P7R.15

VERTICAL PROFILE CORRECTION ON SPANISH RADAR REFLECTIVITY DATA

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1. INTRODUCTION

The intents to obtain reliable precipitation fields from meteorological radar measurements are as old as the instrument.

At the beginning, the efforts were oriented mainly in two directions: the knowledge of the microphysical and dynamical properties that drive the relationship between radar reflectivity and precipitation, and the improvement of the precipitation field estimation integrating in a common product radar and gauges data. (Battan, 1973) and (Wilson and Brandes, 1979) revise this working lines whose results were applied in radar systems as the UK-Met Office (Collier, 1986) and US-NEXRAD (Hudlow et al, 1992).

In 1986, (Koistinen,1986) suggested a new approach, showing the influence of the vertical echo structure in the radar precipitation estimates. New developments of (Joss and Walvogel, 1990), (Koistinen, 1991), (Andrieu and Creutin, 1991), (Divjak, 1994) and (Joss and Lee, 1995) followed this point of view and showed its fecundity.

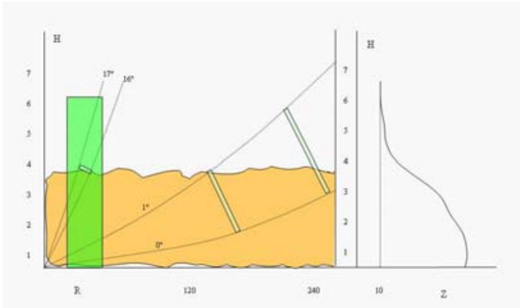
The advantage of the method is its robustness, for it allows a coherent treatment of the bias using only radar data and reserves so, gauge data for verification purposes

2. PROBLEM DESCRIPTION

Radar precipitation estimates shows an inherent range dependent bias as the precipitation field derives from measures fulfilled at altitudes increasing with range.;

An illustration of this problem is show in Fig.1. On the left, an RH diagram shows in brown colour a four km. thick precipitation system; the dotted lines are the limits of two radar beams of one degree beam width pointing at different elevations (the lowest one is the first) and the rectangles in them, are the space resolution volumes of three different radar bins.

Any radar precipitation estimate have to be obtained from the reflectivity data derive from these bins, which has an inherent range dependent error, due of the increased bin height and partial echo filling where part of the beam surpass the precipitation system.



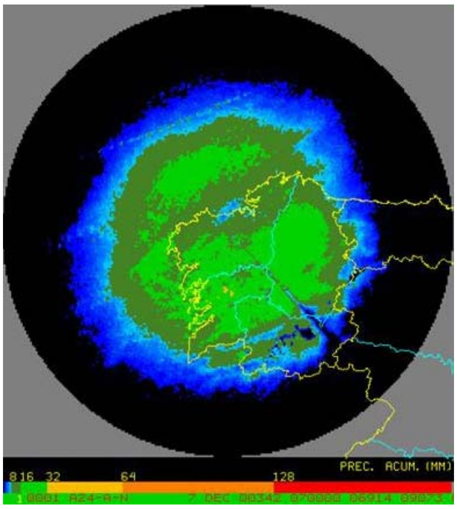


Fig. 1. Above, a RH diagram and ZH mean profile obtained from Z radar data in the dark green region. Down, a radar image of rain accumulation that shows the bias as a typical circular pattern.

The bias appear clearly in radar accumulation images as a circular and unrealistic pattern that shows rain, only around the radar, a feature that limits the hydrological use of the radar to the first 90 km of coverage.

Following Koistinen ideas, all that is needed to apply a bias reduction scheme is a reflectivity profile estimate obtained from climatology or, as we have done in Spain, from radar data collected nearby at different elevations.

3. PROFILE DEFINITION

The Spanish INM scheme apply to the intensity mode scan, composed by twenty elevation, Φ_i, of reflectivity data, that is collected by the radar from all the azimuths with a beam width of 0.9º.

