<u>Response to reviewer's comments</u>

We would like to thank the reviewer for the constructive comments and corrections on the paper.

Responses to the specific comments:

Q1) At line 13 of page 6304, it is mentioned "… time span of approximately one hour prior to the designated retrieval time". But 1.5 hour and 2 hour prior data are used for test (Table 1). Is there any reason?

A1) In the construction of a-priori databases (DBs), this study tried to acquire at least 5 matched observed scenes from the radar and satellite about one hour before a retrieval time. The radar and satellite data were available every 10 and 15 minutes, respectively. For this reason, there are usually 3 time steps that match two datasets at the exact time intervals and two datasets with a temporal mismatch of 5 minutes, within about an hour. In fact, the two datasets with 5 minute time difference are added to increase the sample numbers of the DBs. However, the satellite data are unavailable occasionally due to the satellite albedo monitoring (e.g., 20:30 and 20:15 for case 2, 11:30 and 11:15 for case 3). The missing period of the satellite data then increases the collection time of the datasets for the a-priori databases by about 1.5 or 2 hour. We have modified the sentence as follows:

"… time span of approximately 1.5 or 2 hour prior to the designated retrieval time"

Q2) At test data of table 1, time differences of prior database are very different. Some case time difference are 10 or 15 min and some are 30 or 40 min. Is there any reasons for different time step?

A2) As mentioned in A1, the satellite data are not available as shown in case 2 and 3 at some intervals. However, the algorithm is designed to use a DB consisting of 3 datasets at the exactly matched times and 2 datasets with 5 minute time difference for the consistency. These make different time steps in the DB.

Q3) At Line 26 of page 6304, "… have a smaller weight than the matched one…". How much is smaller? Please define "smaller" with quantitative values.

A3) The weight of the mismatched dataset is the half of the matched one. This explanation is added in the revised version of the paper as follows:

"In order to minimize the effects of the temporal inconsistency, the weight of the mismatched dataset was assigned to the half of the matched one."

Q4) At Figure 3, could you let me know why 6.7μm is very different with other channels? And why in case of greater than 40 mm/hr it is fluctuating?

A4) The infrared band between 10~12 μm is transparent to the atmospheric absorbing gases, which is called the atmospheric window. The infrared channels in the atmospheric window are thus used to observe cloud top temperature and the Earth surface. Meanwhile, absorption by water vapor is a dominant feature at 6.7 μm. Brightness temperatures at 6.7 μm are then affected by the amount of atmosphere water vapor. As such, brightness temperatures measured by the infrared channels in the atmospheric window (10~12 μm) are generally warmer than those from the water vapor channel (Soden, 2000).

In typical cold-type cloud systems, brightness temperatures in the infrared bands decrease as rainfall intensities increase. However, it has been known that this relationship between rain rate and infrared brightness temperature is weaken especially in shallow stratiform precipitation (Kuligowski, 2002). A warm-type cloud system, characterized by warm cloud top temperature can also produce extensive precipitation (Todd et al., 2001). The various relationships for different cloud systems can make the fluctuations over the heavy precipitation regions as in Figure 3.

Q5) Original radar rain rate and rain rate merged with satellite or AWS data are compared. For this evaluation, first original radar rain rate and AWS comparison should be performed. This comparison will provide understanding of how much original radar rainfall and AWS rainfall are biased or scattered.

A5) Comparisons of the radar and AWS rain rates are performed as suggested (Fig. A1). One of the merging techniques in this paper uses AWS to determine the weights of the individual precipitation datasets. That is, the purpose of using the AWS data is to decide the optimal weights. The conclusion of the paper is that the equal weight merging method tends to produce better-merged results than the optimal weight merging using AWS. It is due to the sparse distribution of AWS observations. From the viewpoint of determining optimal weights, we think, AWS observations do not need to be matched well to the radar estimates.

Q6) At figure 10, twelve cased are compared here. But they are not explained anywhere. Are these cases are different with previous four cases?

A6) Among 12 cases, cases 1~4 are directly shown as figures and cases 5~8, and 11~12 are the same cases as cases 1~4 but for the different gap areas. In addition to the previous cases with different gap areas, two different cases including 10 Jul 2011 12:00 (local time) and 7 Aug 2011 16:00 are also used for figure 10 as cases 9 and 10. New cases and gap areas are mentioned in the revised version of the paper as follows:

"An attempt was made to analyze the impacts of the satellite precipitation estimates on the merged results with additional radar gap areas at different locations and two different precipitation cases including 10 Jul 2011 12:00 (local time) and 7 Aug 2011 16:00."

Minor comments:

Q1) Line 6-7 of page 6303, it will be better to use "southwestern" than only "west".

A1) We use the word "west" in the revised version of the paper as suggested. We have modified the sentence as follows:

"…in the west part of the Korean peninsula (Fig. 2) was used in this study."

