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Atmospheric Measurement Techniques Discussions

Interactive comment on "A video precipitation sensor for imaging and velocimetry of hydrometeors" *by* X. C. Liu et al.

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This paper describes a new instrument to measure shapes and other characteristics of rain drops falling through its sensor area. Details of instrumentation are given together with image processing and calibration procedures. Results are presented but only for small and tiny drops and for low rainfall rate events.

Response: Thanks for your constructive comments of our work, which enables us to further improve the quality of our manuscript.

It is a reasonably well written paper and well structure but it lacks clarity in many places.

1) Line 23 under section 2.1: What are EP and XP

Response: EP is short for Entrance Pupil, and XP is short for Exit Pupil. We have added that in the revised manuscript.

2) Section 2.2: The authors claim that the horizontal and vertical velocity for each particle can be determined depending on the exposure interval and the displacement. The authors should note that this is only in one plane (say X-Z) and does not include the velocity component in the Y-Z plane and hence only limited or partial information can be obtained.

Response: Thank you for your comment; we have noted that in the revised manuscript.

3) Para after eq. (1): It is not at all clear how orientation is determined from each image.

Response: The orientation of each drop is calculated according to the included angle between the vertical direction and the symmetry axis of each drop. We have added the detail descriptions and a schematic diagram in the revised manuscript.

4) Fig 6: Much more information is required to explain this figure and how it related to the flow chart in Fig. 5.

Response: Thank you for your comment; we have added more informations about Fig.6.

5) Fig. 9 is presented without any explanation; if it is an important figure, then explain what the image array represent in a step by step manner.

Response: Fig. 9 is only a sample images of raindrops, because it is not an important figure, we deleted it in the revised manuscript.

6) Section 5, 2nd para: how is the canting angle derived – please explain.

Response: The canting angle of each drop is calculated according to the included angle between the vertical direction and the symmetry axis of each drop. Detail descriptions are added in Section 3.1, 2nd para.

7) Section 5, 2nd para: The Atlas-Ulbrich 1977 formula is not correct. The authors should be comparing with the Atlas et al. (1973) formula for the velocity – diameter variation. The reference is wrong but Fig. 10(a) contains the right curve and the formula.

Response: Thank you for your comment, we have corrected it in the revised manuscript.

8) Fig. 10(b) shows an enormous amount of spread in axis ratios – other previously reported measurements show much less variation. Why is this?

Response: The axis ratios of drops are calculated according to the ratio of short axis and long axis, the mismatch of short axis and long axis might cause the abnormal variation of axis ratios. Therefore we propose a matching algorithm to remove the outliers in the revised manuscript. There are also lots of variations in axis ratio (oblateness) from the 2DVD measurements (Kruger, A., and Krajewski, W. F., 2002) , the possible explanation is splashing and mismatching of two line cameras. Considering that the axis ratio of large raindrops (Deq > 1 mm) is the focus of research, the variation of small raindrops (Deq < 1 mm) can be removed to some extent.

9) Fig. 10(c): was his derived for all drops including the small and tiny drops, and if so what errors are to be expected - please quantify for various diameters.

Response: Not all of drops are inluded in the Figure 10(c), the reason is that the small and tiny drops take spherical shapes, the discussion about the orientation of small and tiny drops has no meaning. Only raindrops larger than 0.5 mm are taken into account about the orientation analysis.

10) Fig 11: It would be more informative if rain accumulation comparisons are also included. Also, it is to be noted that only a light precipitation event is considered in this case.

Response: Thank you for your suggestion, we have added the discussion and the

figure about the rain accumulation comparisons in the reviesed paper. Also we noted that only a light rainfall event is considered in this case, the accuracy of VPS in heavy rainfall remains to be examined in the future.

11) There are also some minor language errors. The authors should stress that their measurements basically represent projections of the drop shapes onto only one plane and hence will have limitations and restrictions on axis ratio measurements, particularly if drops are oscillating with significant component of the asymmetric modes, which will give rise to drops without any axis of rotational symmetry. The authors should also note that when referring to Tokay et al. (2001) and Sayler et al. (2002) on page 10167, there have also been several publications relating to 2DVD based drop shape measurements since then, and that the authors of the second reference in particular (viz. Sayler, Testik et al.) do not have much understanding of the principles behind the 2DVD instrumentation and have made many erroneous statements in their publications regarding 2DVD – which regrettably have gone unnoticed until now.

Response: Thank you for your comments, we have correced the language errors in the revised manuscript. The two-dimensional measurement of VPS has its own limitations on axis ratio and oscillation measurement, we will refine our instrument by two orthogonal cameras and three-dimensional measurements. Also we have added several citations about 2DVD in the revised manuscript.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 10165, 2013.