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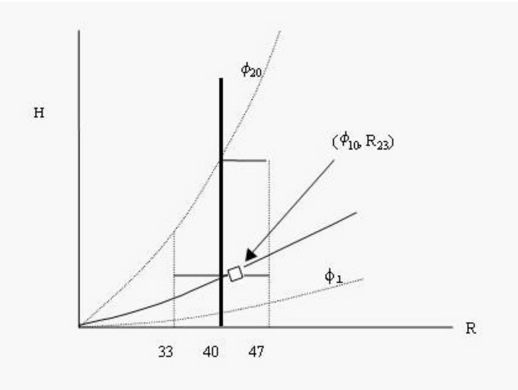
The data of each elevation are reflectivity, Z, corresponding to 419 azimuth sectors of 120 range cells, two km apart. The data process uses a clutter mask obtained from a scan in a clear day to remove clutter from the images.

The profile definition procedure (see Fig. 2) fix , for each one of the 30 height levels above the site (from 0 to 6 km, 200 m apart), the volume scan pairs (elevation: Φ_i , range: R_j) with a distance from the radar between 33 and 47 km and whose central height are the closest to each particular height level.



VERTICAL PROFILE DEFINITION

Number of levels: 29
Minimum height: 400.0

Level	Elev_nb	Range_nb	Height	Nb_data
1	1	19	403.5	281
2	2	16	651.7	298
3	2	19	790.9	326
4	2	23	983.1	314
5	3	18	1171.5	330
6	3	21	1386.8	305
7	4	17	1561.1	366
8	4	19	1759.0	386
9	5	17	2021.2	414
10	4	23	2160.5	385
11	5	20	2402.5	418
12	6	18	2635.4	417
13	6	19	2790.4	419
14	7	17	2997.6	419
15	7	18	3183.4	419
16	6	23	3414.9	419
17	7	20	3556.4	419
18	9	16	3780.8	416
19	9	17	4028.6	419
20	8	20	4166.1	419
21	8	21	4384.6	419
22	8	22	4603.6	419
23	11	16	4799.1	419
24	9	21	5024.5	419
25	9	22	5274.7	418
26	12	16	5386.4	408
27	10	21	5663.3	419
28	11	19	5741.1	419
29	13	16	6024.7	419

Fig. 2. RH diagram and table that illustrate the profile definition procedure.

The table in Fig. 2, shows the results of the profile definition for the radar site of La Coruña. There, a column says the true height of the closest pair to each level and the other (Nb_data) the number of polar volume cells on each level, that are less than the total azimuth data for some of them are clutter.

The correction (VPC) apply to the PPI data, a Cartesian projection obtained from the polar volume data through a conversion table that fix for every pixel the four closest polar data assigning to them interpolation weights according to the pixel distance.

To manage the correction, the profile definition procedure calculates or adds to the table items some values, namely, the mean true pixel height, the altitude of its projected geographical position and its partial beam occultation, one data that could be obtained from theoretical studies or radar climatology (VPC do not use the latest two parameters yet).

4.- MEAN PROFILE AND VPC

The INM weather radar produces every ten minutes an intensity mode, twenty elevations, volume scan, at the same frequency that runs the procedure of HZ profile calculation.

For each level of the profile, the procedure tries to establish the mean Z value as the average of the Z values of the corresponding polar cells. The calculation has some restrictions to assure reliability and if fails, the level is marked as no data. At last, a valid profile must have, at least, six levels with significant mean Z values.

At the end, the procedure calculates a mean vertical reflectivity profile applying a two hours window moving average that uses up to the six more recent valid profiles in the window, and passing it through a smoothing process.

