# Response to the comments from the reviewer 5

## Responses to the general comments:

We would like to thank the reviewer for the constructive comments and corrections, especially about the English language. The invaluable comments help improve our paper. Our responses are as follows.

In this document, for each comment (black font), we display an answer (blue font)

## Responses to the specific comments and Technical corrections:

*Q1) Page 1, title: I would suggest "Dual-polarization radar rainfall estimation in Korea according to raindrop shapes obtained by a 2D Video Disdrometer".*

A1) I'll take it into account

*Q2) Page 1, ll.23: What did you mean with "a new axis ratio of raindrop relations"? it's a relation between the raindrop axis ratio and the raindrop diameter? Please specify. It's my opinion that you should better introduce this relation both in the abstract and in the introduction.*

A2) The average shape of a raindrop can be inferred by the shape-size relationship of a raindrop. The equilibrium raindrop shapes are defined by the relation between the raindrop axis ratio versus equivolume diameter D [mm]. As your comments, we added the information of axis ratio relation.

*Q3) Page 1, ll.24-25: If you say: "polarimetric rainfall algorithms were derived using different axis ratio relations", it seems that the polarimetric algorithm changes depending on the axis ratio relation you consider. But if we observe table 3 you applied each polarimetric rainfall relation with the same 4 axis ratio relations. Instead, the polarimetric parameter depend on the shape of raindrops you assumed, as it's better specify at page 7 lines 28-29. So you should rephrase.*

A3) Each theoretical polarimetric variables were simulated according to different mean axis-ratio relations (the shape of the raindrops), from them, polarimetric rainfall algorithms were derived. As your comments, manuscript has been revised.

*Q4) Page 1, ll.25-26: What did you mean saying "radar-point one hour rain rate"? A radar estimates rain in a pixel not in a point. A rain gauge measures rain in a point. Could you specify if the pixel in question includes within it the rain-gauge location? Furthermore with "one-hour rain rate" did you mean the average rain rate in a hour? It would be better if you put the unit. I would suggest to write "the radar-pixel hourly mean rain rate".*

A4) In this study, one-hour rain totals that were obtained from the radars and gauges were compared. We examined "point" estimates of the one-hour rain accumulation. By point estimate we mean an hourly total averaged over a small (1km x 2°) area centered on a rain gauge.

*Q5) Page 1, ll24-27: you wrote: "Second, polarimetric rainfall algorithms were derived using different axis ratio relations, and estimated radar-point one hour rain rate for the differences in polarimetric rainfall algorithms were compared with the hourly rain rate measured by gauge." The sentence is too long, please split it. Moreover, I suggest writing: "the estimated radar-pixel hourly mean rain rate obtained from the different polarimetric rainfall algorithms" instead of "estimated radar-point one hour rain rate for the differences in polarimetric rainfall algorithms"*

A5) As your comments, we split the sentence, and the manuscript has been revised as follow:

*After*

"Second, polarimetric rainfall algorithms are derived using different axis ratio relations. The estimated radar-point hourly mean rain rate obtained from the different polarimetric rainfall algorithms are compared with the hourly rain rate measured by a rain gauge."

*Q6) Page 1, ll.27-28: I would change "in relation to calibration bias of reflectivity and differential reflectivity" into "to calibrate reflectivity and differential reflectivity biases".*

A6) I'd appreciate your input on this. The manuscript has been revised

*Q7) Page 1, ll.28-29: the sentence is poorly written, I suggest to write: "For D <1.5 mm and for D >5.5 mm the shape of raindrops obtained by the new axis-ratio relation developer by the 2DVD is more oblate than the shapes obtained by the existing relations."*

A7) As your comments, the sentence has been revised

*Q8). Page 2, ll.6-9: the sentence is poorly written, I would write "Zh and ZDR biases were calculated by comparing Zh and ZDR radar measurements with the same parameters simulated by the 2DVD. In order to produce more accurate rainfall estimation." (it is redundant to say that a bias is used to correct a bias). In addition it's my opinion that you should better specify what is the aim of your work. If I understood, you developed an new axis-ratio relation with the 2DVD. You developed also the polarimetric rainfall algorithms by using the same tool? Then, you applied polarimetric rainfall algorithms to calculate the rain by utilizing as inputs the polarimetric parameters, which are both measured by the radar and simulated by the disdrometer, according to 4 axis-ratio relations. You corrected also Zh and ZDR biases by comparing radar measurements of polarimetric parameter with the disdrometer simulations of the same parameters. Finally you validated the rainfall estimations obtained by both the radar and the disdrometer by a comparison with the rain gauges measurements considered as the ground truth. In many past works the rain gauge observations have been considered as the ground truth, for example in both Lombardo et al. (2006) and Sebastianelli et al. (2013) which I suggest the authors to cite:*

