ANALYSIS OF THE UNCERTAINTY OF QUANTITATIVE PRECIPITATION ESTIMATES OF THE SMC WEATHER RADAR NETWORK

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I. INTRODUCTION

In order to quantify the uncertainty of the radar-derived point quantitative precipitation estimates (QPE), a comparison has been made with a network of raingauges. Three C-band Doppler radars and more than 340 telemetered gauges are used. Both networks cover the area of Catalonia (NE Spain).

One year of daily data has been analysed, considering different specific time periods and also complete rainfall events. For each individual radar, three different products are obtained: short-range, long-range, and corrected radar QPE. The corrected product is generated by the EHIMI system (Hydrometeorological Integrated Forecasting Tool, Sánchez-Diezma et al., 2002; Bech et al. 2005). Additional products are considered for network composite QPE.

The first part of the analysis has been centered in the uncertainty quantification for all precipitation products. Different beam blockages and distance dependence have been considered, to obtain more detailed information. The second part has been the individual analysis of the uncertainty of each rain gauge, comparing with each rainfall radar product. These results will allow improving the knowledge about areas with underestimation and overestimation for every radar product. This will enhance the radar QPE over the area of interest benefiting a number of applications including verification of high resolution NWP precipitation forecasts.

II. DATA AND METHODOLOGY

The weather radar network of the Meteorological Service of Catalonia (Table 1) is made up of three C-band Doppler radar systems operating in a highly complex topography environment often affected by heavy rainfall events (Bech et al., 2004). Therefore, some of the important factors to be considered in this area for radar QPE are ground clutter, beam blockage (Bech et al., 2003), C-band attenuation (Berenguer et al., 2002), and attenuation over the radome (Sempere-Torres et al., 2002). Additionally, other usual problems must also be considered such as non-precipitating echoes caused by anomalous propagation of the radar beam (Berenguer et al., 2005), or errors caused by the variation of the Vertical Profile of Reflectivity (VPR).

The radars (Table I) provide equivalent reflectivity factor (hereafter Z) –both Doppler corrected and uncorrected– in two acquisition modes: a single elevation scan in long range mode (240 km) and a volumetric short range mode (130 km for PBE and PDA radars and 150 km for CDV).

Radar	Code	Longitude (ºE)	Latitude (ºN)	Altitude (m)
Puig Bernat	PBE	1.88	41.37	610
Puig d'Arques	PDA	2.99	41.89	535
Creu del Vent	CDV	1.40	41.60	825

TABLE I. SMC weather radars used in this study

Precipitation estimations are obtained through previous conversion of rainfall rate (R) from Z using a standard power-law Marshall and Palmer (1948) Z-R relationship. In total, eleven radar QPEs are obtained: 3 for each of the 3 radars (long range, short range and EHIMI).

In spite of the different nature of radar and raingauge observations, they are usually compared to assess radar QPE quality (Joss and Waldvogel, 1990; Collier and Hardaker, 2003).

Two different statistics have been selected to compare gauge and radar data: the bias, expressed in dB:

BIAS (dB) = 10 log (R/G)

and the root mean squared factor RMSf:

$$RMSf = \exp\left\{ \frac{1}{N} \sum_{i=1}^{n} \left[\ln\left(\frac{R_i}{G_i} \right) \right]^2 \right\}^{\frac{1}{2}}$$

as they provide complementary information about the absolute and signed difference of two quantities (Gjertsen et al. 2002).

III. APPLICATIONS AND RESULTS AND CONCLUSIONS

Two different applications have been analyzed. The first one evaluates daily rainfall accumulation field during a 36 week period. In total, nine radar QPEs are ontained: 3 for each of the 3 radars (long range (240km), short range (130km) and EHIMI). The results found (Table II) have been analyses using different distances and beam blockages (BB).

The second one analyzes in detail the monthly QPE product for two selected gauges (codes Z9 and WW), with the purpose to assess the BB correction processed with the EHIMI system (Table III). Additionally, the gauge with less BB (code WW) has been used to calculate the frequency distribution of daily BIAS for the same 36 week period used in application 1 (Figure I).