Q2) Eq(2), eq(3) and eq(7) use same character for weight. But it make confusing. It will be better to use different character.

A2) We change "W_i" to "T_i" at eq(3). However, eq(7) does not use the same character to eq(2) or eq(3). Eq(6) rather uses the same character for weight, we thus change the word "w_k" to "I_k" at eq(6) in the revised version of the paper. The revised equations are as follows:

$$T_i = exp\left(\frac{-t_i}{t_{max}}\right) \qquad (3)$$

$$I_k = exp(\frac{-d_k^2}{2r}) \qquad (7)$$

Q3) Line 23 of page 6309, terminology, "radar rate" is not proper for radar based rain rate estimation.

A3) The terminology "radar rate" is changed to "radar rain rate" in the revised version of the paper. We have modified the sentence as follows:

"…and the mean radar rain rate to the mean radar rain rate."

Q4) Figure captions are not described properly. Some figures have (a),(b),…, but at caption they are not explained (ex, figure 4) and vice versa (ex, figure 8).

A4) We remove unnecessary characters of (a), (b).. at figure 4. The revised figure 4 is presented at Fig. A2. In addition, explanation for (a), (b).. is added to Figs. 5-6 as follows:

"Figure 5. ... after bias correction for the four precipitation cases of (a) case 1, (b) case 2, (c) case 3 and (d) case 4."

"Figure 6. Images of the Jindo radar rain rate estimations for the four different precipitation cases of (a) case 1, (b) case 2, (c) case 3 and (d) case 4."

Figure 8 is revised by adding characters of (a), (b), (c) at the top of the figure. The modified figure 8 is presented at Fig. A3.

Q5) At figure 5 caption of page 6320, "Scatter… of the radar observed (???) and satellite …", "observed" may be not proper.

A5) The word "observed" is changed to "estimated" as pointed out by reviewer. The first sentence of figure 5 caption is revised as follows:

"Scatter density diagrams of the radar rain rate estimation and satellite estimated precipitation after bias correction for the four precipitation cases."

Q6) Figure captions 6-10 have same issue. The terminology, "observed" or "observation" is not used for rain rate. Typically the terminology, "estimated or estimation" is used.

A6) The figure captions is revised as suggested. The modified figure captions are as follows:

Figure 6. Images of the Jindo radar rain rate estimations for the four different precipitation cases.

Figure 7. Precipitation distributions estimated by the Jindo radar for…

Figure 8. Scatter diagrams for the radar rain rate estimations versus the merged precipitation….

Figure 9. ... The first correlation in the abscissa is obtained from the satellite estimates and radar rain rate estimations. The other correlation in the ordinate is from the merged precipitation estimates and the radar rain rate estimations. ...

Figure 10. The correlation coefficients between the merged precipitation and radar rain rate estimation over the different gap areas. ...

Reference

Kuligowski, R. J.: A self-calibrating real-time GOES rainfall algorithm for short-term rainfall estimates, J. Hydrometeorol., 3, 112-130, 2002.

Soden, B. J.: The diurnal cycle of convection, clouds, and water vapor in the tropical upper troposphere, Geophys. Res. Lett., 27, 2173-2176, 2000.

Todd, M. C., Kidd, C., Kniveton, D., and Bellerby, T. J.: A combined satellite infrared and passive microwave technique for estimation of small-scale rainfall, J. Atmos. Ocean. Tech., 18, 742-755, 2001.