*- Lombardo, F., Napolitano, F., Russo, F., Scialanga, G., Baldini, L., and Gorgucci, E.: rainfall estimation and ground clutter rejection with dual polarization weather radar, Adv. Geosci., 7, 127– 130, doi:10.5194/adgeo-7-127-2006, 2006b.*
*- Sebastianelli, S., Russo, F., Napolitano, F., & Baldini, L. (2013). On precipitation measurements collected by a weather radar and a rain gauge network. Natural Hazards and Earth System Science, 13(3), 605-623, doi:10.5194/nhess-13-605-2013.*
*In particular, the radar estimations reliability is assessed before and after the calibration*

*In particular, the radar estimations reliability is assessed before and after the calibration to test the effectiveness of the calibration process. Could you better clarify this aspect in the text by briefly describing the methodology followed in your work?*

A8) I'd appreciate your input on this, the sentence modified as suggested in your comment.

*Q9) Page 2, ll.13-16: I would write: "in particular, a dual polarization radar can estimate rainfall more accurately than a single polarization radar by providing reflectivity ($Z_H$), differential reflectivity ($Z_{DR}$), differential phase ($\Phi_{DP}$), specific differential phase ($K_{DP}$), and cross-correlation coefficient ($\rho_{hv}$)."*

A9) As your comments, the sentence has been revised.

*Q10) Page 2, ll.17: what did you mean with backscatter? Perhaps you meant back-scatted signal?*

A10) Yes. Backscatter is back-scatted signal from the raindrop

*Q11) Page 2, ll.17: I would delete " of hydrometeors" because for me it is redundant*

A11) The sentence has been revised.

*Q12) Page 2, ll.17: I suggest to say: "Dual-polarization radar provides characteristics of the precipitation such as precipitation type by means of... obtaining more informations about DSD (Cifelli et al., 2011), and reducing the impact of DSD variability on rainfall estimation. For these reasons rainfall estimates provided by polarimetric weather radar are better than that given by a single polarization weather radar."*

A12) The sentence modified as suggested in your comment.

*After*

"Dual-polarization radar provides characteristics of the precipitation by backscatter and differential propagation phase and therefore can reveal uncertainty in rainfall estimation resulting from DSD variability (Cifelli et al., 2011). Polarimetric parameters are sensitive to the DSD properties such as diameter, concentration, orientation, and shape. Rainfall rates derived from polarimetric radar measurements are affected by the mean shape of raindrops and canting (Brandes et al., 2002). In addition, the multi-parameters can distinguish precipitation type, and reducing the impact of DSD variability on rainfall estimation. For these reasons dual-polarization rainfall algorithms used $K_{DP}$ or combinations of $Z_H$, $Z_{DR}$, and $K_{DP}$ are better than using reflectivity factor only (Ryzhkov et al., 2005)."

*Q13) Page 2, ll.25: I would remove "of the rain" because for me it is not necessary.*

A13) The sentence modified as suggested in your comment.

*Q14) Page 2, ll.27: please split the sentence into two sentences by replacing the word "and" by a mark.*

A14) As your comments, we split the sentence

*Q15) Page 2, ll.32: I would replace "with types of storms and stages of storm development" with "with both types and stages of storm development".*

A15) The sentence modified as suggested in your comment.

