
Weather observations are conventionally performed by single-polarimetric C-band weather radars with temporal and spatial resolutions of 5 min and 1 km, respectively. However, in recent years, weather radars have been upgraded from single to dual-polarimetric for improved weather measurements. For example, the dual-polarimetric capabilities might lead to more accurate rainfall estimation than that of single-polarimetric. Still, these temporal and spatial resolutions might be undesirable for the detection of localized heavy rainfall which is usually required to model fast rainfall-runoff processes in urbanized areas. Moreover, small but threatening patterns associated with severe weather might be unseen. In this work, a dual-polarimetric X-band weather radar, IDRA hereafter, located in the Netherlands (NL) is used to obtain accurate rainfall estimation and observe and derive physical processes of storms, at high temporal and spatial resolutions. In this work, rainfall estimation was based on the specific differential phase ($K_d$), for moderate and convective storms. In addition, an advanced method to estimate $K_d$ from pure rain at X-band frequencies is proposed. To analyse the impact of resolution quality on the variability of rainfall intensities, estimates of rainfall intensities by IDRA were used to simulate rainfall intensities at coarse resolutions. Preliminary results have shown significant variability in rainfall intensities when the spatial resolution was decreased from 30 m to 1000 m. Observations of multiple storms by IDRA were compared with those of the operational C-band radars of the NL. High resolutions observations by IDRA were able to capture essential patterns, such as the hook-like echo, associated with non-supercell storms which were difficult to detect by the C-band radars.

Why $K_d$?
- Independent to radar calibration and attenuation.
- Independent of rainfall mixtures.
- Low sensitivity to variability of rainfall size distribution.
- High sensitivity to rainfall shape and liquid water content.
- Suitable candidate to estimate R.

K$_d$ Estimator:
$$K_d = \sum_{j=1}^{M} \psi_j - \sum_{j=1}^{M} \phi_j$$

$\psi_j$ is the phase observed at $\phi_j$.

$\Delta(\psi)$ is AHK.

Part I: Specific Differential Phase ($K_d$) and Rainfall (R) Estimators

K$_d$ Analysis:
- $L = 4$ km and averaged $K_d = 0.25 \pm 0.1$ km$^{-1}$
- Low computational time
- High spatial resolution of 30 m
- High $K_d$’s values

Estimator and Precision of R:
$$\hat{R} = 1.3K_{dp}^{0.75}$$

Comparison of Rainfall Accumulation:
- An advanced method to estimate $K_d$ from pure rain at X-band frequencies was proposed. The method aims to obtain high spatial resolution of $K_d$ estimators while controlling their inherent bias-variance dilemma. Results shown that $K_d$ was 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.
- It is found that weather surveillance performed by dual-polarimetric X-band radars would lead to early detection of crucial storm patterns and improve the quality of radar-based rainfall estimation as recommended by both, weather-forecast and urban-hydrology communities.

References: