P2.6

IMPROVEMENT OF ACCURACY OF RADAR RAINFALL RATE BY REAL-TIME ClassZR

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1. INTRODUCTION

Stout and Mueller(1968) presented that Z-R relationship should be used differently according to precipitation types to reduce the uncertainty of rainfall estimation. Sims(1964) suggested that different parts of a storm have significantly different relationships. Fuziwara(1965) showed that Z-R relationship was different on the types of precipitation and suggested relationship of $Z=300R^{1.37}$ for the convective rainfall and $Z=205R^{1.48}$ for the stratiform rainfall through the case studies.

The single Z-R relationship is generally applied to one radar in domestic radar network, Korea. It is needed to calculate Z-R relationship by precipitation regime for improvement of the accuracy of quantitative rainfall rate in case of coexistence of different precipitation types.

Therefore, in this study, we classified the types of precipitation into convective and stratiform, produce the optimum Z-R relationship according to precipitation types and finally calculated the quantitative rainfall rate from new relationships in real-time (hereafter referred to as ClassZR).

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The estimated rainfall rate by real-time optimum Z-R relationship considering cloud types(ClassZR) would be verified through objective analysis and tested by comparing with the estimated rainfall rate by Marshall and Palmer's relationship (hereafter referred to as MP) and RAR (Radar-AWS Rainrate) being operated for the product of quantitative rainfall rate at KMA (Korea Meteorological Administration).

2. DATA AND METHODOLOGY

This study used the raw volume data of Mt. Gwangdeok radar(hereafter referred to as GDK) and raingauge data of KMA. Fig. 1 shows the location of GDK and raingauge network within 240-km distance from GDK.

Raingauge data is needed for search of the optimum Z-R relationship and validation of ClassZR. For the objective evaluation of ClassZR, other radar data at KMA were applied expansively.

In this study, we mainly used rain classification algorithm by Biggerstaff and Listemaa(2000) and improved their algorithm for ClassZR. After convective/stratiform partitioning was performed on a criterion of 10 mm/hr rainfall intensity (Short et al.,, 1993), it was checked to determine if the radar reflectivity was correctly classified. Stratiform condition in convective area and convective one in stratiform area were determined using the horizontal and vertical gradient of radar reflectivity from Biggerstaff and Listemaa(2000) and BBF(Bright band fraction) from Zhang *et al*.(2006). Table 1 shows the threshold for classification.

Table 1. The threshold value for classification

Type / Items	Stratiform	Convective
Horizontal gradient of reflectivity	<= 3dB/km	> 3dB/km
Vertical gradient of reflectivity	>= .5dB/km	< 3.5dB/km
BBF	< 0.4	> 0.6

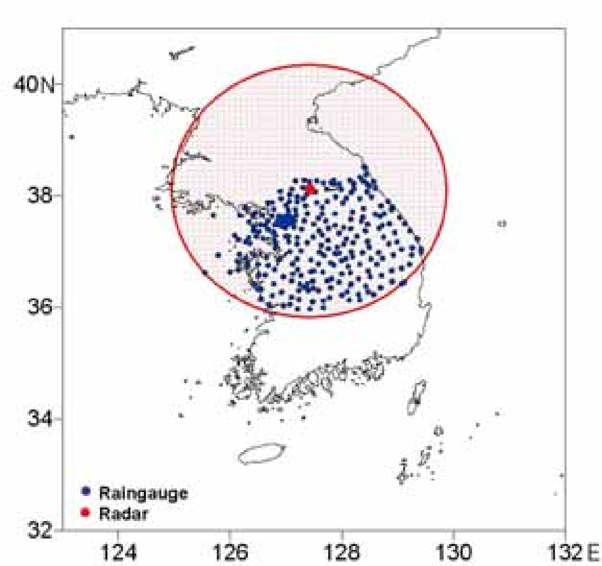

Fig. 1. The location of Mt. Gwangdeok weather radar(a red dot) and raingauges (blue dots)

The new optimal Z-R relationship was respectively adopted on classified area using one hour-averaged CAPPI radar reflectivity and one hour-accumulated rainfall of raingauges. To define new Z-R coefficients, we compared correlation of rain rates between radar and raingauges. Data for Z-R coefficients were chosen as they were greater than 0.5, and when they had more than two times of RMSE between radar rainfall and raingage rainfall, we calculated new correlation coefficients again from remained ones. The maximum number of these repetition works was five. Fig. 2 indicates the procedure flow diagram to obtain ClassZR.