*Q16) Page 3, ll.4: I would say "rainfall estimations by polarization radars are affected by errors due to different sources of uncertainties such as . . . Reviews of the different sources of uncertainties are made by different Authors in the past, for example by Zawadzki (1984), Villarini and Krajewski (2010), Sebastianelli et al., 2013, and Spina et al., 2013, which i suggest the Authors to cite:*

- Zawadzki, I.: Factors affecting the precision of radar measurements of rain, in: Proceeding of the 22d Conf. Radar Meteorology, Zurich, Switzerland, 10–13 September 1984, Amer. Meteor. Soc., 251–256, 1984.
- Villarini, G. and Krajewski,W. F.: Review of the different sources of uncertainty in single polarization radar-based estimates of rainfall, Surv. Geophys., 31, 107–129, 2010.
- Sebastianelli, S., Russo, F., Napolitano, F., & Baldini, L. (2013). On precipitation measurements collected by a weather radar and a rain gauge network. Natural Hazards and Earth System Science, 13(3), 605-623, doi:10.5194/nhess-13-605-2013.
- S. Spina, S. Sebastianelli, E. Ridolfi, F. Russo, L. Baldini, and L. Alfonso: Data selection to assess bias in rainfall radar estimates: An entropy-based method, AIP Conference Proceedings 1558, 1665 (2013); doi: 10.1063/1.4825849.

A16) The sentence modified as suggested in your comment.

*Q17) Page 3, ll.5: please delete "These measurement errors affect rainfall estimation." Because for me it's redundant.*

A17) The sentence modified as suggested in your comment.

*Q18) Page 3, ll.6: I would replace "accurate measurement and calibration of ZH and ZDR" with ZH and ZDR measurements.*

A18) "calibration of $Z_H$ and $Z_{DR}$" differ "$Z_H$ and $Z_{DR}$ measurements"

*Q19) Page 3, ll.7: I would change "accommodation" in "assessment".*

A19) The sentence modified as suggested in your comment.

*Q20) Page 3, ll.9: I would replace "measured $Z_H$ and $Z_{DR}$" in "$Z_H$ and $Z_{DR}$ measurements".*

A20) The sentence modified as suggested in your comment.

*Q21) Page 3, ll.10-11: I suggest to use the wording "vertical profile of reflectivity" instead of "measured ZH from the radar profiler (at vertical incidence)". See for example Sebastianelli et al. (2013)*

A21) The sentence modified as suggested in your comment.

*Q22) Page 3, ll.11: the disdrometer-inferred ZH*

A22) Yes.

*Q23) Page 3, ll.12: please change "by comparing reflectivity between radar and disdrometer" into "by comparison between radar and disdrometer reflectivity".*

A23) The sentence modified as suggested in your comment.

*Q24) Page 3, ll.12:* the principle has been theorized by Gorgucci et al., 1992, please insert citation.

A24) we insert Gorgucci et al. (1992)

*Q25) Page 3, ll.22-23: a mean axis ratio and a polarimetric rainfall algorithms*

A25) The sentence modified as suggested in your comment.

*Q26) Page 3, ll.24: please remove "the" and change "after" in "hereafter".*

A26) The sentence modified as suggested in your comment.

*Q27) Page 3, ll.25-26: please put into the brackets "and newly derived axis-ratio relation from 2DVD data".*

A27) The sentence modified as suggested in your comment.

*Q28) Page 3, ll.30: please remove "the" before "data"*

A28) We have modified the sentence

*Q29) Page 4, ll.2: please replace "drawn" with "given"*

A29) We have modified the sentence

*Q30) Page 4, ll.6-9: please check the English grammar and rephrase. I would write "data were used to develop a mean raindrop axis ratio relation. . .", and "The disdrometer data used in this study were collected by a 2DVD from. . ."*

A30) We have modified the sentence

*Q31) Page 4, ll.21: a frequency.*

A31) We have modified the sentence

*Q32) Page 4, ll.23: I would write "Data are obtained by using six. . ."*

A32) The sentence modified as follows.

*After*

*"The considered data are taken from six elevation angles ….."*

*Q33) Page 4, ll.29: I would say "both for Zh and ZDR calibration".*

A33) We have modified the sentence.

*Q34) Page 5, ll.1: and for rainfall estimation.*

A34) We have modified the sentence.

*Q35) Page 5, ll.2: please replace "from" with "due to".*

A35) We have modified the sentence.

*Q36) Page 5, ll.7: please write "the 2DVD rainfall estimations" instead of "rainfall calculated from 2DVD data".*

A36) We have modified the sentence.

*Q37) Page 5, ll.19-20: please rephrase. I suggest to say "In Fig. 2b and 2c we compare the axis ratio-diameter relation of Pruppacher and Beard (1970) with that found by the disdrometer before and after the correction, respectively.*

A37) We have modified the sentence.

