# REVIEW REPORT

Review of amt-2019-51-manuscript-version1

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Manuscript Title – Estimating raindrop size distributions using microwave link measurements

## GENERAL COMMENTS

In the manuscript the Authors exploit the microwave links for the estimation of drop size distribution (DSD). The study include analysis based on simulated data and analysis conducted on real data collected by three collocated microwave links and four OTT Parsivel disdrometers. I think that the research topic is of high interest and have potentiality to improve the DSD knowledge and estimation, however in some part the paper is a bit hard to follow and confused. Furthermore some Figures should be done in a different way because now it is really hard to identify the differences among the different datasets. The Authors made a lot of different analysis and, in order to help the reader, more clarity and explanations are needed. I suggest a major revision and recommend the publication of the paper on the Atmospheric Measurement Techniques after addressing the following comments and suggestions.

## SPECIFIC COMMENTS

1. Introduction, first paragraph: Regarding the use of "signal of opportunity" to retrieve precipitation, in the last decade some studies has been carried out to investigate also the usefulness of geostationary broadcast television satellite links. A reference also to this technique should be inserted in the Introduction section (such as Giannetti et al. 2017 and references therein.

   Giannetti, F., Reggiannini, R., Moretti, M., Adirosi, E., Baldini, L., Facheris, L., Andrea Antonini, Melani S, Bacci G., Petrolino A., Vaccaro, A. (2017). Real-time rain rate evaluation via satellite downlink signal attenuation measurement. Sensors, 17(8), 1864, doi: https://doi.org/10.3390/s17081864

2. Section 2.1, first paragraph: To help the reader to understand the advection-based temporal interpolation technique, can the Authors add few information regarding this technique? I understand that the DSD retrieval is based on the polarimetric radar data, but which is the role of disdromter data? How many disdromteters there are in the 20 km x 20 km area? Which is the location of the disdrometer? Which is the distance of the 2D interpolated DSD field from the radar?

3. Section 2.1, second paragraph: How do the Authors select the position of the transect? Does the latter choice has an impact on the results? The transect consist in 1x200 pixels, correct?

4. Section 2.1, third paragraph: Can the Authors quantify the impact of binning effect on the results? Basically, it would be useful to know which is the differences in terms of

attenuations and differential phase shifts considering DSD binned as Parsivel and DSD re-binned in regular diameter grid with dD = 0.1 mm. Knowing the latter information will help the reader to understand the impact of the binning on the results.

5.  Section 3.1: I suggest to change the title of this subsection with "Theoretical background" or something similar. It not describe a new procedure but a well-known methodology to retrieve attenuation and specific phase shift from DSD.

6.  Section 3.2, second-last line: "In order to prevent this we restrict the root finding algorithm to a limited range of parameter values". Which are these ranges? How did the Authors define them?

7.  Page 8, first 2 lines: If I understand well the Authors basically change the first guess values until the method converges and finds a solution. Is it enough? I mean in this way the methods find a solution for all the DSDs? Which is the percentage of samples that do not have a solution?

8.  Page 9: "We prefer this method because it is not based on gradients and therefore guaranteed to find a solution if it exists". Similar to comment #7, How many times the solution does not exist? Please provide a percentage.

9.  Section 3.4, first two lines: "We test the capability of the methods to accurately retrieve DSDs and their associated statistical moments with two different datasets of **measured** drop size distributions". The Authors use also smilated DSD dataset. Correct? Please clarify

10. Section 3.4, first paragraph: Please put the TS96 abbreviation before, when the Tokay and Short (1996) method is cited for the first time. Furthermore if the Authors want to use this abbreviation to refer to the method of moment proposed by Tokay and Short (1996), please use it within all the text and Figure. In many Figures and in some part of the text the Authors referred to Tokay and Short (1996) method with "method of moments" and some times with "TS96". Chose one!

11. Section 3.4, first paragraph: It is not clear to me how the TS96 results are applied to "distinguish between cases where the gamma distribution is simply not a good fit for the measured DSD and cases where the retrieval itself is the cause for inaccuracies". Please clarify it.