CDV

bb \ km	40-100			100-160		
	# Gauges	Bias	RMSf	# Gauges	Bias	RMSf
0%	99	-3,90	2,58	22	-4,43	3,17
		-5,10	3,36		-5,78	4,19
1 - 50%	85	-5,34	3,73	45	-6,54	5,08
		-5,79	4,01		-7,43	6,15
50 -70%	5	-11,26	13,71	1	-14,05	25,43
		-7,49	5,70		-9,76	9,46

PDA

bb \ km	40-100			100-160		
	# Gauges	Bias	RMSf	# Gauges	Bias	RMSf
0%	42	-9,69	9,60	12	-8,39	7,01
		-10,87	12,66		-10,28	10,76
1 - 50%	46	-11,15	13,36	23	-11,31	13,89
		-12,12	16,79		-11,94	16,01
50 -70%	6	-12,88	19,81	3	-14,19	27,99
		-11,61	15,36		-13,38	24,03

PBE

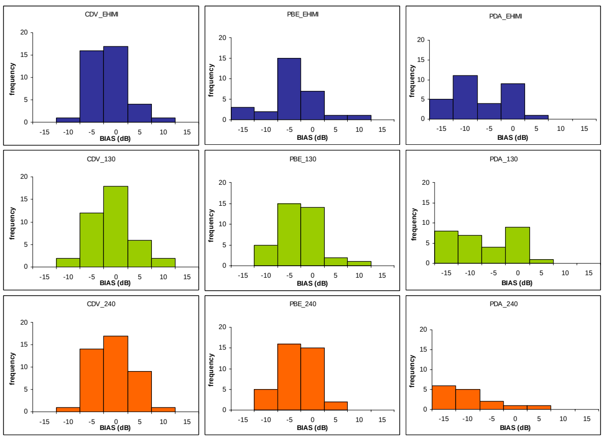
bb \ km	40-100			100-160		
	# Gauges	Bias	RMSf	# Gauges	Bias	RMSf
0%	47	-7,59	5,90	24	-8,63	7,41
		-9,65	9,58		-12,78	20,17
1 - 50%	84	-8,19	6,78	63	-9,62	9,61
		-9,59	9,30		-11,10	13,32
50 -70%	3	-10,13	10,61	1	-8,71	7,43
		-9,01	8,11		-7,61	5,77

TABLE II: RMSf and mean BIAS for different distance and blockages for the SMC weather radars. Shaded values corresponds to EHIMI data and the others to uncorrected data.

		gauge **Z9**		gauge **WW**	
	QPE type	BB (%)	BIAS	BB (%)	BIAS
CDV radar	CDV_EHIMI	64	-7,69	1	-4,19
	CDV_130		-10,63		-2,99
	CDV_240		-8,03		-3,69
PDA radar	PDA_EHIMI	33	-16,69	14	-8,67
	PDA_130		-12,55		-8,20
	PDA_240		-13,01		-9,89
PBE radar	PBE_EHIMI	40	-13,18	1	-7,73
	PBE_130		-12,28		-6,01
	PBE_240		-10,92		-5,93

TABLE III: Mean monthly BIAS stratified for different BB for the selected gauges as seen from the different SMC weather radars. The EHIMI correction are applied over the short range area of each radar.

FIG. 1: Frequency distribution of daily BIAS for the WW gauge as seen from the different weather radars and products: EHIMI (blue), short (green) and long range (orange).



IV. CONCLUSIONS

A comparison between radar QPE and gauge observations is presented for the Doppler radar network of the SMC.

Several statistics applied to a 36-week period indicates the improvement in the BIAS of the EHIMI QPE product for high blockages. In terms of radar, is CDV the one with better scores of BIAS and RMSf. Furthermore, CDV and PBE generally show the expected BIAS and RMSf dependence with distance and BB for each QPE product. However PDA shows a more complex dependence with distance.

In the second part, monthly variability is similar for the different radars and QPE products and the two gauge sites present consistent results with application 1: EHIMI QPE improves BIAS when blockage > 50% but not in other cases, where other factors may dominate. Individual histograms of radar daily BIAS indicate that CDV radar is less biased than the others. PDA shows a flatter pattern, more platykurtic, also left skewed.

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