*Q38) Page 6, ll.12-13: the sentence is poorly written, please rephrase. I suggest to write "We analyzed the rainfall cases occurred during the period . . . . Fig. 3 shows six of these cases.*

A38) The sentence modified as suggested in your comment.

*Q39) Page 6, ll.18: As the 2DVD…*

A39) We have modified the sentence.

*Q40) Page 6, ll.25: the error is with respect to rain-gauge data? Please specify.*

A40) The sentence modified as follows.

*After*

"Therefore, the rainfall differences between 2DVD and rain gauge used in this study are limited to a maximum of 20% error, and the 2DVD data were excluded from the analysis when rainfall difference between 2DVD and rain guage was exceeding 20%."

*Q41) Page 7, ll.1: you wrote "in suit". What did you mean? Perhaps you meant "on site"?*

*A41) the rain rate calculated from the 2DVD observation to collocated rain gauges.*

*Q42) Page 7, ll.1-3: What's the criteria you used to distinguish between the different rainfall event types? Any references? In Sebastianelli et al., 2013 you can find a description of the rainfall events types from the radar point of view. Look also the works cited in that paper about that, in particular Zhang et al., 2008, and Zhang and Qi, 2010 which define events consisting of a stratiform part and a convective one (in relation to your table 2). So I suggest to add the following references:*

*- Sebastianelli, S., Russo, F., Napolitano, F., & Baldini, L. (2013). On precipitation measurements collected by a weather radar and a rain gauge network. Natural Hazards and Earth System Science, 13(3), 605-623, doi:10.5194/nhess-13-605-2013.*

*- Zhang, J. and Qi, Y.: A real-time algorithm for the correction of brightband effects in radar-derived QPE, J. Hydrometeorol., 11, 1157–1171, 2010.*

*- Zhang, J., Langston, C., and Howard, K.: Brightband identification based on vertical profiles of reflectivity from the WSR-88D, J. Atmos. Ocean. Tech., 25, 1859–1872,2008.*

A42) We have divided rainfall event into three rainfall types such as stratiform, convective and mixed rainfall events using the radar reflectivity and one-hour rain rate calculated by rain gauge and 2DVD. We were referring to Chang et al. (2009), and rainfall rate was modified. The criterion of the rainfall events are as follows:

| | Stratiform | Convective | Mixed(Str+Con) |
|---|---|---|---|
| Reflectivity [dBZ] | ≤ 35 | > 35 | - |
| Rainfall rate[mm/hr] | ≤ 5 | > 5 | - |

Chang, W. Y., Wang, T. C., and Lin, P. L.: Characteristics of the Raindrop Size Distribution and Drop Shape Relation in Typhoon Systems in the Western Pacific from the 2D Video Disdrometer and NCU C-Band polarimetric Radar, J. Atmos. Oceanic Technol., 26, 1973-1993, 2009.

*Q43) Page 7, ll.3: precipitation type.*

A43) We have modified the sentence.

*Q44) Page 7, ll.4: what did you mean with "difference rainfall"? Maybe you refer to the difference between disdrometer and rain gauge rainfall?*

A44) Yes. The word "difference rainfall" means difference between disdrometer and rain gauge rainfall

*Q45) Page 7, ll.7: I would change "larger" in "greater".*

A45) We have modified the sentence.

*Q46) Page 7, ll.17: you would write "reach about"?.*

A46) We have modified the sentence.

*Q47) Page 7, ll.18: established within.*

A47) We have modified the sentence.

*Q48) Page 7, ll.22: major and minor axis.*

A48) We have modified the sentence.

*Q49) Page 8, ll.1: 10.7 cm wavelength.*

A49) We have modified the sentence.

*Q50) Page 8, ll.2: we calculated.*

A50) We have modified the sentence.

*Q51) Page 8, ll.2: relations which.*

A51) We have modified the sentence.

*Q52) Page 8, ll.15-16: you wrote "Polarimetric rainfall relations between R and dual-polarimetric parameters are derived when rain rate is greater than 0.1 mm hr-1.". Why? to avoid the smallest raindrop diameter and therefore the particles outliers? Please clarify.*

A52) Simulated polarimetric parameters are very small when the rain rate is below 0.1 mm/hr, and to exclude the non-precipitation data, we use polarimetric parameters and rain rate data when rain rate is greater than 0.1 mm/hr.

