On the potential of 2D-Video Disdrometer technique to measure micro physical parameters of solid precipitation

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Answer to anonymus reviewer comment #2

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General Comments

We would like to thank the anonymous reviewer #2 for his well considered comments.

Specific Comments

1. *In section 2, the authors introduce an updated matching algorithm building on the work of Huang et al. (2010). Section 2.4.2 starts with a rather controversial proposal. To compare the manufacturer supplied matching algorithms, the authors use a real snow fall event whereas the new matching algorithm is evaluated with Styrofoam particles of known size. Besides mentioning the procedures, no results were presented. The authors need to explain why they introduce the new procedure and how it compares to the one provided by the manufacturer. It is better? Why only velocity was measured in this step? Why not use the Styrofoam for both cases? Why not use it to test for all other parameters (elongation, roundness, etc.)?*

   The reviewer has good ideas for further evaluation of the data presented in this work. As mentioned in the discussion and underlined by the results presented in Tab.3 the reason for implementing a new matching algorithm was that with the original matching algorithm a huge number of mismatches, identified by means of high fall velocities and unreasonable geometric appearances, was detected. The vertical velocity is a very important parameter which is subsequently used to calculate size and shape parameters. In addition, mismatches can be

very easily identified by means of unreasonable velocities. Therefore, we primarily focused on the evaluation of the velocity measurement. One central goal of this work was to present minimum requirements for 2DVD users that want to measure solid phase precipitation, such as the implementation of a suitable matching algorithm. Another key aspect of the study was to test the output of the device for shape parameters which are commonly used for the description of snowflake surface structure. It so far has never been tested which influence the spacial quantization (which is inherent in the 2DVD measurement principle), has on the measurement of such shape parameters. For this reason we decided to present reproducible experiments with spheres from which we know the nominal shape parameters. Evaluating the output of the instrument, for example, when one and the same irregularly shaped object is dropped several times through the sensitive area, will be done in a further study.

2. *Since this is a matching algorithm comparison section, I was expecting comparison based on how well the two algorithms can match particles (camera A and camera B). As it is presented right now, it makes little sense to even mention it, altogether.*
   The results presented in Tab.3 are a sufficient evidence that the original matching algorithm does not work properly. Nevertheless, Fig.1 (in this document) shows the results of the ensemble measurement evaluated with the original software. It shows, that a large amount of mismatches can be identified with very small velocities. We apologize for the small marker size in the figure, but the original Joanneum-software does not allow another way of presentation.

   For reasons of copy right, the manufacturer does unfortunately not give any insight of how the original algorithm works. The newly implemented matching algorithm finds the most probable matching partner on the basis of the geometric conditions mentioned in Tab.1 and 3. For that reason it is not reasonable to evaluate the new matching algorithm according to the same conditions, as done for the original one.

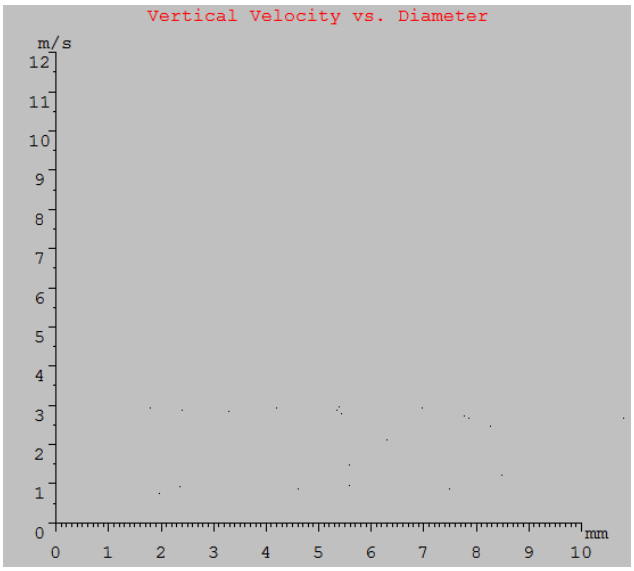

Figure 1: The ensemble measurements evaluated with the original matching software.

3. *Also, I am a bit confused by the logic presented in Figure 5. Is there any reason why camera A is used to initiate the "search" (and not the camera B)? Why is the search area shifted in the positive (from 977 to 1016) direction? Is it possible that the particle that triggered camera A at time corresponding to line 977 could trigger camera B at the same (or earlier) time? This should be clarified.*
   The reason why the search area in camera B can be shifted only in positive direction is, that camera A is the upper camera, which is first hit by the hydrometeor. Obviously, a more sophisticated matching algorithm could be developed, which initiates a parallel search in reverse direction from camera B. This is an idea which certainly should be investigated in further studies. The matching algorithm we showed can easily be implemented as a minimum requirement for 2DVD users who want to measure solid phase precipitation.

