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Atmospheric Measurement Techniques Discussions

Interactive comment on "Effect of sampling variation on error of rainfall variables measured by optical disdrometer" *by* X. C. Liu et al.

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1 Summary

This manuscript presents a simulation study of the sampling effects on various quantities related to rainfall measured by optical disdrometers. The arrival of raindrops is supposed to be a Poisson process, and its parameter is related to climatological/characteristic DSD measured for different types of rain events in China. The sampling effect due to the size of the sample, the size of the sampling area and the rain rate are then investigated for different moments/descriptors of the DSD and for different optical disdrometers, as well as the sampling uncertainty in fall speed estimates. These errors appear to be limited for the considered quantities.

2 Recommendation

The idea motivating this study is interesting and relevant as the DSD is more and more commonly measured and used, in particular for radar rain rate estimation. However, the approach employed and the results presented in this manuscript are not well explained/ introduced. So the reader is a bit confused on what exactly is investigated and how. In addition, there are major issues in my opinion (e.g., reflectivity values in the order of 100 dBZ) which question the validity/reliability of the results and conclusions. Given the large amount of work required to address these issues and to reshape the manuscript, I recommend to reject this manuscript. In order to help the authors improving their manuscript, I provide below a list of comments/suggestions about issues to be addressed.

Response: Thanks for your comments of our work. We have modified our manuscript and corrected issues to make this manuscript more publishable. The details are as follows.

3 General Comments

1. The English is not good enough for publication in an international journal like AMT. Although I am not a native speaker, I found many strange or misleading sentences in the text that must be corrected. For example, the use of the terms "number", "concentration", "size" and "denstity" throughout the text is confusing/misleading. Just in the abstract, what exactly is "water concentration" on l.9, "number density" on l.11, "margin probability" on l.12, "sampling size" on l.14? I am aware that this is not easy for non-native speakers, but this must be done.

Response: Thanks for your comments of our work. We have modified the above errors in our revised manuscript according to your suggestions. "water concentration" was replaced by "water content", "number density" was replaced by "number concentration", "margin probability" is defined as the probability of drops partially seen by the measurement beam, was replaced by "probability of margin raindrops", "sampling size" is defined as the size of sampling area. Besides, we have invited professional English native speaker to check for the spelling and grammatical errors to make this manuscript legible.

2. Section 2 is not clear, and the approach to simulate raindrops arrival time and DSDs should be better explained (and the required assumptions and associated limitations should be mentioned). This is a key issue as all the results and conclusions depend on the quality of the simulated DSDs.

Response: Thanks for your comments of our work. We have added more explanation about the simulation and approach.

3. Related to the previous item, the fact that the authors provide radar reflectivity values in the order of 100 dBZ is a big concern. First such values are not realistic (reflectivity in rain is around 60 dBZ max, maybe a bit more in exceptional cases, but I have never seen measured values around 100 dBZ). Second, this raises the question of the maximum (equivolumetric) raindrop diameter simulated, about which I could not find any info in the text. So I am wondering if the authors have rigorously check their simulations. . .

Response: 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 be corrected in the revised manuscript (The maximum reflectivity is 63.44 dBZ when rainrate is 100 mm/h). Second, the interval of equivolumetric raindrop diameter simulated in this manuscript is 0.05mm $\sim$ 6.0 mm.

4. The goal is to quantify the sampling effect in DSD measurements from optical disdrometers. The DSDs are however simulated from Gamma DSD fitted to measured DSDs. The quality of the fit of the Gamma DSD model on the measured DSD spectra should be discussed or at least mentioned.

Response: Your suggestions are reasonable, however, this paper mainly discuss the

sampling effect on DSD measurement based on different types of rainfall, the parameters of DSDs in Table 1 are from several studies about DSDs measurements and analysis, this manuscript didn't fit the measured DSDs but summarized their conclusions. The different DSDs are only a reference for simulation; we don't think that the assessment of quality of the fit could help to understanding the simulation in this manuscript.

4 Specific comments

1. P.8896, l.26: a better reference than Battaglia et al. (2010) presenting the Parsivel is Löffler-Mang and Joss (2000).

Response: Thank you for your suggestions, we have modified it.

2. P.8897, l.8-9: this radar is known as MRR. The POSS could also be mentioned (Sheppard, 1990).

Response: Thank you for your suggestions, we have modified it.

3. P.8898, l.9-11: The sampling uncertainty associated with Parsivel has been experimentally investigated and quantified Jaffrain and Berne (2011). This reference should be in this manuscript.

Response: Thank you for your suggestions, we have added this reference.

4. P.8899, Eq.1 and l.2-3: N(D) given in Eq.1 is not the concentration of drops per unit volume, N(D)dD is (the number of drops with diameter between D and D + dD per unit volume). In addition, N0 in Eq.1 is not the total concentration number (its units depend on μ). Moreover, the units should be provided for quantities/variables used in all the equations throughout the paper.

