Optimizing the capabilities of weather radars: The impact of error correction and uncertainty identification on quantitative precipitation estimation for hydrological applications

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Over the last decades weather radars have been used to obtain real-time information on observed precipitation systems. Unfortunately, weather radar measurements are affected by multiple sources of error, which in many situations are to a limited extent operationally corrected for using the available volumetric information. Instead, usage is made of operational rain gauge data to correct for additional bias. However, small-scale variability of precipitation and limited spatial representativity of rain gauge networks complicate this approach.

We envision that much better use can be made of the real time available volumetric data to improve quantitative precipitation estimates by weather radars without relying on rain gauges. In the current work, we will motivate this vision by presenting the impact of coherently correcting the volumetric weather radar information for reflectivity measurement and conversion errors for two different datasets.

First, we will evaluate its impact on the quality of the volumetric weather radar measurements during an intense long duration Mesoscale Convective System that resulted in 160mm of total rainfall accumulations in The Netherlands. The operational weather radar network was only able to estimate 30% of the total rainfall accumulations, without performing any bias correction using rain gauge information. Second, the long-term impact of volumetric error correction is evaluated for a weather radar situated in the Belgian Ardennes region for a winter season. Also here, the operational weather radar underestimates precipitation amounts.

By coherently correcting both datasets for the different types of reflectivity errors (e.g. clutter, VPR, wet radome, attenuation, Z-R variability) the quality of both weather radar datasets becomes comparable to precipitation estimates obtained by the operational rain gauge network, without performing any direct bias correction using gauge information. As such, hydrological simulation using the weather radar provides similar results as using the rain gauge product.

Even though both products provide comparable precipitation results, considerable uncertainty in the radar precipitation product exists. To identify the impact and possibilities of making use of this uncertainty, three different approaches are presented assessing the impact of VPR, Z-R and drop size distribution (DSD) variability. The uncertainty obtained by the former two approaches result in much better runoff peak simulations when the volumetric weather radar data are used, which from an operational perspective is of high importance and interest. Next, taking the impact of DSD variability into account we observe a positive correlation between the different DSD parameters. For future applications this can result in a decrease in the uncertainty of the applied Z-R and Z-k relationships.