4. *Section 3.1 deals with the calibration procedure. Is this the manufacturer supplied methodology? In such case, this leads to a trivial conclusion that users should follow manufacturer's recommendation and calibrate the instrument periodically.*
   The calibration procedure proposed in our study is a supplementary procedure which should be performed in addition to the plane distance measurement proposed by the manufacturer. To clarify this, the following sentence was included to p3099, l20: "The half-yearly

calibration of the plane distance which is recommended by the manufacturer should be supplemented with a test of the size calibration."

5. *I am disappointed that the authors decided not to use Styrofoam to test for elongation, roundness, shape factor, etc.*
   Thank you for that suggestion, but as already mentioned, this work had the aim of highlighting the need of a special matching algorithm for solid phase hydrometeors. The aim of the experiment with styrofoam particles was to validate the matching algorithm. It is certainly an excellent idea to perform further experiments with asymmetrically shaped objects. These experiments can be evaluated, for example, according to statistical stability of certain shape descriptors, consistency between camera A and B, etc.

6. *I am not convinced that statistics reported for perfectly round, metal spheres can tell us much about how well the instrument is doing when characterizing solid, irregular precipitation.*
   A key aspect of the study was to test the output of the device for shape parameters which are commonly used for the description of snowflake surface structure. It so far has never been tested which influence the spacial quantization (which is inherent in the 2DVD measurement principle), has on the measurement of such shape parameters. For this reason we decided to present reproducible experiments with spheres from which we know the nominal shape parameters. Evaluating the output of the instrument, for example, when one and the same irregularly shaped object is dropped several times through the sensitive area, will be done in a further study.

7. *Reporting just consistency is like saying that we are always right or always wrong, we don't know, but we are consistent about it. This is not a very useful way of reporting.*
   To clarify the linkage between the consistency of shape parameters retrieved by means of a 2DVD and their micro-physical interpretation, the following paragraph was included (p3096, l23): "Mean values of roundness, shape factor and elongation are able to describe whether a snowfall event consists, for example, more of complex shaped aggregates of snow crystals or more of simply shaped pellets or graupel particles. Intervals with high mean elongation are expected to have low

mean roundness and low mean shape factor and vice versa. Intervals with a low mean shape factor should also have a low mean roundness. Testing whether this behavior can be reproduced in 2DVD measurements gives information on the self-consistency of the instrument when real snowfall events are recorded."

8. *Why are the results presented separately for cameras A and B? From a user perspective, the instrument should provide a "final" answer and I honestly don't understand the logic of reporting individual cameras. The results should be combined to a single result for the instrument. This is how is the instrument is utilized in the filed, so the overall performance is much more valuable.*
   Thank you for this important comment. There are two different groups of data types produced by the 2DVD. The first group consists of parameters which need both cameras. These are, for example, the maximum dimension, the hydrometeor volume, the equivalent diameter or the vertical velocity. The other group of data is represented by parameters which can be measured for each camera individually. These are, for example, the elongation, the roundness and the shape factor. In our opinion it should be left to the user, how he wants to use these parameters. According to Grazioli et al. (2014) the information gained with a single camera is consistent between the two cameras. The influence of using a combination of both cameras (for example, mean values) should be analyzed in a further study.

Final Comments

1. *The authors overpromised in the title of the paper and left with many questions to be answered. I applaud the initiative to test the 2DVD and I especially like the concept of using irregular particles for assessing the capability of deducting complex shape characteristics. This is not what the paper offers. This paper has a lot of potential to be a valuable contribution, but at this point it needs some*
   We thank the reviewer very much for this comment and we apologize for the somehow over-promising title. Therefore, the title was changed to: "On the consistency of 2D-Video Disdrometers in measuring microphysical parameters of solid precipitation".

Minor Comments

1. *Figure 8 should use the same axis ratio (1:1) for a better visual effect.*
   Unfortunately, using the same axis ratio does not really improve the visual effect. We think that the important information (the overall offset (left panel) and the improvement after the correction (right panel)) is clearly visible in the figure as it is.

2. *In my humble opinion: The naming and section, sub-section convention is somewhat overused. I can see how a simpler structure for this (rather short paper) could work better. Short format is good, but using fewer sub-sections could make it better.*
   To reduce the nested structure of the manuscript we unified sections 2.4.1, 2.4.2 and 2.4.3 under one section 2.4 which is called "Experimental Methods".

3. *Page 3100, line 20 – konvex should be convex.*
   "konvex" was changed to "convex".

References

Grazioli, J., Tuia, D., Monhart, S., Schneebeli, M., Raupach, T., and Berne, A.: Hydrometeor classification from two-dimensional video disdrometer data, Journal of Atmospheric Measurement Technique, 7, 2869–2882, 2014.