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Hydrological use of radar data for extreme value analysis: Observed Range Effects

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The hydrological use of radar data for extreme value analysis has just been started, due to reliable observation time series of at least ten years (Overeem, 2009; Koistinen et al., 2008). Works of Einfalt and Scheibel (2014) have shown a small scale variability of extreme rainfall in the order of 20% for the highest events within a nine pixel surrounding. Additionally, Schellart et al. (2012) have shown the variability of point rainfall within 1 km^2 being also in the order of 20%. Therefore, uncertainties encountered should be analysed more in detail, pinpointing their causes.

The current work investigates into the occurrence frequency of reflectivities at the radar location Essen in Germany, as function of distance from the radar and azimuth (including the effects of elevation and scan volume of the precipitation).

The preliminary part of the investigation was a theoretical computation of the effect of the different measurement volumes on extreme precipitation. For this, it was assumed that a 60 dBZ measurement was made for a precipitation cell within one pixel at 5 km distance from the radar with no rain outside the pixel and that the reflectivity factor was directly related to the measurement volume only. The precipitation cell of 0.005 km^3 size was then moved away from the radar and it was calculated for successive distances from the radar how much reflectivity would be measured by the radar within the larger measurement volume. This calculation was purely geometric and resulted in a reduction of reflectivity from 60 dBZ at 5 km from the radar down to 31 dBZ at 125 km from the radar. A similar computation was performed for a cell at 20 km from the radar which resulted in a final reflectivity factor of 44 dBZ at 125 km. Variations have been performed with different neighbouring reflectivity values around the original cell.

The result from these calculations showed a clear tendency to a decrease of reflectivity values with growing distance from the radar. The objective of the second part of the study was the quantification of the effect in order to possibly produce a correction for extreme value statistics.

Basic data for this second part of the analysis are corrected (Frerk et al. 2012) polar scan data of the precipitation scan, a scan of 1° x 1km performed every 5 minutes at an elevation of 0.8°. Available data comprise the time interval of 1 November 2001 to 31 October 2014, i.e. 14 years of observations.

Within the observation period, three different instruments were used:

- Essen1, a C-band single pol radar which was equipped with Doppler since March 2004 (11/2001 to 4 march 2010) with 1.1° beam width
- Essen_interim, a C-band single pol Doppler radar (4 March 2010 to 11 April 2012) with 1.6° beam width
- Essen2, a C-band dual pol Doppler radar (since 11 April 2012) with 0.9° beam width

Due to the differences of the instruments, the investigation period was cut into three sub periods, corresponding to the respective operation periods of the different radars.

Complete time series of dBZ values were analysed for an extract of 900 points: the points were selected with a range step of 5 km (5 - 125 km) and an azimuth step of 10° (10 - 360°). The occurrence frequency of each reflectivity class (0.5 dBZ to 65 dBZ) was computed and aggregated.

The emphasis of the study was the effect of range on the observation of extreme values - therefore it was attempted to exclude bright band effects, snow and beam overshooting by restricting the analysis to the months June, July and August.

The results of the investigation showed that

- the three radars performed profoundly different
- a clear range effect could be observed on radars Essen1 and Essen_interim, but not Essen2
- occurrence frequencies were very different at different distances, for the three radars:
  - the two older radars showed a clear decrease in sensitivity for small values of reflectivity at far distances
  - a maximum of detected precipitation was a medium range
  - the highest occurrence values close to the radar were between 5 and 10 dBZ
  - high reflectivities beyond 50 dBZ are relatively rare and therefore statistically unstable

- a range dependent correction function also needs to be reflectivity factor dependent (and is therefore impractical)

As a conclusion, a range (hight and volume) dependent correction of the data of the three radars cannot be recommended in this stage of investigation at the radar Essen due to the high variation in the data and the missing range effect at Essen2 radar.

References:

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