Response to the reviewers' comments

Reviewer 1

The Authors evaluated the effects that different aspects/assumptions can have on the mu-lambda relations and retrieved the mu and lambda parameters from and S-band radar and compared the retrievals with a disdrometer.
The papers il well organized and the methodology and results are well described. I suggest the publication on AMT after addressing my comments.

1) *Section 2.1. Some more information regarding disdrometer data processing are needed. For example, did the Authors apply any kind of pre-processing to disdrometer data such as the elimination of spurious drops using a fall velocity filter (see for example Tokay et al 2001)? There is a minimum number of drops in each considered rainy minute?*

Answer

Thanks for noticing that. Yes, similar to Gatidis et al. (2020) we applied two criteria to the disdrometer data before the analysis. One in order to ensure all the precipitation is in liquid form, and a second in order to remove suspicious observations.
To clarify, the following sentence was added:
"Similarly to Gatidis et al. (2020), pre-processing is applied to the disdrometer data.

- Only the liquid type of precipitation was considered for further analysis. All DSDs with observations above the twenty-second diameter class (drop diameters greater than 7mm) were discarded, since they correspond to mixed or solid precipitation.
- Each DSD should be comprised of at least three different diameter size classes in order to exclude spurious observations not related to rain."

2) Section 2.2. Some more information regarding the locations of the devices are needed. For example, which is the distance between radar and disdrometer? Is the disdrometer located along the constant azimuth of the TARA? If yes (or around) which is the height of the first useful TARA bin above the disdrometer?

Answer

Thank for your comment. We added the following sentences in the text:
"The TARA radar was collocated with additional sensors. This included a Parsivel disdrometer (see Pfitzenmaier et al. 2018, Fig. 1) provided by the Leibniz Institute for Tropospheric Research (TROPOS). For this experiment, the radar antenna elevation angle of TARA was fixed at 45° with constant azimuth. The collected polarimetric radar observables included the reflectivity factor at horizontal polarization (Z_{hh}) and differential reflectivity (Z_{dr}) at 200 m height (corresponding to the minimum range of TARA)."

3) Section 3.1. Please note that also Adirosi et al (2016), among others, have investigated the validity of the gamma assumption to model natural DSD.

Answer

We have added the following reference in the text:

- Adirosi, E., Volpi, E., Lombardo, F., & Baldini, L. (2016). Raindrop size distribution: Fitting performance of common theoretical models. Advances in Water Resources, 96, 290-305.

4) Section 3.2. It is not clear to me why the Authors used the CF. To estimate mu? Why do not estimate it with MoM as written in the previous sentence? Please clarify

Answer

Thanks for your comment. Even though we mentioned MoM in the manuscript, in reality we did not use it, since the gamma DSD is expressed as

a normalized gamma DSD (Thurai et al. 2014). We re-formulated the text in order to avoid any confusion to the reader:

"The best parameters (μ, D_m and N_w) for describing the DSDs measured by the disdrometer are obtained by using normalized parameterization of the Gamma DSD model based on D_m (ratio of 4^{th} to 3^{rd} order moment). To estimate μ, we first calculate D_m and N_w (directly from the measured DSD spectra). The value of μ is determined by testing all possible values of μ between -3 and 15 and choosing the one that minimises the cost function (CF, Eq. 6). Finally, we derive Λ through its relationship with D_m and μ (Eq. 5)."

5) I suggest to move section 3.4 before section 3.3

Answer

Done.

6) Section 4.1. To help the reader can the Authors briefly recall the criterion defined in Gatidis et al (2020) and adopted in the paper? Can the Author provide the percentage of DSD discarded for each event?

Answer

We added the following sentence in the manuscript:

"For this, a filter was applied identical to Gatidis et al. (2020) and only the cases which satisfied the gamma model hypothesis were considered. The adequacy of the gamma model was assessed based on a combination of Kolmogorov–Smirnov goodness-of-fit test and Kullback–Leibler divergence. In total, approximately 40% of the DSDs passed the tests and were accepted. On an event to event basis, that number varies between 36% to 45%."

7) Section 4.2. What about the mu-lambda relations obtained considering only the "non-gamma DSD"? If (as I guess) it is similar to the one obtained with the whole dataset or considering only "gamma" DSD it means that the assumption that the gamma assumption do not influence the mu-lambda relation is strengthen. Am I correct?

Answer

Actually, this information was already provided in the paper: As stated in the manuscript, α changes from 0.514 to 0.518 and 0.531 respectively and β from 1.339 to 1.328 and 1.312 respectively for the Non Gamma DSDs. Therefore, the acceptance or rejection of the Gamma hypothesis only results in small differences in terms of μ-Λ scatterplots. The fact that the relationship remains relatively stable regardless of the gamma DSD assumption, shows that the accuracy of the model assumption does not significantly influence the μ-Λ relation itself. However, we should not forget that our dataset consists of relatively similar, stratiform events with light to moderate intensity rain. So, it would be interesting to expand this study to convective events in order to have a more complete picture of the gamma assumption and its influence on the μ-Λ relation.

8) Line 235: "previous section" is section 4.1 or 4.2?

Answer

The overall μ- Λ relationship was introduced and discussed in section 4.1. In order to clarify, we modified that particular sentence as follows:
"Using the overall relationship from Section 4.1 as a reference, the influence of the number concentration on the μ- Λ relationship was investigated."

9) Section 5.1.1. How do the Authors compute Zh and Zdr from disdrometer data? I guess electromagnetic simulation (such as T-matrix). Please specify

Answer

Indeed, some details were missing. We added the following sentences in order to clarify how Z_{hh} and Z_{dr} were computed from disdrometer data.
"For the sake of the comparison between TARA and Parsivel observables, the radar equivalent reflectivity factor derived from disdrometer data was used as the measured reflectivity factor at horizontal polarization ($Z_{hh,Pars}$). As for the differential reflectivity, using Rayleigh scattering, the calculated radar cross-

sections of raindrops with equivolume spherical diameter D at horizontal and vertical polarization were used (Eq. 9) for estimating reflectivity at horizontal and vertical polarization, respectively. From those, the differential reflectivity value from Parsivel ($Z_{dr,Pars}$) can be obtained."

10) Section 5.1.3. I don't understand the need of performing the retrieval considering un-corrected Zh and Zdr. I suggest to eliminate this part and start with the retrieval of the DSD parameter from unbiased Zh and Zdr. This is just a suggestion. The Authors can decide to keep this part but in this case probably a justification is needed.

Answer

Thanks for your suggestion. We show the retrievals before and after the correction in order to highlight the importance of the calibration. As we clearly state in the text, the calibration of radar observables (Z_{hh} and Z_{dr}) are often overlooked. Hence we think it is really valuable to show both results.