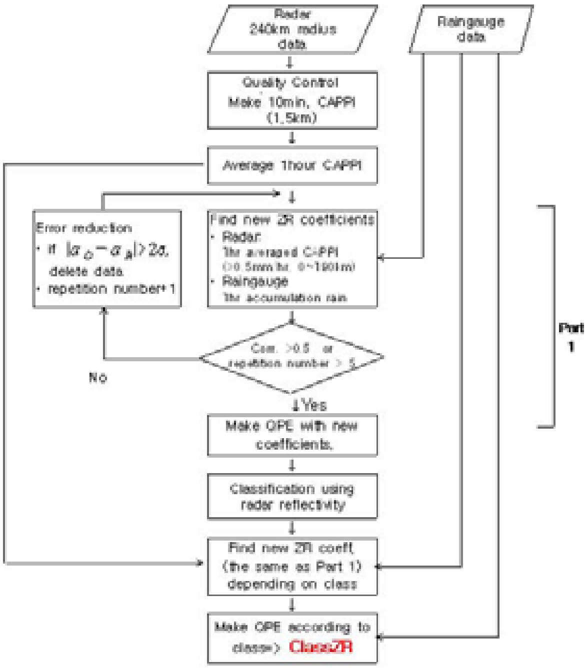

Fig. 2. Flow chart for ClassZR

3. RESULTS

Fig. 3 shows the examples of classification by precipitation types. Fig. 3a and Fig. 3b shows MP and the corrected rainfall rate by the new single Z-R relationship (hereafter referred to as SingleZR) at 0400 LST on July 28, 2005. Fig. 3c indicates the classified examples on the criterion of 40 dBZ. Red color means convective precipitation zone as compared with stratiform's by green one. In Mt. Gwangdeok radar, there were not widely distributed over 40 dBZ, which was the classification threshold value of Steiner *et al.*(1995). It was difficult to calculate relationship for convective area since there were not enough pairs of radar and raingauge data belonging to convective rainfall. Therefore, we set threshold as 10 mm/hr which Short et al.,, (1993) and Rosenfeld and Amitai(1995) suggested, and divided reflectivity into two regimes on the basis of the rainfall intensity of 10 mm/hr in SingleZR which was corrected by raingauge. Fig. 3d indicates an example of 10 mm/hr threshold classification using enough data in convective regime for the detection of ClassZR.

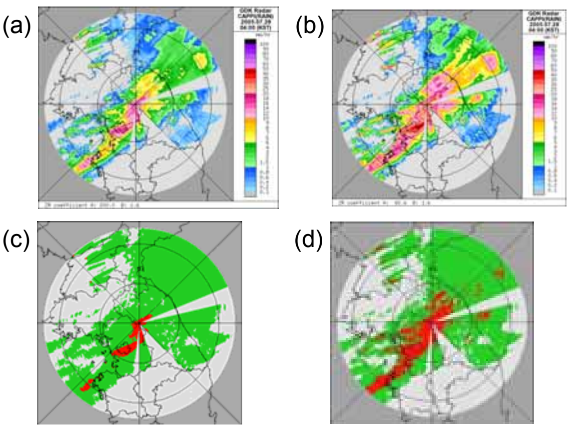

Fig. 3. The comparison of radar rainfall rates with each classification method: (a) by MP relation, (b) by a new singleZ-R coefficient, (c) by reflectivity (red:>40 dBZ, green:≤40 dBZ), and (d) by rainfall rate (red:>10 mm/hr, green:≤10 mm/hr).