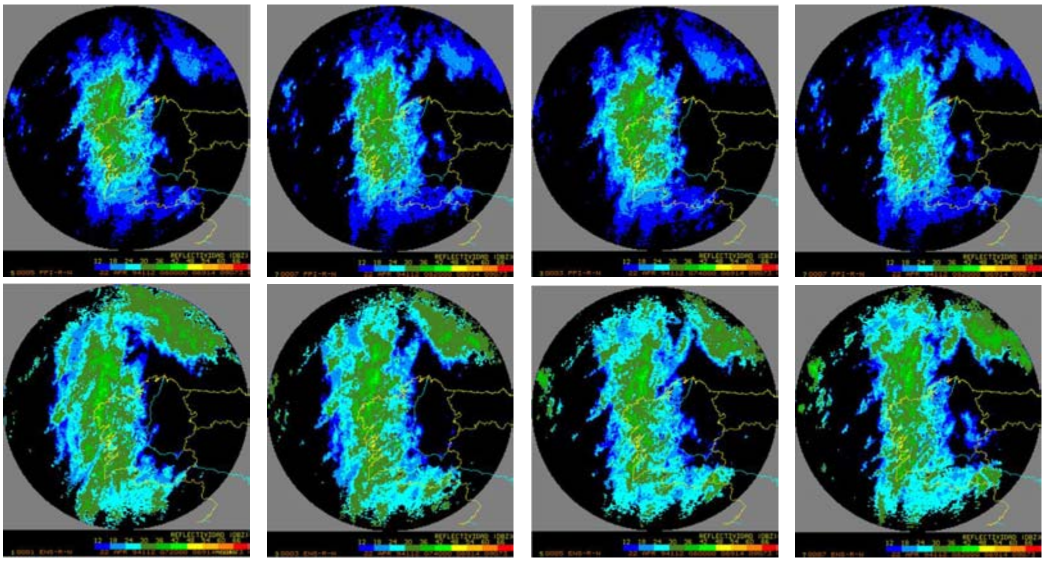
Whenever a valid mean profile is available, the radar is ready to generate, in the next cycle, a PPI vertical reflectivity profile correction as a new radar product that represents the ground reflectivity estimate and that is done according to the formula

$$Z(x,y,0) = Z(x,y,h) + \frac{N}{6}\left(Z_P(0) - Z_P(h)\right) f(m)$$

Z(0) is the reflectivity at radar level, *Z(h)* the PPI value, Z_p the corresponding profile values at the two levels and N the number of profiles in the smoothed mean profile.

As the VPC procedure enhances shrunk convection in stratiform rain, the formula includes a factor, *f(m)*, that reduce quadratically the correction as the PPI pixel value differs from the mean profile data at the same level.

Fig. 3 (see next page) shows some VPC results of La Coruña radar in two sequences, one showing original PPI and daily accumulation images and the other the correspondent VPC corrected ones. The table in the same Fig., shows a quality control check of the accumulation images, made by comparison of their pixel value with the corresponding records of 117 rain gauges. That check confirms the visual impression as the correlation between radar and gauge data increase from 0.66 to 0.73 and the rain flux ratio moves from 0.83 to 0.98.



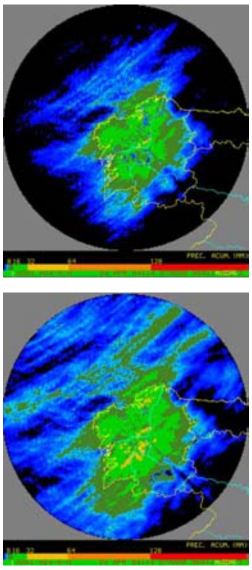


Fig. 3. Radar image sequences from La Coruña radar. Above: PPI and correspondent VPC images (22-APR-1994, from 7:20 to 8:20, 20 min. apart). Left and down: original daily accumulation image, VPC corrected one and table with the results to compare their data with the daily accumulation data of 117 raingauges

		Num.	Oc. of rain R,P >=0.8					Pop. detected (R,P)>=0.8					
	N_EST	.	PCT	PDT	PFA	PET	POC	NUM	PCT	PCD	PCM	PCF	C_TOT.
Original data	117	117	905	935	38	444	64	101	792	833	789	0	0.83
Modified data	117	117	940	1000	60	777	0	108	842	709	907	0	0.98

	Pop. detected R>=0.8, P>=0.5			
	M_DIS.	D_DIS.	P_REG.	C_COR.
Original data	-0.10	0.32	0.57	0.66
Modified data	-0.01	0.28	0.72	0.73

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