Interactive comment on "Effect of Sampling Variation on Error of Rainfall Variables Measured by Optical Disdrometer by X. C. LIU et al

General Comments

The subject of this paper is the sampling error in disdrometers due to the finite size of their measurement area. This is a well known problem that in most instruments it is reduced by increasing the measurement area up to the limit that other factors (like system dimensions in 2DVD, which can measure many particles at a time, or the need for narrow sampling laser beam in Parsivel, which measures one particle at a time) impose. The paper uses only simulated data and no actual measurements, in order for example to compare the various disdrometers. The number (six) of tables is too large (almost equal to the number of figures) and the number of pages is small for a normal paper. Also, unrealistic huge number of reflectivity values (close to 100 dBZ) are reported, which are obviously due to calculation errors. The conclusion that the reflectivity (sixth order moment of diameters, for which the large droplets are more important) has lower relative sampling error than other estimated rainfall variables should be explained. Probably, calculation errors are involved in this conclusion. The authors should verify their calculations, add results from actual measurements from available disdrometers and resubmit the paper.

Response: Thanks for your comments of our work. 1) We are sorry for the obvious error of reflectivity values, the reason is that the radar reflectivity values were calculated by logarithm base e instead of base 10 mistakenly, it has been corrected in the revised manuscript; 2) in P8905 section 3.2, we attributed the lower relative sampling error of reflectivity (sixth order moment of diameters) to the logarithmic transformation with units dBZ, according to the your specific comments, we have analyzed the error of the reflectivity with linear units ($mm^6 m^{-3}$) in the revised manuscript, and more reasonable results are obtained. 3) We have verified our calculations, and added more discussions.

Specific comments:

Page 2, line 5: “to measure precipitation” should be changed to “to measure the drop size distribution of precipitation”. Rain gauges are the typical instruments to measure precipitation, while disdrometers give information on the precipitation spectrum.

Response: Thank you for your comment. We have modified accordingly.

Page 2, lines 19-22: more recent studies about non-homogeneous models should be referenced, too. The homogeneous model fits better to the less frequent stationary precipitation.

Response: Thank you for your comment. We have read these papers carefully and learned a lot. It is helpful for us to complete this paper. In our revised manuscript, more references about non-homogeneous models are added in appropriate places.

Page 4, line 1: the correct term is “equivolumetric” instead of “equivalent” diameter. The parameter No is an “intercept” parameter and it is not the total drop concentration (the integral of the drop size distribution). The parameter μ is not the order of the gamma distribution but a measure of its shape (shape parameter).

Response: Thank you for your comment. We have modified accordingly.

Page 4, line 17: the term “two categories” should be changed to “two steps”. In addition, a third step in the simulation process is to specify the arrival time.

Response: We have modified accordingly, and added the third step about the arrival time.

Page 4, Eq. (4): this equation is valid for the arrival time of individual drops. But, in 2DVD the measurement area is on purpose quite large (10 × 10 cm) and simultaneous drops can be measured. Also, the description of the process of arrival time needs more details according to Smith (1993).

Response: We have added the description of the process of arrival time, which is also valid for 2DVD.

Page 6, section 2.3: The error in the estimation of the parameters No, μ and most important of rainfall rate should also be examined. Also, the right side of Eq. (14) is in error. A normalization by $\sum N(D)$ is needed.

Response: We have added the normalization of $\sum N(D)$.

Page 6, line 21: The 2DVD can measure the full shape (from two orthogonal views) of the particles.

Response: Yes, it's our mistake. We have modified related words.

Page 7, line 1: Is not clear where in the paper Eq. (15) for the axis ratio of drops is used.

Response: The axis ratios of drops are used when the volume of raindrops and rain rate are calculated.

Page 7, lines 5-10: A similar method for the margin area treatment is used in 2DVD. What about the errors, for example in Parsivel, when two or more drops pass simultaneously though the laser beam.

Response: Parsivel can only measure one drop in the same time, therefore when two or more drops pass simultaneously through the laser beam, it would cause the overestimation of size of drops and underestimation of number density.

Page 7, lines 25-26: A clear definition of marginal drops is needed.

Response: We have added a clear definition of marginal drops, which are the drops that fall at the margin of laser beam.

Page 8, line 1: the correct term "water content" instead of "water concentration". The huge value of 100 dBZ of reflectivity is obviously in error.

Response: We have replaced "water concentration" by "water content", which are the drops that fall at the margin of laser beam. We are sorry for that the radar reflectivity values were calculated by logarithm base e instead of base 10 mistakenly, it has been corrected in the revised manuscript

Page 8, lines 5-9: Higher moments depend on larger drop diameters and are expected to have higher error. The reflectivity units should be linear units (mm^6 m^{-3}) when the relative error is computed.

Response: We analyzed the relative error based on the linear units (mm^6 m^{-3}) in the revised manuscript, in which the higher moments have higher error.

Page 9, line 4 and Tables 4 and 5: The convective (named cumulonimbus) rain is a highly non-stationary rain and the homogenous model used in the simulation process is not valid.

Response: In order to compare the three types of rainfall, we used the homogenous model under the ideal conditions, while a larger error of rainfall variables would be obtained if a non-homogenous model is used.

Page 10, lines 19-21: 2DVD measures the fall velocity directly by the difference of the time of arrival between the levels of the two orthogonal optical beams.

Response: Yes, it's our mistake, we have corrected related words.

Page 11, Conclusions: Conclusions should have more discussion of results than the Abstract.

Response: We have added more conclusions about the discussion of results.