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Atmospheric Measurement Techniques Discussions

Interactive comment on "Application of bias correction methods to improve the accuracy of quantitative radar rainfall in Korea" *by* J.-K. Lee et al.

J.-K. Lee et al.

myroom1@daejin.ac.kr

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Manuscript information

Title: Application of bias correction methods to improve the accuracy of quantitative radar rainfall in Korea Authors: Jae-Kyoung Lee, Ji-Hyeon Kim, and Mi-Kyung Suk

Comments for the Anonymous referee#1

We thank the reviewer very much for reading our paper carefully and for the comments. Detailed responses to the comments are given below.

Question#1: Please provide relevant background information. Please clearly define each bias term (i.e., reflectivity measurement, mean field, and local biases), and what causes these biases and why the authors need to correct them.

Answer: In manuscript, we defined two kinds of biases, Z-bias and QPE model bias. Weather radar hardware system cannot operate normally all the time. Hardware error affects the accuracy of the measurement variables. Therefore, we try to correct these errors using two kinds of methods. First method is readjustment of the radar hardware and second method is correction of measurement variables. So, we chose the second method and defined the Z-bias. Z-bias meant the only reflectivity measurement bias that occurred from the weather radar hardware system. We revised the sentence as follows: Before: "The measurement bias is defined as the reflectivity measurement bias (hereafter Z-bias) which was reflected in all bias which occurred while using weather radar to detect precipitation." After: "The measurement bias is defined as the only reflectivity measurement bias (hereafter Z-bias) which occurred while using weather radar hardware systems to detect precipitation."

Question#2: Please clarify which rain gauges are used in each estimation (e.g., WPMM), bias correction, and validation steps. Just saying "321 for calibration and 321 for validation" is not sufficient. Please provide rain gauge locations and configuration of each calibration and validation set. This is related to "independence" in the analysis.

Answer: In manuscript, we had 642 rain gauges information in the Korean Peninsula and used different rain gauges for the WPMM (calibration) and the bias correction (validation). And each 321 gauge is evenly spread across the nation.

Fig. 1 (a) 321 rain gauges for the calibration; (b) 321 rain gauges for the verification

We revised the sentence as follows: Before: "321 rain gauges for the calibration and 321 rain gauges for the validation" After: "321 rain gauges for the calibration and 321 rain gauges for the validation, respectively"

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Question#3 & 4: Please evaluate the quality of reference radar using ground reference (e.g., rain gauges). There is only absolute (self) calibration procedure presented in the manuscript. There is no information on the accuracy or reliability of measured or estimated quantity by reference radar. Since there is no evaluation of reference radar, I am not sure how accurate the presented results on estimated Z-biases in Table 3 are. The values ranging from 4 to 8 dB differences (Table 3) look very strange and suspicious. This might be caused by difference error sources (e.g., attenuation).

Answer: Many researchers studied the accuracy of reference radar. Generally, the correlation coefficient and hit ratio show more than 0.8 on average. To calculate the Z-biases for target radars, first of all, we calibrated the reference radar through the process in 2.3.1 (a). And then we estimated the Z-biases for target radars through the process in 2.3.1 (b) and Fig. 4. Z-biases had the range from 4to 8 dB because, actually, the target radars have been not operated well and the accuracy of these radars was not good. Therefore, the target radars have been calibrated regularly.

We added the sentence as follows: Addition: “The Accuracy of reference radar shows more than 80 % on average in quantitative and qualitative test (You et al., 2014; Jeong et al., 2014; Kim et al., 2015)”

References Kim et al. 2015: Assessment of dual-polarization radar for flood forecasting, Journal of Korea Water Resources Association, 48(4), 257-268. You et al. 2014: Rainfall estimation using specific differential phase for the first operational polarimetric radar in Korea, Advances in Meteorology, Article ID 413717. Jeong et al. 2014: Runoff analysis using dual polarization radar and distributed model, Journal of Korea Water Resources Association, 47(9), 801-812.

Question#5: Many things are wrong in the “Local Gauge Correction method” in section 2.3.2 and different from Zhang et al. (2011) that the authors referred to. Please read Zhang et al. (2011) carefully. As an example, D is not a scan range, but the radius from a radar pixel where the additive error is interpolated (because there is no collocated rain

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gauge). The basic concept of the local bias correction is the additive error interpolation for radar pixel locations that do not have collocated rain gauges.

Answer: I completely agreed the referee's comments. My descriptions and rotations for LGC method in manuscript confused you, probably. We mainly revised the manuscript as follows:

Before#1: "D is the scan range" After#1: "D is effective radius for calculating the radar rainfall bias"

Before#2: "m is the number of AWSs within the radar scan range" After#2: "m is the number of AWSs within the effective radius"

Before#3: "revised weights have been calculated by multiplying α and original weights." After#3: "revised weights have been calculated by multiplying α and original weights ( )"

Minor comments: We revised the manuscript as following your comments. C#1: We revised the sentence C#2: We revised the sentence C#3: We revised the sentence C#4: We agreed your comments. However, we distinguished the model structure and model parameters. Z-R relation is in the model parameters. In model structure, for example, we have different results between single variable regression and multi variable regression. C#5: We revised the sentence C#6&7: We revised the sentence C#8: We revised the sentence C#9: Before the merging methods, the bright band effect is detected and removed in the data quality control stage. However, this process was not descripted in manuscript. C#10: We revised the sentence C#11: We revised the sentence C#12: We revised the sentence C#13: Mean field bias was performed after merging process. Merging process is included in the QPE model. C#14: We revised the sentence

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 4011, 2015.