ANALYSIS OF IMPROVED RADAR PRECIPITATION ESTIMATES IN THE PYRENEES AREA

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I. INTRODUCTION

The Pyrenees is an area that presents substantial challenges in terms of obtaining representative radar quantitative precipitation estimates (QPE). The study area, centred in Andorra (small country with an extension of 468 km^2 and 1996 m mean altitude) is covered by the weather radar network of the Meteorological Service of Catalonia (SMC) (Bech et al., 2004). Four C-band Doppler radars, located all at more than 115 km from Andorra, compose the network. In this area beam blockage (Bech et al., 2003), beam overshooting, ground clutter (Berenguer et al., 2002), C-band attenuation and attenuation over the radome (Sempere-Torres et al., 2002) are among the factors influencing the quality of radar QPE.

According to previous results where a general underestimation by the radar QPE compared to rain gauges was found (Trapero et al., 2009), this work is focused on developing a simple procedure for unbiasing radar QPE. The study includes Andorra and the surrounding southern Catalonia area. Events from 2008 with significant daily accumulation measurements in the rain gauges located in the study area have been selected. This procedure aims to correct local bias underestimation as well as to improve radar QPE in the Pyrenees area. This is a necessary step before attempting quantitative applications of radar QPE such as hydrometeorological modelling or verification of high-resolution NWP precipitation forecasts in this area and is illustrated with several heavy rainfall cases.

II. METHODOLOGY

The procedure tested is applied at the end of the operational radar data processing chain and is based on the adjustment of the radar precipitation field using a factor obtained from previous daily bias results – sectorized by range and beam blockage. The radar products used are: short range (130 km for PBE, PDA and 150 km for CDV), long range (240 km) and short range corrected radar QPE. The corrected product is processed by the Hydrometeorological Integrated Forecasting Tool (EHIMI) (Sànchez-Diezma et al. 2002), (Bech *et al.*, 2005), a software package designed to correct radar observations in real time.

The bias-adjusted precipitation estimates (Rcor) are calculated daily for each QPE product (R) using a previous day bias-adjustment factor F.

$$R_{cor}(i,j) \equiv \frac{R(i,j)}{F} \qquad \text{(Eq. 1)}$$

This factor can be derived from the requirement that the mean-field bias should be zero after adjustment (BIAS=0):

$$BIAS \equiv \frac{1}{N}\sum_{n=1}^{N}\left[\frac{R(i_n,j_n)}{F} - G_n\right] = 0 \qquad F = \frac{\sum_{n=1}^{N} R(i_n,j_n)}{\sum_{n=1}^{N} G_n}$$

where (i_n,j_n) are the values of the pixel corresponding to each rain gauge, N is the number of available rain gauges and G_n is the gauge measurement of the 24h rainfall amount (Holleman, 2007).

III. RESULTS AND CONCLUSIONS

1. *Daily BIAS adjustment for CDV radar*

A five day episode (17-20 April 2008) has been selected to apply a previous day bias-adjustment factor. The corrected daily bias has been calculated classifying rain gauges in different distances (D) from the radar and beam blockage (bb).

The corrected average bias obtained for each case (Table 1), improves substantially the general underestimation previously calculated for all QPE products. In some cases (distance >100 km) the improvement is greater than 8dB.

Blockage	Range (km)							
	40-100				100-160			
	# Gauges	Bias	Bias cor	F	# Gauges	Bias	Bias cor	F
0%	0	N/A	N/A	N/A	2	-9.58	-5.26	0.53
		N/A	N/A	N/A		-9.26	-2.20	0.32
		N/A	N/A	N/A		-9.68	0.28	0.19
1 - 50%	6	-10.38	-2.18	0.15	11	-15.90	-3.00	0.05
		-9.32	-1.08	0.15		-13.90	-1.67	0.06
		-9.03	-0.57	0.14		-14.12	-1.49	0.05
50 -70%	7	-15.94	-7.74	0.08	2	-16.27	-2.92	0.08
		-12.30	-4.06	0.11		-11.28	0.95	0.13
		-14.94	-6.48	0.05		-13.34	-0.71	0.09
>70%	1	-10.27	-4.87	0.01	1	-13.38	-0.47	0.20
		-15.97	-7.73	0.32		-12.46	0.05	0.10
		-10.45	-4.85	0.01		-14.52	-1.82	0.07