*Q53) Page 9, ll.2: you wrote "The polarimetric radar contains systematic bias of the radar itself." It would be appropriate to introduce a bias definition. You can find a bias definition in Spina et al., 2013. In this work the calibration bias error is defined as a systematic error affecting radar estimates of rainfall independently from both the instant of measurement and the location of the sampling volume.*

A53) I'd appreciate your input on this. The sentence modified as follows.

*After*

"The radar measurements are affected by various observational errors, such as ground echoes, beam broadening and abnormal propagation echoes."

*Q54) Page 9, ll.3: I would suggest to replace "accomodation" with "assessment".*

A54) We have modified the sentence.

*Q55) Page 9, ll.4: I would suggest to write "the radar calibration" instead of "the calibration of the radar"; moreover, why the calibration was done only for light rainfall event? Maybe to avoid rain gauge error due to wind action which deflects the falling raindrops from the vertical, or it prevents the fall of the drops (updraft). So for the radar calibration you consider only stratiform cases? It is correct to say that?*

A55) Yes, you're right. We chose a continuous rainfall event for the continuity of measurement data, and we also use stable light rainfall event in order to avoid the impact of the unstable rain. In addition, to achieve accurate calibration bias of radar, the process of calibration bias should be performed in continuous and stable rainfall systems. Therefore, time of observation is short and unstable rainfall events were excluded.

*Q56) Page 9, ll.10: I would change "are point measurements" into "consist of point measurements".*

A56) We have modified the sentence.

*Q57) Page 9, ll.10: I would write "whereas radar data are measured in a sampling volume".*

A57) We have modified the sentence.

*Q58) Page 9, ll.18: I suggest the Authors to put into brackets "see Fig. 5".*

A58) We have modified the sentence.

*Q59) Page 9, ll.23: I suggest the Authors to write "… Relation derived by measurements in the wind tunnel".*

A59) We have modified the sentence.

*Q60) Page 9, ll.26-29: the sentence is too long and it is poorly written, please rephrase. I suggest to split it into two sentences. I suggest the Authors also to write "The Beard and Chuang (1987) polynomial relation (Eq. (9), black dashed line) is from 2.5 to 6.5 mm lower than the new mean axis-ratio relation values".*

A60) We have modified the sentence.

*Q61) Page 10, ll.2-3: I would write "With the exception of this case, the new axis ratio was similar to Eq. (10) for diameters ranging from 3 to 5.5 mm".*

A61) We have modified the sentence.

*Q62) Page 10, ll.5-6: please remove the sentence "This means that raindrops in South Korea are more oblate than the others"; it is my opinion that you can not assert this by comparing results of different models, which were obtained in different ways and with different data. To say something like that you should derive a mean axis-ratio relation with the same 2DVD in different part of the word.*

A62) I'd appreciate your input on this. The sentence modified as follows.

*After*

"These differences of raindrop shape can be caused by a variety of reasons, such as instrumental effects, fitting method, event selection, and different climatic regimes."

*Q63) Page 10, ll.12: please change "from" in "by utilizing".*

A63) We have modified the sentence.

*Q64) Page 10, ll.13: I would write "and it was compared with R derived from the 2DVD (Eq. (2))".*

A64) We have modified the sentence.

*Q65) Page 10, ll.14: the correlation coefficient. What correlation coefficient? Pearson correlation coefficient?*

A65) Yes

*Q66) Page 10, ll.*15: I would write rain rate estimation as it is a disdrometer.

A66) We have modified the sentence.

*Q67) Page 10, ll.*19: observed rain rates.

A67) We have modified the sentence.

*Q68) Page 10, ll.*23: please check English grammar.

A68) Yes

*Q69) Page 10, ll.24: I would change "when compared" in "in comparison".*

A69) We have modified the sentence.

*Q70) Page 11 ll.2: I would replace "from" with "measured by a".*

A70) We have modified the sentence.

*Q71) Page 11 ll.9: with the hourly rain rate.*

A71) We have modified the sentence.

*Q72) Page 11 ll.14: obtained by the radar.*

A72) We have modified the sentence.

*Q73) Page 11 ll.15: measured by the rain gauge.*

A73) We have modified the sentence.