12. Section 4.1, first 2 lines: Which input data are used for this "typical three-parameter retrieval"? Data from Ardèche dataset? Please explain

13. Section 4.1, second line: In Figure 7 there are different lines that refer to different frequencies, not only to the 38 GHz, why in the text the Authors refers only to the 38 GHz? Please explain

14. Section 4.1, third line: "$N_m$ is the originally measured DSD", is the world "measured" correct? If yes please clarify why the section title refer to simulated DSD and why in the previous line the Authors refer to simulations ("between the retrieved DSD and the original simulation procedure"). It is not clear to me.

15. Section 4.1: I don't understand this sentence "The difference in the total drop concentration is $\Delta N_T < 0.2 \cdot N_T$ in the first case, while the difference in the total rain intensity is $\Delta R < 0.03 \cdot R_o$.". Please clarify

16. Ficure 7c: Why the Authors do not puts the differences between original DSD and TS96 DSD?

17. Section 4.2: Can the Author identify the type of the two events (26 November 2012 and 27 October 2013)? Stratiform or Convective?

18. Figure 8:

    a.  Most of the time it is not possible to see the TS96 line (blue line). Please provide another method to visualize the results such as a scatterlot between TS96 and the 26GHz or 38Ghz retrievals.

    b.  Please put the legend in a position that not cover the data

    c.  the method of moments is TS96? If yes please for clarity refer always to the same acronym/name within the text. The latter is valid for all the Figures. Try to use for all the figures the same color for the same dataset. Example: blue line is for "original" in Figure7 and for "method of moments" in Figure 8

    d.  I am not confident with your advection-based temporal interpolation technique used to retrieve DSD from radar data, however usually the DSD retrieval techniques from radar data provide mu and lambda. Why the Authors do not use this data (the so called "original data" in Figure 7 and 9) to compare the obtained results at 26 GHz and 38Ghz?

19. Section 5, first sentence: Here the retrieval from disdrometer data are compared with disdrometer data. Correct? Please specify. Please explain clearly in each figure which is the reference ("true") line/dataset

20. Figure 9:

    a.  See comment 18c

    b.  See comment 18a

    c.  Why here do the Authors insert the retrieved 15 Ghz and 32 Ghz and in Figure 8 there aren't? Please explain

21. Table 2: The MOR MAD and 95AD have been computed between retrieved DSD at different frequencies and the TS96 values? Please clarify. If yes, why the Authors do not use the R obtained directly from disdrometer DSD?

22. Section 5.1, first paragraph: Which are the percentage of failed retrieval for the two-parameter and the three-parameter methods? Here the Author provide the differences

between the two percentages (1.7%), however I think that is useful also to have the two percentage values.

23. Figure 10:

    a. See comment 18c

    b. See comment 18a

    c. Add the label on x-axis

    d. In figure10a the reference value is the TS96, while in Figure 10b and c the reference is the original DSD, correct? Please add this information in the text

24. Table 3: The MOR MAD and 95AD values are obtained comparing the retrieval with the original or with the TS96? Please clarify

25. Figure 11: Can the Authors explain why the 3-parameter retrieval overestimates the small drops with respect to 2-param retrieval?

26. Section 5.2, second line: Please clarify the two dataset used to compute the MOR, MAD and 95AD. Disdrometer based R and 2-parameter retrieved R?

27. Figure 14: Please provide a better explanation of the figure. what is a)? and b)?

28. Section 6: I believe that this is the most important part of the paper, therefore all the analysis and results have to be explained with more detail and clarity.

29. Section 6, line n.10: A lot of different analysis have been done in the paper, therefore to help the reader please identify which is the Table to be compared with Table 4.

30. Section 6: "Nevertheless, at the important higher order moments related to e.g. liquid water content, rain rate, kinetic energy and radar reflectivity the bias is around 7 % for the dual-polarization retrieval". The bias between….? It is not clear to me the 2 dataset used to compute the bias. Please clarify

31. Figure 16:

    a. In Figure 16b) also the R from original DSD ca be added

    b. please provide the label for x-axis

# TECHNICAL CORRECTIONS

1. Section 2.2, first line: erase the word "second"
2. Figure 2: please put the legend outside the plot area, otherwise it covers some lines
3. Figure 5: Probably the Author can eliminate this figure and add the lamda-mu relation in Figure 4b. It is just a suggestion

4. Page 23, line n. 2: "Because" should be uppercase
5. Page 23, line n. 4: "It" should be lowercase
6. Section 7.2, first line: "Firstly" should be lowercase