Response: Thank you for your comment, we have corrected them.

5. P.8899, l.23-24: there are also studies in the literature that do not support the Poisson model for raindrops (see the work by Jameson and co-authors for example).

Response: Indeed, there are also studies that do not support the Poisson model and many non-homogeneous models for raindrops, but this paper are restricted to the application of homogeneous Poisson model.

6. P.8900, Eq.4: λ here is confusing with λ in Eq.1. It should be changed.

Response: Thank you for your comment; we have replaced λ by in Eq.4.

7. P.8900, Eq.7: a reference should be given for this model, as it does not seem to be commonly used (maybe I am wrong...).

Response: Eq.7 is come from a book published in china, but due to the unphysical discontinuity at D=0.1 and 1 mm, we used the velocity model of raindrops by Atlas and Ulbrich in the revised manuscript.

8. P.8901-8902, Eq.11-14: over what range of diameter are these sums computed?

Response: the range of diameter simulated is: 0.05mm $\sim$ 6mm.

9. P.8903, l.2: if it is true, a reference showing that Parsivel is the "the most widely used instrument" should be given.

Response: we are sorry for the inaccurate expressions, "the most widely used instrument" was replaced by "one of the most widely used instruments".

10. P.8903, l.5: I think that this sampling area of 180*27 mm2 corresponds to the PMTech instrument, and I think it is 180*30 mm2 for the OTT Parsivel.

Response: the sampling area of 180*27 mm2 is from the Battaglia et al. (2010), in which the OTT PARSIVEL was analyzed.

11. P.8903, l.19: why 10 runs and not 5 or 100?

Response: We have tested the simulaiton with different runs, because one single simulation shows obvious randomness, the randomness of single simulation can be eliminated by many runs of simulation; while too less runs are esily influenced by random-

ness, too more runs mean a waste of time and of no help to the simulation results, therefore a compromise runs (10 runs) for each simulation are used.

12. P.8903, l.20: what is the definition of this relative error?

Response: the relative error is defined as . where and denote the simulated variables and retrieved variables.

13. P.8904, Section 3.2: what is the sample size (in number of drops) or duration considered in this analysis?

Response: the detailed number of drops simulated can be found in Table 3. and Table 4.

14. P.8906, l.26-27: as the drops partially crossing the beam are better detected (and removed) by Parsivel thanks to the 2 photodiodes, I am surprised that the error is positive in Nd in Table 6 (+0.14%), indicating an overestimation of the total number of drops. I would expect an underestimation if the "margin fallers" are removed...

Response: according to the retrieval rational of OTT PARSIVEL, the raindrops partially crossing the beam were removed by 2 photodiodes, but at the same wihle the sampling area becomes , hence the relative error might be positive. After many simulations, the probability of negative relative error is greater than that of positive relative error. It has been corrected in the revised manuscript.

15. P.8906, Section 3.4: it would be very interesting to investigate the probability to have multiple drops at the same time as a function of the sampling area. This is the main reason to keep it relatively small (except for the 2DVD for which the 2 perpendicular cameras help solving this issue).

Response: We mainly focus on the sampling area and DSDs in this paper, the probability of multiple drops at the same time could be very interesting, but 2DVD can detect multiple drops at the same time, other disdrometers can not detect, this error source of disdrometers will be discussed in another paper.

16. References: the article by Battaglia et al. (2010) was published in 2010 not in 2009. Response: Thank you for your comment, we have corrected it.

17. Table 1: the parameter μ of the Gamma DSD model should be given as well. In addition, the units are erroneous for N0.

Response: Thank you for your comment, we have added the parameter μ and corrected the unit of N0.

18. Tables 2-3-4: the values of reflectivity reported in these tables are way too large.

Response: 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 be corrected in the revised manuscript.

19. Figure 1: the notation R... in the legend of the figure is confusing as R is supposed to be constant (as indicated in the caption). Maybe the term “DSD" should be used?

Response: Thank you for your advice, we have corrected it.

20. Figure 2: I am surprised that the higher order moments of the DSD (like Z) are less sensitive to the sample size. A few big drops less (or more) due to sampling effects have a larger influence on the higher order moment values. The authors should comment on this.

Response: the unit of radar reflectivity Z in this manuscript is dBZ, the larger influence of sampling effects on the higher order moment values is distorted by the logarithmic transformation. According to the advices of referee, we analyzed the Z with the linear units (mm6 m-3) and computed the relative error in the revised manuscript, where the sampling effects showed the largest influence on Z error.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/5/C4028/2013/amtd-5-C4028-2013-supplement.pdf

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 8895, 2012.