Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-652-RC3, 2017

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Comparison of precipitation measurements by Ott Parsivel^2 and Thies LPM optical disdrometers" *by* Marta Angulo-Martínez et al.

Anonymous Referee #3

Received and published: 19 December 2017

This is a review of the paper titled "Comparison of precipitation measurements by Ott Parsivel^2 and Thies LPM optical disdrometers", by M. Angulo-Martínez, S. Beguería, B. Latorre, and M. Fernández-Raga, submitted to Hydrol. Earth Syst. Sci. Discuss. as HESS-2017-652.

The paper presents a comparison of two optical disdrometers: the OTT Parsivel^2 and Thies LPM. The work is well written and generally clear, with a good review of existing literature and the instruments compared. The results are of interest to researchers using optical disdrometers. This work should be published, but there a few revisions required to strengthen the manuscript. In particular, more filtering of raw data is required,

the GLMM results need better explanation, and you should reconsider highlighting the results for which the DSD size classes are similar (the "filtered" results).

The writing contains numerous small English errors, so I suggest a thorough proofreading of the paper to fix these. There is a lot of repetition between the introduction (Section 1) and the discussion (Section 4). It reads as though Section 4 was written separately and put into the manuscript after the rest was written. I suggest that you carefully combine these sections so that the introduction contains background information about disdrometers, intstrument types etc, and the discussion is more a discussion of your results with relation to previous findings in the literature. Please also better explain what the results mean for the community and researchers interested in using these instruments.

For the time steps tested and when bulk rainfall variables are calculated, I think it is important to carefully filter the data returned by the instruments. Two filters should be applied - the first to ensure no solid precipitation is included in the results and that the instrument lasers were functioninig correctly (Parsivel flags can be used for this), and the second to remove particles that are unlikely to be raindrops (using a relationship between particle size and expected velocity, as per for example in Jaffrain and Berne (2012)).

It appears that one of the main differences between Thies and P2 disdrometers shown here is that Thies records many more small particles (and lower velocities) than Parsivel. But, Thies can record from 0.125 mm and Parsivel can record from 0.25 mm. I think it's important to carefully show which differences arise from this simple instrumentation difference. You have done this with your filtered results, but I feel that the filtered results are mentioned rather as an aside when they are in fact a fairer comparison between the instruments. Indeed in the abstract you mention that Thies records nine times as many particles as Parsivel for some rain rates, yet in the paper this reduces to about three times if the different class definitions are taken into account by your filtering. It should, at the least, be emphasised that some of the differences shown can be explained by the different drop size ranges.

You use a Gamma generalised linear mixed model (Gamma GLMM) to analyse whether the differences between the instruments and location are significant. This is a nice, rigourous idea, but then the writing in the paper does not analyse the results in enough detail. I have the feeling that while the GLMM results are shown in tables, most of the conclusions shown in the paper were rather drawn from kernel densities which are easier to interpret by eye. It's important to explain the results so that for example the meaning of the different coefficients found using Gamma GLMM are clear. For example, possible random differences caused by the mask are controlled for, but there is no discussion in the text of the influence shown by this random variable and therefore it is difficult for the reader to interpret the results shown in Tables 4, 5, and 6.

Specific comments

1. Page 2, line 30: Please carefully define what you mean by PSD here. Your point is that pressure disdrometers do not measure velocities, which is correct, but the PSD is often used to refer to volumetric particle size distributions which are calculated using a velocity (either measured or estimated).
2. Page 3, lines 10–15: the 2DVD is perhaps considered a reliable reference, but it should also be noted that it has been found unreliable for small drops (see e.g. Tokay et al. (2013) and Thurai et al. (2017)). Is the 0.3 mm limit mentioned on line 13 from Tokay et al. (2013) or another article that can be cited?
3. Pages 3 and 4: Your literature review showing the different version histories of Parsivel and Theis disdrometers is excellent. However you mention that they have each been compared to more accurate disdrometers, but without saying what the comparisons found. I think you should briefly outline the results of these comparisons.

