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Radar based precipitation estimation in real time for flood and drainage management in urban areas

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Flood and drainage management in urban areas requires rainfall information highly resolved in space (dx/dy $\approx$ 500 – 1.000 metres) and time (dt $\approx$ 1 – 5 minutes). Radar rainfall data are able to provide this information, but for direct use in runoff models a high level of accuracy of quantitative precipitation estimates is strictly necessary. Further, radar rainfall information must be provided in real time to meet the requirements for operational aspects (flood warning, real time control).

However, radar rainfall measurements at X- and C-band frequencies are highly uncertain and suffer mostly from signal attenuation due to rainfall and spatio-temporal variability of R-Z relations to convert reflectivity into rainfall. The common approach – mean field bias adjustment of radar measurements by rain gauges – is prone to underestimate the rainfall in convective situations which is a matter of the insufficient density of gauge networks compared to the small areal extend of convective precipitation structures.

To overcome these problems a radar data processing methodology for single polarized radar data was developed which comprises the following steps:

I. Radar correction:

1. Clutter correction
2. Wet radome attenuation correction
3. Radar signal attenuation correction
4. Areal differentiated allocation of R-Z conversion based on texture analysis of reflectivity fields and assignment of predefined characteristic R-Z relations

II. Mean field bias (MFB) adjustment using ground observations to reduce the remaining systematic error.

The methodology is applied to 21 rainfall events between 05/2012 - 09/2014 which occured in the catchments of the rivers Emscher (775,5 km^2) and Lippe (4.889,9 km^2). Radar reflectivity data (DX-product) were provided from the Essen C-band radar (polar coordinates, gate length: 1 km, azimuth: 1°, dt = 5 minutes). 69 rain gauges located in the catchments operated by Emschergenossenschaft/Lippeverband (EG/LV), two self-governing water boards under special law were used for MFB-adjustment.

The averaged results for the 21 events demonstrate that:

- Wet radome and radar signal attenuation account for the most portion of radar underestimation.
- The attenuation correction is effective to reconstruct the “true” reflectivity field in convective situations.
- The areal differentiated R-Z conversion shows significant improvement compared to the constant use of a single R-Z relation.
- The mean absolute error for radar correction and subsequent MFB-adjustment is found at a magnitude of 1.0 mm/gauge.

The alternative testing of geostatistical merging methods, here regression kriging, instead of step II MFB-adjustment provides further improvement in situations of radar signal loss, bright band etc, only.