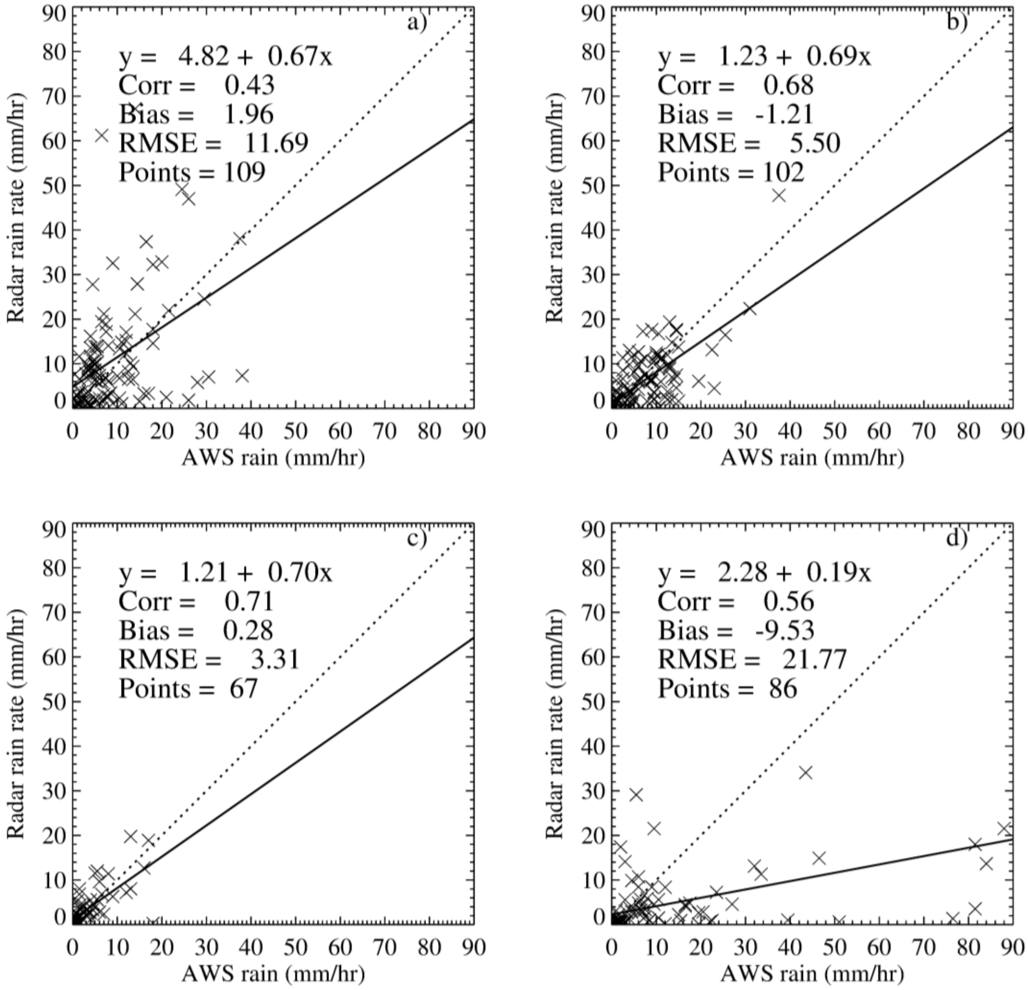

Figure A1. Scatter diagrams of the AWS observed and radar estimated precipitation over Jindo radar coverage at (a) case 1, (b) case 2, (c) case 3, and (d) case 4.

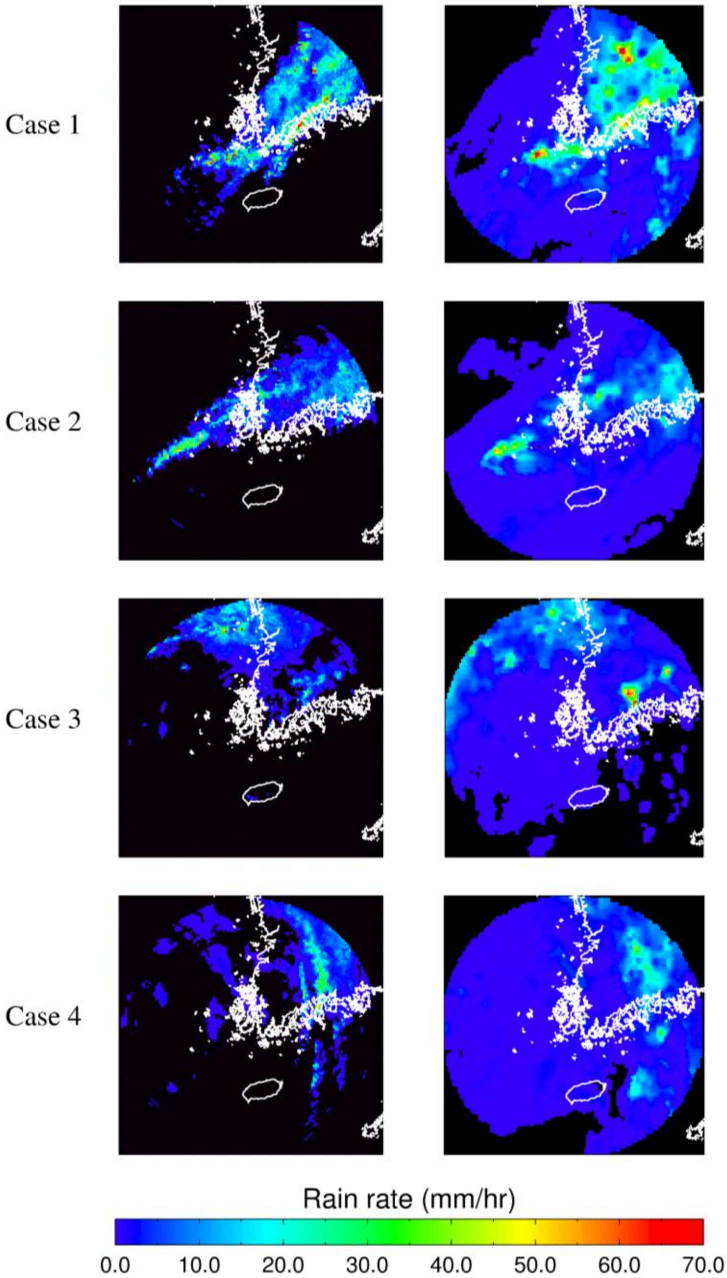

Figure A2. Images of the Jindo radar rain rates (left column) and satellite precipitation estimates after bias correction (right column) for the four precipitation cases.