*Q74) Page 11 ll.16: I would write "2DVD rainfall estimation".*

A74) We have modified the sentence.

*Q75) Page 11 ll.16: decide if you want to use showed or shown in the text.*

A75) Yes

*Q76) Page 11 ll.16: why good results. With respect to rain gauges? Please specify.*

A76) 2DVD rainfall estimation shown good results in $R(K_{DP}, Z_{DR})$, and radar rainfall estimation shown best results in $R(Z_H, Z_{DR})$.

*Q77) Page 11 ll.17: I suggest the Authors to remove the sentence part "$R(K_{DP}, Z_{DR}) > R(Z_h, Z_{DR}) > R(K_{DP}) > R(Z_h)$", and to describe the concept just in words because in this way it seems that $R(K_{DP}, Z_{DR})$ is greater than rainfall estimated by each other formula. What did you mean is that the $R(K_{DP}, Z_{DR})$ algorithm give the most reliable rainfall estimation, it's right?*

A77) As mentioned in A76), the accuracy of the rainfall estimation improved when the $K_{DP}$ parameter was used for 2DVD rainfall estimation. In the single rainfall relation with $Z_h$ (Figure 7a), an amount of scatter is present (MAE=0.95 mm $h^{-1}$ and RMSE=1.23 mm $h^{-1}$), and the scatter decrease (MAE=0.70 mm $h^{-1}$ and RMSE=0.92 mm $h^{-1}$) when the $K_{DP}$ parameter was used for 2DVD rainfall estimation (Figure 7b). These results are influenced by the variability of DSDs, and the effect of the DSD variability is declined in rainfall estimation with the $R(K_{DP})$ or $R(K_{DP}, Z_{DR})$ than that with the $R(Z_h)$. However, the accuracy of the rainfall estimation declined when the $K_{DP}$ parameter was used for radar rainfall estimation. Moreover, the radar rainfall estimations from $R(K_{DP})$ and $R(K_{DP}, Z_{DR})$ exceeded rainfall gauge measurements at lower rain rates ($\leq$ 5 mm $hr^{-1}$), whereas rainfall estimations from $R(Z_h,$

$Z_{DR}$) were similar to rainfall by measured by gauges. In other words, as the rain rate increased, the uncertainty of $K_{DP}$ from the radar declined. This was because $K_{DP}$ is noisy in light rainfall. These results show that, the R($K_{DP}$, $Z_{DR}$) relation is useful for heavy rainfall and R($Z_h$, $Z_{DR}$) is suited for light rainfall (Ryzhkov et al., 2005).