TABLE I: Mean BIAS and mean corrected BIAS, for the three day period, calculated for different distances and blockages for the CDV weather radar. Values with GREY background correspond to long range uncorrected data, DARK background to short range corrected data and the light ones to short range uncorrected data.

2. *Sectorized BIAS correction*

The sectorized bias correction is based on the use of the mean bias adjustment factor (F) obtained for the 4 day April period, in order to correct (Eq. 1) the radar QPE data collected in 32 daily episodes that affect the study area from May to October.

The CDV radar results obtained for the short range uncorrected QPE product are shown in Table II. The general underestimation substantial decreases with F-application compared to the original data. In some cases a slightly overestimation (3.25 dB) is detected.

Blockage	Range (km) 40-100				Range (km) 100-160			
	# Gauges	Bias	Bias cor	F	# Gauges	Bias	Bias cor	F
0%	0	N/A	N/A	N/A	2	-6.76	1.66	0.25
1 - 50%	4	-7.11	2.02	0.22	10	-9. 98	3.25	0.11
50 -70%	4	-11.31	-2.18	0.10	1	-11. 29	1.94	0.05
>70%	1	-12.95	-3.82	0.05	0	N/A	N/A	N/A

TABLE II: Mean BIAS and mean corrected BIAS, for the 32 episodes, calculated for different distances and blockages for the CDV weather radar. Values with correspond to short range uncorrected data.

These results are a first attempt to obtain a procedure for correcting local bias underestimation as well as a previous step to improve the radar QPE in the complex terrain study area.

V. REFERENCES

Bech J., E. Vilaclara, N. Pineda, T. Rigo, J. López, F. O'Hora, J. Lorente, D. Sempere, and F. X. Fàbregas, 2004: The weather radar network of the Catalan Meteorological Service: description and applications. *European Radar Conference*, 416 - 420.

Bech, J., B. Codina, J. Lorente, J., and D. Bebbington, 2003: The sensitivity of single polarization weather radar beam blockage correction to variability in the vertical refractivity gradient. *J. Atmos. and Oceanic Technol*, 20: 845–855.

Bech, J., T. Rigo, N. Pineda, S. Segalà, E. Vilaclara, R. Sánchez-Diezma, D. Sempere, E. Velasco, 2005: Implementation of the EHIMI software package in the weather radar operational chain of the Catalan meteorological service. *Proceedings 32nd International Conference on Radar Meteorology*.

Berenguer, M., G. W. Lee, D. Sempere-Torres, I. Zawadzki, 2002: A variational method for attenuation correction of radar signal. *Proceedings of 2nd European Radar Conf. European Meteorological Soc*. Delft, Holland.

Holleman, I., 2007: Bias adjustment and long-term verification of radar-based precipitation estimates. *Meteorol. Appl.* 14: 195–203.

Trapero L., J. Bech, T. Rigo, N. Pineda, D. Forcadell, 2009: 'Uncertainty of precipitation estimates in convective events by the Meteorological Service of Catalonia radar network'. *Atmos. Res.* 93: 408-418.

Sánchez-Diezma, R., D. Sempere-Torres, J. Bech, E. Velasco, 2002: Development of a hydrometeorological flood warning system (EHIMI) based on radar data. *2nd European Radar Conference.*

Sempere-Torres, D., R. Sánchez-Diezma, M. Berenguer, R. Pascual, and I. Zawadzki, 2002: ASCMORE: an algorithm to control radar rainfall measurement stability using mountain returns in real time. *Geophys. Res. Abstracts*, 4, 6319.