4. Page 4, line 24: These statements on the average annual precipitation at the field site need a reference. Also, you should include a brief further description of the properties of the site – e.g. is it in complex terrain? What types of precipitation does it experience? etc.
5. Figure 1: It would be helpful to label the different disdrometers in the image.
6. Page 5, line 13: I believe that recent Parsivels automatically remove margin fallers. Please confirm and mention this here. Do the Thies instruments also remove margin fallers?
7. Page 6, line 11: Define units for P_r. Equation 1 would benefit from having N_{ij} instead of just N.
8. Equation 1: What units does KE have? By my calculation the equation results in J m^{-2} cm^{-3} mm^2 and it is not clear why the $\frac{1}{12}$ appears. Please check this equation.
9. Page 6, line 24: The normal sampling area quoted here is correct, but normally an adjustment is made for large drops because margin fallers are uncertain or removed. See e.g. Battaglia et al. (2010). Note that they use $D/2$ to account for bias due to edge-fallers, but if margin fallers are automatically completely removed this should be D. I see that in your paper you are focussing on computing variables calculated by the instrument hardware, so I think all that is required is that you mention this adjustment at this point in the article. For variables calculated from the DSD, you should use such an adjustment of sampling area, or justify why you choose not to.
10. Table 2: If these are one-minute values, what is the difference between rain rate R, mean rain rate Rm and max rain rate RM? (Same for kinetic energies and number of particles).

11. Page 7, line 24: The 2DVD has a resolution of roughly 0.2 mm so it can measure drops smaller than 0.3 mm; but other studies (e.g. Tokey I referenced earlier) have shown it is not reliable for these drops.

12. Page 7, paragraph around line 25: disdrometers often record particles that are very unlikely to be rain drops (they could be droplets caught in spider webs, insects, snow etc). It is common to filter drop counts using some constraints on the particle size to particle velocity relationship, against expected velocities (see for example Jaffrain and Berne (2012)). For the variables that you calculate yourself using the raw data, I think it is important to perform such a filter. Also, Parsivel disdrometers give a weather type indicator that can be used to determine when the instrument has detected solid precipitation. They also provide laser status that can indicate if the laser is dirty or malfunctioning. Did you use these indicators to subset the data to only rainfall and remove any possible solid precipitation? Again I think this is an important filter to apply.

13. Equation 2: please define N here; I gather it is the normal distribution, but then the symbol also clashes with your N in Equation 1.

14. Table 3: Is there a reason why the Parsivel on M2 recorded such different propertions of spring/winter/autumn records than the Parsivel on M1 (and the Thies disdrometers)? Here again I wonder whether you accounted for possible snow in winter?

15. Page 9, lines 21-22: The filter here is just removing drops below 0.3 mm in diameter, if I understand correctly. I think the differences, while slightly smaller than in the unfiltered case, are still significant between the disdrometers in this case.

16. Figure 3: Please differentiate between M1 and M2 in the caption.

17. Page 9, line 26: "number of drops per minute" – is this what is shown, ie the raw number of drops recorded every minute, or are you showing N_t [m^{-3}] in Figures 3?

18. Figure 4: It strikes me as strange that the theoretical velocities for large drops (the black line) are smaller than those for drops of 4-5 mm diameter. How does this model compare to other terminal velocity models?

19. Page 10, line 7: Can you be sure that the larger spread of particles are filtered out of the P2 output, or is it instrumental effect of the Thies disdrometers that increases the spread of velocities? As a comment, the large number of drops with low velocities recorded by the Thies disdrometers would explain large values of total drop concentration N_t [m^{-3}], because the calculation of the DSD contains a division by the velocity.

