IMPROVING THE ACCURACY OF WEATHER RADAR RAINFALL ESTIMATES IN THE EVENT OF FLOOD

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ABSTRACT

Weather radar estimates may suffer from different error sources such as spatial and temporal variability of rain, clutter, orography, beam shielding, antenna calibration etc. The pixel-based SCR (Statistically Corrected Rain) algorithm (PSCR) developed by the authors is aimed to improve the accuracy of weather radar estimates affected negatively by these error sources. Employing rain gauge observations and radar estimates, multi-parameter regression equation was derived and used to find the gauge-adjusted radar rainfall estimates. In order to test the performance and reliability of these rain gauges employed during this extreme case, six different rain integrations from 10 minutes to 12 hours were evaluated and compared with the disdrometers collocated with some of these rain gauges. The statistics between those two equipments were evaluated for the flood event occurred between 8 September 2009 and 9 September 2009 and caused economical hazard and casualties along the Thracian region of Turkey, city of Istanbul and vicinities. Averaging radar rainfall at the radar pixel where a rain gauge station located and its eight neighboring pixels, one-hourly, three-hourly and six-hourly radar rain integrations were derived. Looking at the statistical analysis, absolute mean bias decreased 60% while RMSE decreased 64% where weight factor is taken radar rain for six-hourly integration.

1. INTRODUCTION

Meteorological weather radars are widely used systems to get information about the direction, the location and the speed of meteorological targets. This information is very useful for nowcasting and forecasting of the severe hydrological events such as flood. However, weather radar precipitation estimates may suffer from different error sources such as beam shielding and orography, and spatial and temporal variability of rainfall.

In this study, a regression equation is generated for radar rainfall estimates in order to improve the accuracy. The variables are selected as time-independent parameter which may cause difference between radar and ground rainfall measurements and total rainfall is used to eliminate the temporal variability. These variables are chosen to be the distance between radar and rain gauge (D), the topographical height of rain gauge (HG) and the minimum height above the rain gauge that the target is visible from the radar (HV_{min}). The variable D is related to the beam broadening, HG is related to orography and HV_{min} is a bias source caused by beam shielding. Eighteen rain gauges located in the circular area with the radius of which is 120 km with the radar location as being the center, are used in this study. A flood event occurred between 8 September and 9 September 2009 is the most extreme rain event during last 80 years in the Thracian region of Turkey, city of Istanbul and vicinities is selected for this study. It caused a devastating flood; 41 people were killed and millions of dollars were lost.

2. METHODOLOGY

Gauge adjustment is a statistical technique aimed to improve radar rainfall accuracy by using radar rainfall estimates and observations. For each rain gauge point, the assessment factor (AF), which is the ratio of total radar rainfall (R) to the total Gauge rainfall (G) is defined in Eq.1 below. Due to the possibility of time mismatching of measurements performed by different devices, here the radar and the rain gauge, it is more logical to use total rainfalls (Zawadski, 1975; Collier, 1986).

$$(AF)_j = \frac{\sum\sum(R)_j}{\sum\sum(G)_j} \qquad (1)$$

Gabella *et al.* (2000) proposed a relationship between Assessment Factor and three time independent variables as in Eq.2 below,

$$(AF)_j(dB) = a_0 + a_D.\log(D_j) + a_{HV}.(HV_{\min})_j + a_{HG}.HG_j \qquad (2)$$

With the help of the obtained coefficients, the estimated logarithmic AF function is generated, and then it is anti-transformed to non-logarithmic AF to correct the total radar rainfall through the following expression where R_c is the corrected and estimated radar rainfall and AF_e is the estimated assessment factor:

$$\sum\sum(R_c)_j = \frac{\sum\sum(R)_j}{(AF_e)_j} \qquad (3)$$

The pixel-based SCR (Statistically Corrected Rain) algorithm finds exact HV_{min} values for all radar pixels and reduces the computational time remarkably. Statistical characteristics resulting from the comparison between the estimated improved radar rainfalls obtained by taking weights as w=1, w=G and w=R and gauge rainfall are presented in Table 1. The regression equation resulting smallest RMSE is given below:

$$(AF)_j(dB) = -0.189 - 2.645\log(D_j) - 0.296(HV_{\min})_j + 23.643HG_j \qquad (4)$$

Table 1. Statistical characteristics resulting from the comparison between the estimated improved radar rainfalls obtained by taking weights as w=1, w=G w=R and w=R (HV-out) and gauge rainfall.

Radar-AWOS comparison	AME (mm)	RMSE (mm)
R – G	**19.77**	**31.17**
R_c – G (w=1)	9.42	15.37
R_c – G (w=G)	8.07	12.39
R_c – G (w=R)	7.85	11.22
R_c – G (w=R) HV-out	7.93	12.34

7. CONCLUSIONS

The gauge-disdrometer scatter diagrams depict that the agreement between these two instruments improves with increasing time span. It was seen that the agreement was above 0.9 at all stations for one-hourly rainfall integration while percent absolute bias varied from 23% to 87%. The results express that pixel-based SCR algorithm reduced RMSE and AME remarkably for all regressions. The best RMSE is obtained when W=R is used. Looking at the results, AME decreased 60% while RMSE decreased 64% where W=R for six-hourly integration. The deviation between neighboring pixels was also examined and found reasonable for most of them. However, it was noticed that the rain around Bandirma and Olimpiyat gauge stations had higher deviation than the others. The deviation indicates that the rain can show variability in a small-scale area (2.25 km^2) and average rain may deviate from the original value 67% even though our case is not a convective case. It is clear that more deviation may be expected between neighbor pixels during convective events. This deviated number may also affect the Assessment Factor (AF), regression equation, corrected rain and the success of the correction method adversely.

(3)

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