We partitioned precipitation type by using SingleZR data and calculated optimum Z-R relationships for convective rainfall and stratiform's. ClassZR was obtained by new relationship according to echo types. The results were presented in Fig. 4, which shows ClassZR, MP and raingauge rainfall at 2200LST on Jun. 26, 2005. One hour-accumulated rainfall around Seoul city were about 50 mm/hr in Fig. 4c. ClassZR in Fig. 4a had similar intensities to raingauge rainfall(Fig 4c), however, MP estimated rainfall showed less than 30 mm/hr at (Fig. 4b).

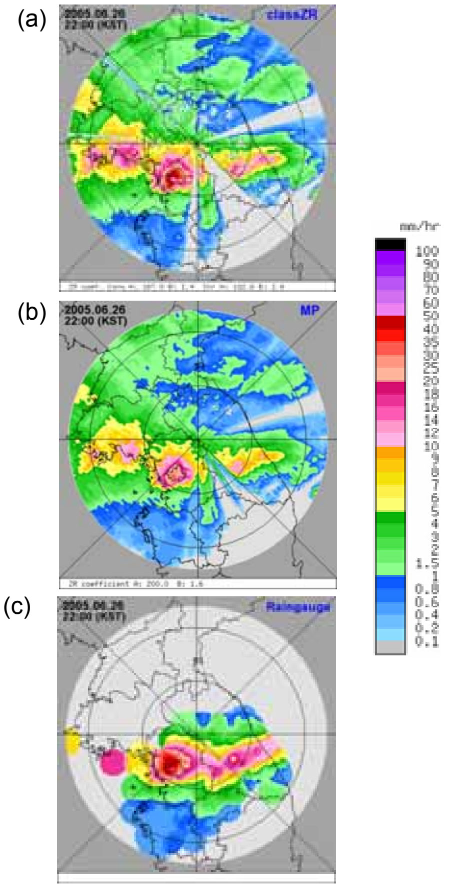

Fig. 4. The example of quantification for radar rainfall rate. (a) ClassZR, (b) MP and (c) Raingauge rainfall at 2200LST on Jun. 26, 2005.

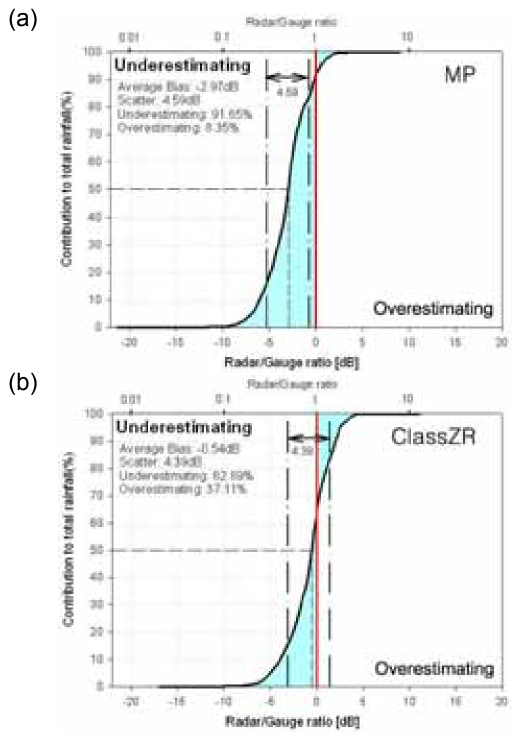

Fig. 5. Error distribution: cumulative contribution to total rainfall as a function of radar-gauge ratio for (a) MP and (b) ClassZR.