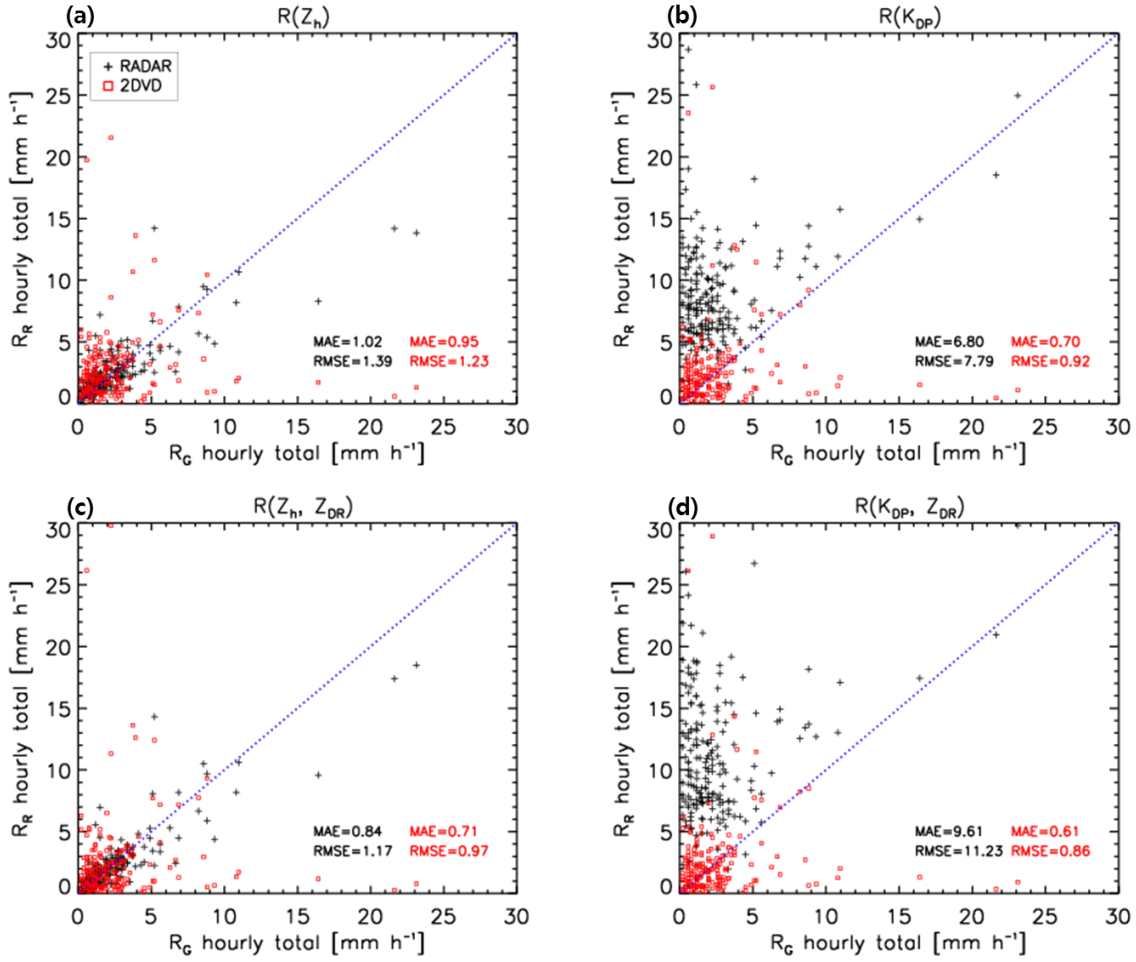


Figure 7. Scatter plot of one-hour rain rate from rain gauge (RG) and BSL S-Band radar (or 2DVD) based on Eq. (4) for 18 rainfall cases: The pluses represents one-hour gauge rain rate versus radar hourly rain rate from polarimetric rainfall algorithms, and squares indicate gauge and 2DVD rain rate by different polarimetric rainfall algorithms.

*Q78) Page 11 ll.17-21: I would change "performed better" with "was more efficient"; it's not clear what did you mean when you write "on DSD statistics".*

A78) "DSD statistics" means the statistical results of the precipitation derived from the 2DVD data

*Q79) Page 12, ll.2: I would replace "declined" with "worsen".*

A79) We have modified the sentence.

*Q80) Page 12, ll.4: for lower rain rates.*

A80) We have modified the sentence.

*Q81) Page 12, ll.3-6: please delete "the radar rainfall estimations from" because it is redundant.*

A81) We have modified the sentence.

*Q82) Page 12, ll.5-6: rainfall measured by gauges.*

A82) We have modified the sentence.

*Q83) Page 12, ll.8: I would write "the uncertainty in radar estimates due to the use of KDP reduces itself".*

A83) We have modified the sentence.

*Q84) Page 12, ll.18: $Z_H$ and $Z_{DR}$ biases were calculated separately for eight rainfall events. So you calculated eight ZH biases and eight ZDR biases?*

A84) Yes. We calculated the daily $Z_H$ and $Z_{DR}$ biases, and the bias of results for each of the eight rainfall events are presented in Table 5.

*Q85) Page 12, ll.22: the BSL ZDR measurements.*

A85) We have modified the sentence.

*Q86) Page 12, ll.22-23: ZDR value is simulated by the 2DVD?*

A86) $Z_h$ and $Z_{DR}$ parameters can be simulated using T-matrix method. This method is introduction in Section 3.3.

*Q87) Page 12, ll.25: please add the word "respectively" at the end of the sentence.*

A87) We add the word.

*Q88) Page 12, ll.27: please replace the word "comparing" with the word "comparison".*

A88) We have modified the sentence.

*Q89) Page 12, ll.30: I would write ". . . obtained before and after the bias correction, respectively, while ...".*

A89) We have modified the sentence.

*Q90) Page 13, ll.1: I would write ". . . obtained before and after the bias correction, respectively, while ...".*

A90) We have modified the sentence.

