Capturing the variability of the DSD actually improves the estimate of the ground rainfall from weather radar

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Based on the concept of normalization of the drop size distribution (Testud et al., 2001) and on the rain profiling algorithm (Testud et al. 2000), the authors have developed a software to process dual pol radar data that has been used for operational purpose in the Mediterranean Alps for more than 10 years. This paper presents an evaluation of the accuracy of the rainfall retrieval, based on its comparison with that observed by experimental and operational rain gauge networks. From dual pol radar, it is possible to derive parameter N_0* characterizing the DSD variability. In this paper, a particular focus is devoted to the impact of N_0* retrieval on the accuracy of the radar derived rain rate.

Weather radar is a remote sensing technique, and as such, requires "ground truth" to be validated. As far as quantitative precipitation estimate is concerned, the only instrument that the hydrologists trust is rain gauge. Thus, the only way to validate rainfall measurement from radar is comparison with rain gauge measurement. However, there is a serious methodologic problem when comparing rain estimates from the two instruments, related to their *quite different sampling* (almost point measurement for the rain gauge, and typically 1 km^2 for the radar) and to the extreme *space and time variability of rain*.

According to Gebremichael and Krajewski (2004), the spatial correlation function ρ of rainfall can be described by the following model: $\rho(h)=\exp[-(h/R_0)^F]$, where h is the separation distance, R_0 is the spatial correlation radius and F is the shape parameter. It is shown that this model (already used in Moreau et al., 2009 for Beauce plain observations) describes remarkably well the recent observations of extreme events (2015-2018) in the Mediterranean Alps. It is confirmed that the "correlation radius" of the rainfall field depends drastically on *space integration* (or pixel resolution), *time integration* and *rain intensity*: the smaller is the pixel resolution, the smaller is the correlation radius; the smaller is the integration time, the smaller is the correlation radius; the larger is the rain intensity, the smaller is the correlation radius.

When comparing rain gauge measurement and radar derived rainfall, at 5 mn integration time, a large scatter is generally observed. It should not be concluded that necessarily one estimate or the other is in error. The scatter may simply reflect the effect of the spatial variability of rain. To obtain significant comparison between rain gauges and radar estimates, it is more appropriate to consider integrated rainfall over one hour or one day for which the space correlation radius of rain is sufficiently long. It is nevertheless important to note that, in most practical *real time hydrological applications*, the data of interest is **the "5 mn integrated rainfall at the scale of 1 km^2 or 0,5x0,5 km^2"**, not the "point measurement" operated by a rain gauge.

An error model for the two instruments –rain gauge, at the scale of the pixel resolution, and dual weather radar is presented on the following basis:

The spatial correlation function derived from analysis of the radar rain maps helped us to construct an error model of the "representation error" of the rain gauge at the scale of the radar pixel.

In parallel, an error model of the radar derived rain rate is established, depending on the radar characteristics and scanning strategy. Are considered the radar statistical error, the error associated with the revisit time, the radar “representation error” (growing with distance as the sampling altitude of the beam); Finally the error inherent to the rain retrieval algorithm, distinguishing the “standard polarimetric” (without N_0* retrieval) and “ZPHI®” (with N_0* retrieval).

The result of the error model is illustrated in the attached figure.

To experimentally validate this model, we use an approach currently used by the hydrologists to characterize the rain regime at a given geographic location: it consists of considering the curve of cumulative frequency of rain rate above a given threshold. In this paper, we compare the obtained curves of this kind obtained:
For the operational raingauges under the radar fooprint;
For the coincident radar pixel, with the «standard polarimetric algorithm »[that does takes into account N0*] and the ZPHI® algorithm (including N0*estimate].

Keywords: Quantitative Precipitation Estimate, Particle Size Distribution, Dual Pol Weather Radar

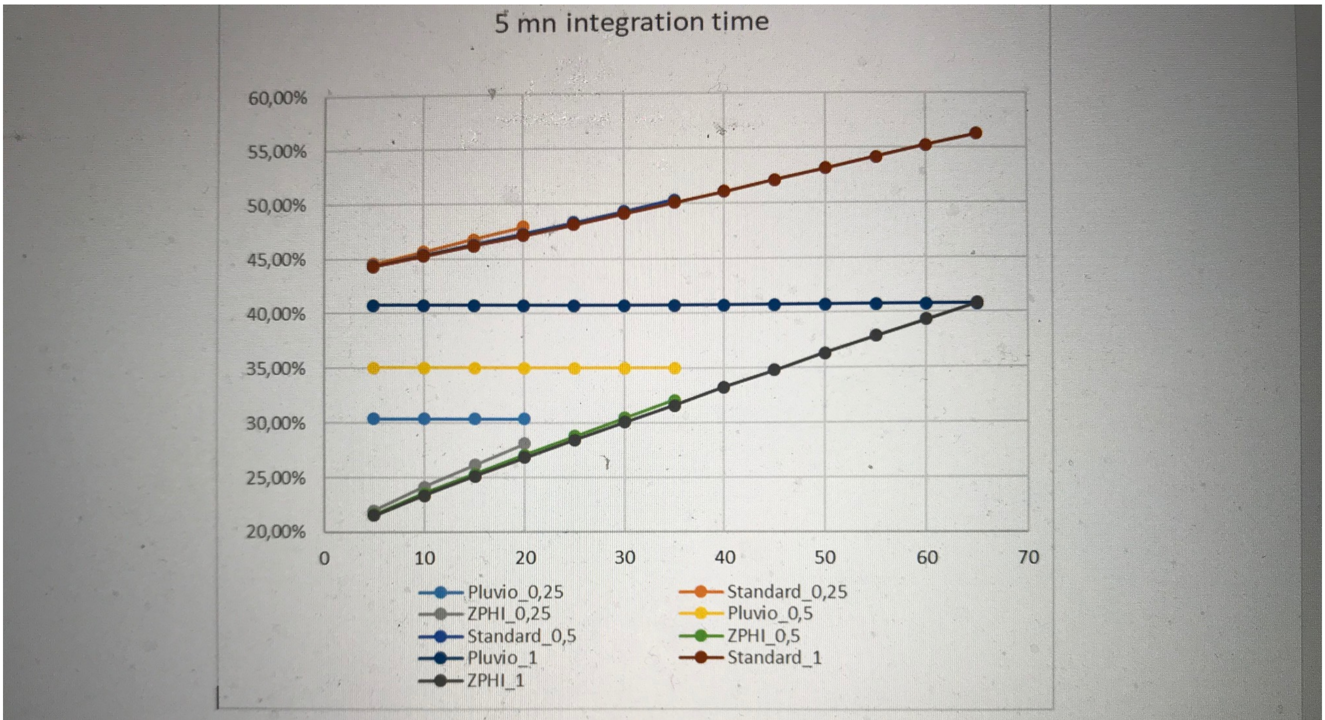

Figure: Measurement uncertainties as a function of distance to radar (km) for: a) rain gauge; b) polarimetric radar processed with the “standard polarimetric” algorithm (correction of Z for attenuation using Φ_{DP}) and c) polarimetric radar processed by ZPHI® (with in addition, N_0 retrieval). For each one three pixel-resolutions are considered: 0.25 km; 0.5 km and 1 km. The integration time of the measurement is here 5 minutes. The charts are stopped at 20km, 35km and 65km respectively for resolutions 0.25km, 0.5km and 1km, to take into account the limit of angular resolution of the antenna (≈1° two-way).*