Response to the comments from the reviewer 4

Responses to the general comments:

We would like to thank the referees for their helpful comments, especially about the description of the motivation and raindrop shapes. These comments will help to improve considerably the quality of the 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:

Q1) Page 2, ll.29: I don't agree that "[t]he raindrop shape is defined by the shape-size relationship of raindrop." The shape is rather defined by interactions between the drop and the atmosphere (and other drops). However, the average shape of a raindrop can be inferred from its size.

A1) The sentence modified as suggested in your comment:

After

"The average shape of a raindrop can be inferred by the shape-size relationship of a raindrop."

Q2) Section 2.1: Additional information about the siting of the 2DVD should be given here: things like closeness to buildings could be significant.

A2) The sentence modified as suggested in your comment:

After

"The disdrometer data used in this study were measured using a 2DVD, and the data were collected from September 2011 to October 2012 deployed in the campus of Kyungpook National University (KNU), Daegu, Korea (35.9°N, 128.5°E). The 2DVD used in this study is compact 2DVD version, which installs in observation field from the buildings."

Q3) Page 5, ll.1: You say that you used the 0.0° elevation "to avoid effects from beam blocking and ground echoes". Surely that would be further reduced by using the 1.6° elevation data? you should say why you opted for 0.0° rather than 1.6° (to have measurements as close as possible in space to the 2DVD?).

A3) 2DVD data are ground measurements and radar data are volume measurements. To compare polarimetric radar parameters, it is necessary to minimize the influence of height difference of 2DVD and radar, and effect by ground. If using 1.6° elevation, we can avoid effects from beam blocking and ground echoes on the measurements, however, this elevation is a very great difference in measurement height. Figure 1 show beam path of the BSL radar and 2DVD location. The 2DVD is located about 22.3 km (17°) away from the BSL radar. The 0.0° PPI radar data can avoid effect from beam blocking and ground echoes. Thus, the 0.0° PPI radar data were used.

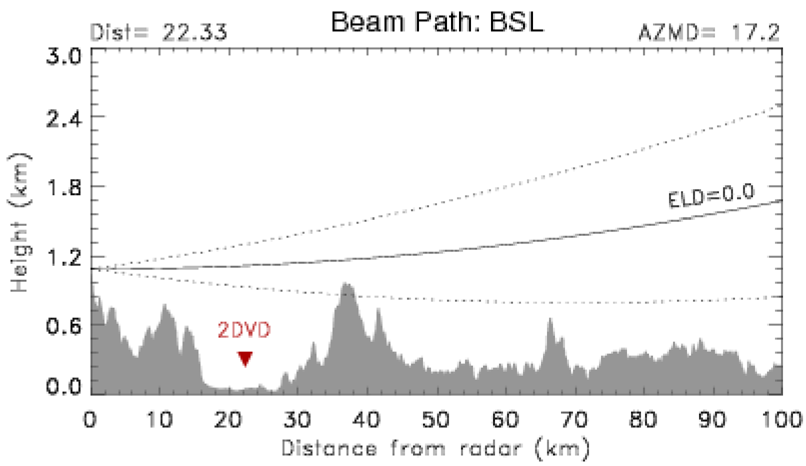

Figure 1. Beam path and terrain map in 17° azimuth angle of the BSL radar.

Q4) Figure 3: You seem to be showing some of the best available cases. Better might be to show a representative sample, including some of the best and some of the worst.

A4) During the period from September 2011 to October 2012, total 38 rainfall events were measured by the 2DVD, five rainfall events were discarded by the quality control process. The excluded five rain events show that rainfall differences between 2DVD and rain gauge were mostly from 22% to 30%. In this study, we did not include five rainfall events. The difference between 2DVD and rain gauge for the 33 rainfall events are listed in Table 2.

Q5) Section 3.2: You should give more information on the dataset you were working with here. What size of diameter bins were you using, what was the minimum number of drops in a bin included in the final fitting, what were the axis ratio standard deviations, etc.?

A5) The Section 3.2 modified as suggested in your comment.

After

"Size of diameter bin is 0.2 mm, and the oblateness data corresponding to raindrop diameter smaller than 0.5 mm were removed when we derived the mean axis-ratio relation, because oblateness is relatively noisy in small raindrop. In addition, although the measured maximum diameter from the 2DVD could reach about 8.0 mm, the fitting was established to within 7 mm in order to obtain accurate information from the appropriate data.

In order to produce the mean axis-ratio relation, a various fitting methods such as linear and polynomial (twice-, third-, fourth-order) fit were tried. As a result, the third-order polynomial relation was the most suitable for the observation data."

Q6) Page 8, ll.12: it may just be typo, but I think you should be using a mean canting angle of 0° and a standard deviation of 7°, not the other way round.

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

After

"The terms $\overline{\emptyset}$ and σ are assumed to be 0° and 7°, respectively.

Q7) Section 3.4: it is not quite clear here whether you are applying these calibration corrections only in table 5, or also in table 4. If in table 4, then assuming the new axis ratio calibration values in all cases would perhaps unfairly disadvantage the other axis ratios considered. Additionally, you should explain why you consider only light rain events for the calibration.

A7) The calibration bias of Z_H and Z_{DR} were applied in Table 5, we did not apply calibration bias in Table 4. Therefore, accuracy of rainfall estimation is evaluated as fair. In addition, to achieve accurate calibration bias of radar, the process of calibration bias should be performed in continuous and stable rainfall systems. Because in order to avoid the impact of the unstable rain (e.g. convective, short observation of time of storms, beginning or an end of the storms). Therefore, time of observation is short and unstable rainfall events were excluded.

Q8) Section 4.2.1: I think that here Re is begin determined by applying the various algorithms to radar polarimetric variables derived from the 2DVD data. is that correct? Either way, you should make this clearer.

A8) Yes, R_e is rain rate from various polarimetric rainfall algorithms. R_e is then obtained from the 2DVD data. The sentence modified as suggested in your comment.

Q9) Table 3: For the K_{DP}, Z_{DR} algorithms, I suspect the 0.1 correlation values are wrong (compare with figure 6)

A9) The manuscript has been revised as follows: 0.10 ⇒ 1.00

Q10) Section 4.2.2: Why do you carry out this validation only on 18 of the rain events and not all 33?

A10) We chose a continuous rainfall event for the continuity of measurement data. In other words, time of observation is short and unstable rainfall events were excluded from the analysis.

Responses to the technical corrections:

Q1) Page 1, ll 26: I think you mean different not differences here.

Q2) Page 6, ll 10: I think you mean that the drop fall velocity formula used was that derived by Brandes et al. (2002)

Q3) Page 7, ll 1: in situ rather than "in suit"

A) We would like to express our sincere thanks to the reviewer for the positive encouragement to our work.

References:

Thurai, M. et al.: "Drop Shapes, Model comparisons, and calculations of polarimetric radar parameters in rain", J. Atmos. Oceanic Technol. 24, 1019-1032, June 2007

Gorgucci, E., Chandrasekar, V. and Baldini, L.: "Can a unique model describe the rain-drop shape-size relation" A clue from polarimetric radar measurements?", J. Atmos and oceanic Technol. 26, 1829-1842, September 2009

Marzuki, Randeu, W.L., Kozu, T., Shimonai, T., Hashiguchi, H. and Schonhuber, M.:"Raindrop axis ratios, fall velocities and size distribution over Sumatra from 2D-Video Disdrometer measurement", Atmos. Res, 119, 23-37, January 2013