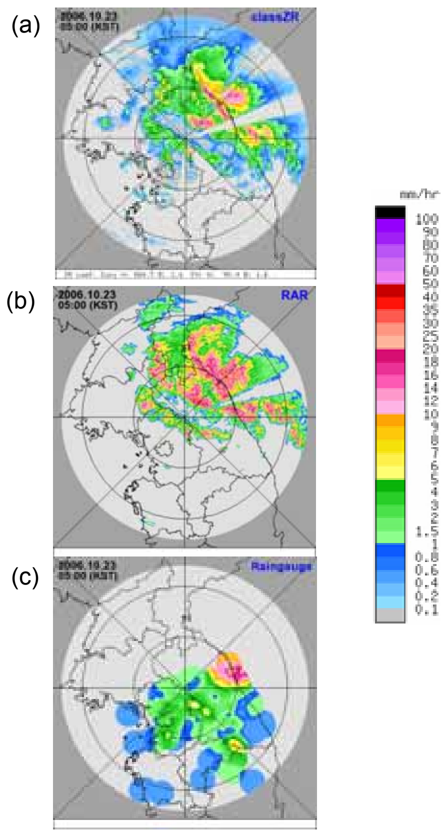

Fig. 6. The same as Fig. 4, but for (a) ClassZR, (b) RAR and (c) raingauge rainfall at 0500LST on Oct. 23, 2006.

Fig. 5 indicates error distribution by Germann *et al.*(2006) for MP and ClassZR of GDK data in 2005. Average bias, scatter and underestimation rate of MP were -2.97, 4.59 and 91.65% (Fig. 5a), while those of ClassZR were -0.54, 4.39 and 62.89% (Fig. 5b).

Fig. 6 shows ClassZR, RAR and raingauge rainfall at 0500LST on Oct. 23, 2006. ClassZR reduced the overestimated effect of RAR.

Fig. 7 shows error distribution for ClassZR and RAR of GDK data in 2005. Average bias, scatter and underestimation to overestimation rate of ClassZR were -0.50, 3.99 and 62:38 (Fig. 7a), while those of RAR were 1.6, 5.88 and 30:70 (Fig. 7b).

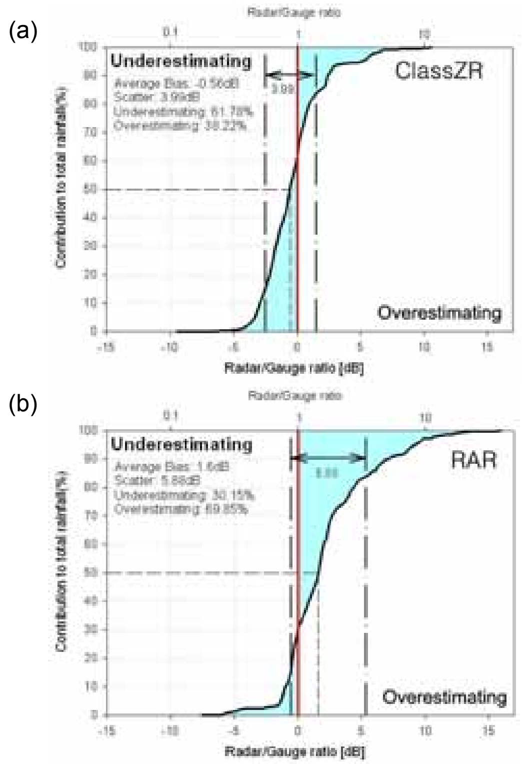

Fig. 7. The same as Fig. 5, but for ClassZR and RAR.

4. CONCLUSION AND SUMMARY

For quantitative precipitation estimation of radar, ClassZR algorithm by real-time optimum Z-R relation according to cloud types was developed and improved as compared with 40 dBZ classification threshold in Biggerstaff and Listemaa(2000), which wasn't proper in Korea peninsula. From the result of this study, rainfall estimation of ClassZR showed higher correlation with raingauge rainfall than that of MP and RAR. ClassZR compensated the underestimation of MP and the overestimation of RAR. Since the average bias and scatter of ClassZR were lower than those of MP and RAR, it proved that the performance of ClassZR had high reliability. Therefore, the algorithm of precipitation estimation by ClassZR considering precipitation type gave an effect of reducing errors from underestimation or overestimation and upgraded the quantitative accuracy of rainfall amount. It is evaluated that ClassZR can be contributed not only to extend the quantitative utilization of radar data but also to improve the accuracy of weather forecasting related with nowcasting.

5. ACKNOWLEGMENTS

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