20. Table 4: Why is the sample size lower than the number of samples available? And how were the samples chosen?

21. Table 4: Very little analysis of these numbers is given in the text, and most conclusions seem to be drawn instead from the kernel densities in Figure 5. Please indicate how the reader is to interpret the numbers in Table 4: what are the meanings of the coefficients (the means for each group for Thies and Parsivel? What about for the mast?). How do you interpret the results for the mast, which show that the mast is sometimes important (e.g. for Ke)?

22. Figure 5: In this plot and the discussion on page 10 the meaning of NP is unclear (note in Table 2, NP has a unit of "unit").

23. Page 10, line 16: You mention that Z and R were higher on Thies but E was lower. Can this be explained physically, ie through differences in the numbers of small drops? Some variables (reflectivity, rain rate) influenced much less than others (total drop concentration) by the numbers of small drops recorded.

24. Page 11, line 23: As shown by the filtered results, the large difference in numbers of particles can be in large part explained by the different drop sizes measured by Thies and Parsivel disdrometers. I think the fairer comparison is shown in the filtered results, in which NP was about three times higher in Theis than in Parsivel data.

25. Page 11, line 27-28: Without another external and more accurate reference, I think you can not say whether one instrument or the other over- or under-estimated the numbers of small particles. What you can say is that there were significant differences between the two instrument types.

26. Figure 6: Are these violin plots for event totals or means or both?

27. Page 12, line 12: I think "complete" might be a strong word here, given the difficulties current disdrometers have in measuring small drops.

28. Page 12, line 28: In more recent Parsivel disdrometers, margin fallers are detected by extra photo-diodes and removed (Battaglia et al., 2010); so please confirm whether this is the case with the disdrometers used in this study.

29. Page 12, line 33: Again I believe that 0.3 mm is not built in to the 2DVD but rather a recommended lower limit.

30. Page 13, line 5: The differences in the numbers of particles measured by the two disdrometers could possibly be due to the P2's splash shield that the Thies does not have. You mention in this paragraph that abnormal size-fall velocity pairs could be used to remove irregular particles; why not apply this kind of filter?

31. Page 13, line 15 and line 23: Two references are missing here.

32. Page 13, line 16: There are differing conclusions about Parsivel^2 performance by drop size reported in the literature. While Raupach and Berne (2015) included

some Parsivel^2 comparisons, their study was primarily based on Parsivel 1 data and large variability meant comparisons for larger drop sizes were only performed for higher rain rates. Tokay et al. (2014) compared the Parsivel^2 specifically but did not conclude that Parsivel^2 overestimates small drops. The recent and in-depth study by Park et al. (2017) shows underestimation of small drops and over-estimation of large drops by Parsivel^2. I suggest you generalise your phrasing here to account for these differing results.

33. Page 13, line 27: There is no discussion in the rest of the article about hydrometeorological regimes, so the claim that there are no differences by regime is not backed up. By "small raindrop spectra" do you mean spectra that exhibit many small raindrops?

34. Page 13, line 31: The paper by Jaffrain and Berne (2011) used Parsivel 1 disdrometers, not Parsivel^2.

35. Page 14, lines 10-11: Please be careful about statements that are speculation – it is not shown by this study whether or not the raw data matrices by P2 disdrometers are post-processed or not.

Minor/typographical comments

1. Page 2, line 13: "for what" should be "for which".
2. Page 2, line 14: reflectivity to rainfall rate relations are usually written $Z - R$.
3. Page 2, line 20: CHUVA should also be written in long-form for consistency with the other acronyms used here.
4. Page 3, line 23: replace "indifferently" with "interchangeably"?

5. Page 4, line 27: replace “every type” with “both types”.
6. Table 2 (and in general): Reflectivity is normally written as “radar reflectivity” to be specific, and its units in decibels are dBZ by convention.
7. Page 9, paragraph one: “being” is in the wrong order, for example the last line should read “with Thies being the one recording the highest rain rates”.
8. Page 10, line 12: change “arouse” to “arise”.
9. Section 4 contains many spelling errors that should be fixed.

References

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