*Q91) Page 13, ll.2-4: the sentence is not clear and poorly written. Please rephrase. Maybe you meant that before the bias correction the precipitation was 12.67 and after was 15.33? What's the corresponding value of the gauge?*

A91) Yes. Rain gauge recorded 15.41 mm, before the bias correction the precipitation was 12.67 mm and after was 15.33 mm. The sentence modified as suggested in your comment.

*Q92) Page 13, ll.4-5: The comparison with the rain gauge rainfall shows that after the bias correction the rainfall radar estimates were improved by about 13.71%, it's right?*

A92) Yes, you're right.

*Q93) Page 13, ll.4: the rain gauge is the ground truth. You should say that also at the beginning of the paper (introduction and abstract).*

A93) We have modified the sentence.

*Q94) Page 13, ll.7: the sentence for me is poorly written, I would say "80.12 mm respectively for rain gauge, radar before bias correction, and radar after bias correction. The radar rainfall …".*

A94) We have modified the sentence.

*Q95) Page 13, ll.8-9: you calculated the bias for each event and then you performed a mean bias? It's right?*

A95) Yes, you're right.

*Q96) Page 13, ll.9: MAE passes from.*

A96) We have modified the sentence.

*Q97) Page 13, ll.10: decreased from.*

A97) We have modified the sentence.

*Q98) Page 13, ll.10: please add "after the bias correction" at the end of the sentence.*

A98) We add the sentence.

*Q99) Page 13, ll.11: I would write "as well as MAE and RMSE values".*

A99) We have modified the sentence.

*Q100) Page 13, ll.12: I would say "both MAE and RMSE values decrease after correcting bias, and this means that rainfall estimation tended to improve after bias correction".*

A100) We have modified the sentence.

*Q101) Page 13, ll.23-24: I would say "obtained through rainfall algorithms".*

A101) We have modified the sentence.

*Q102) Page 13, ll.24: I would say "was assessed by comparing 2DVD and BSL radar data with rain gauge measurements".*

A102) We have modified the sentence.

*Q103) Page 13, ll.25: I would change "was suited" into "is suitable".*

A103) We have modified the sentence.

*Q104) Page 13, ll.25: what's the meanings of "of the DSD statistics"? Maybe you intended "according to the DSD statistics"?*

A104) Yes.

*Q105) Page 13, ll.26: please replace "had" with "have".*

A105) We have modified the sentence.

*Q106) Page 13, ll.29: I would change "was weak" into "is noisy". It's right?*

A106) Yes, you're right.

*Q107) Page 13, ll.32: I would say "radar rainfall estimations were close to rain gauges measurements".*

A107) We have modified the sentence.

*Q108) Page 14, ll.1: I would say "different raindrops axis ratios". Did you mean the shape of the raindrops detected by the disdrometer?*

A108) We have modified the sentence.

*Q109) Page 14, ll.2: I would say "… relations, which were assessed to derive point…".*

A109) We have modified the sentence.

*Q110) Page 14, ll.3-4: I would say "obtained through rainfall algorithms".*

A110) We have modified the sentence.

*Q111) Page 14, ll.4-5: the sentence is too long and it is not clear, please rephrase. I suggest the Authors to write: "Polarimetric algorithms will be developed to obtain areal rainfall estimation. A classification of rain rate based on them will be also performed in a future work".*

A111) We have modified the sentence.

*Q112) Page 19, table 2: in the table caption please write "precipitation type" instead of "type of precipitation".*

A112) We have modified the sentence.

*Q113) Page 19, table 2: what's represents PE[%]?*

A113) *PE[%] is rainfall differences between 2DVD and rain gauge. PE[%] represented Eq. (3).*

*Q114) Page 22, table 5: I suggest the Authors to add two columns, the first one concerning the radar rainfall estimates, and the last one for rain gauge rainfall measurements.*

A114) I'll take it into account.

*Q115) Page 24, figure 2: you should clarify what represents the dotted line. Moreover you should specify that the red color correspond to the greater drop number density.*

A115) As your comments, I'll take it into account

*Q116) Page 26, figure 5: please add (b/a) at the y-label.*

A116) We have modified the figure 5.

*Q117) Page 31, figure 10: it's my opinion that it is better to replace the dotted lines with dashed lines.*

A117) We have modified the figure 10.