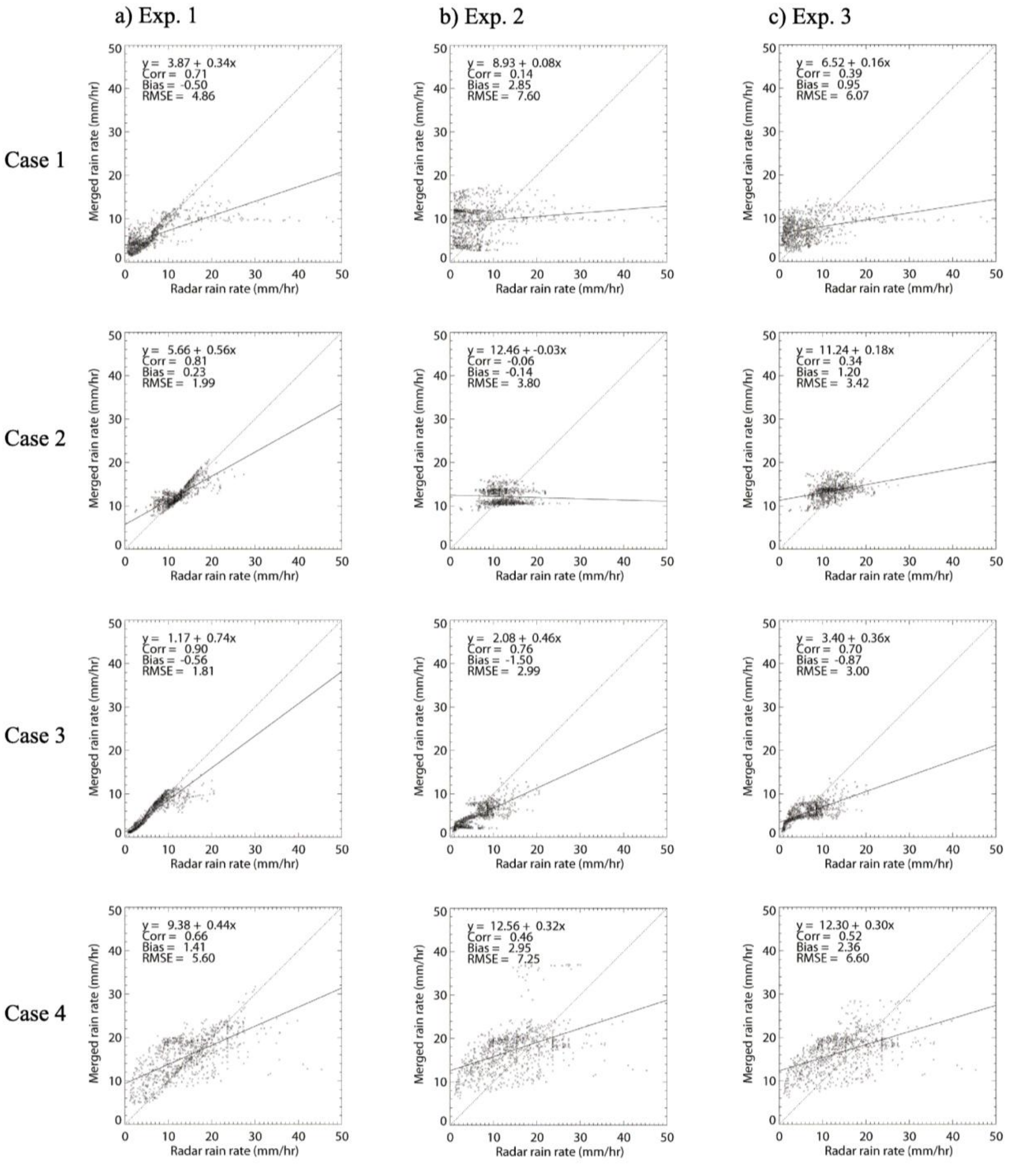

Figure A3. Scatter diagrams for the radar rain rate estimations versus the merged precipitation over the radar gap areas using the merging methods of (a) optimal weight using radar, (b) optimal weight using AWS, and (c) equal weight for each of the precipitation cases.