Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC3
https://doi.org/10.5194/amt-2021-427-RC3, 2022

Comment on amt-2021-427

Anonymous Referee #3

Referee comment on "A Comparative Evaluation of Snowflake Particle Size and Shape Estimation Techniques used by the Precipitation Imaging Package (PIP), Multi-Angle Snowflake Camera (MASC), and Two-Dimensional Video Disdrometer (2DVD)" by Charles Nelson Helms et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-427-RC3, 2022

The sudy is an interesting evaluation of processing algorithms to derive two characteristic dimensions, length and width, of snow particles from 2-dimensional images.
Algorithms from three instruments, PIP, MASC, and 2DVD, and their resulting dimensions are evaluated. The conclusions allow future users of these instruments to chose a suitable algorithm.
Only PIP data are used. Using emulated data for testing other algorithms, which are used with MASC or 2DVD data. This provides a fair comparison of the algorithms only. However, this method cannot compare the actual qualities of the PIP, MASC, or 2DVD measurements related to specific instrumental issues. In particular, incase of MASC and 2DVD, the method cannot evaluate if the PIP-derived emulated or the actual measurements (if available) would more accurately represent the particle's dimensions.
The study clearly describes the chosen method and recognizes its limitations.
I suggest publication of the study after some shortcomings have been addressed.

Major issues:

1) All conclusions are vaguely formulated, some are only speculative.
In general the analysis is not sufficiently quantative in comparing the resulting derived measurements from the various algorithms. Similarly, the Abstract uses many "should" and leaves doubts about the usefulness of the conclusions.
Quantify and better describe things like "spread", "agreement", "reasonable estimates", and "greatly underestimates".
Examples:
Improve discussion around Fig.4. In these scatter plots it is difficult to see the differences tated in the discussion of for example 4a) vs. 4b) or 4d) vs. 4e). As suggested by Referee 1, density plots can be more useful. In addition, some quantitative statistical measures will be useful (e.g. to better argue that "MASC-fitted and tensor-fitted ellipses tend to produce fairly similar particle dimensions", L. 394, and that "MASC-fitted ...ellipses tend to

provide more reasonable estimates of particle dimensions...", L 396).
L. 371-372: reformulate this sentence, using a certain aspect ratio will not increase the spread in dimensions.
Fig.9: a) not needed, instead argue/discuss that the two heights are the same.; b) quantify the range (and maybe distribution as histogram) of ratios between 2DVD width and PIP width (I guess they vary between 0.8 and 20 and will show two modes on a histogram); c) quantify similarly and then compare to b). That will allow for less vague descriptions than "can sometimes underestimate the bounding box width" (L. 473) or "are surprisingly accurate" (L. 477).

2) The ellipse-fitting algorithm (PIP, MASC, or tensor variant) could also be applied to 2DVD measurements. This can be tested within this study on the emulated 2DVD measurements, adding a valuable aspect to 2DVD measurements. Then, the conclusion about the limited usefulness of the 2DVD measurements can be revisited (L. 519-521.)

3) Sect 5.1, L256-258:
"For this study, however, we will examine the theoretical accuracy and precision of the MASC, PIP, and 2DVD area and equivalent diameter measurements in terms of motion blur as determined from the pixel resolution, exposure time (i.e., shutter speed), and particle fall speed."
Motion blur is not related to precision. Overall, I find the discussion around "precison" unnecessary and not well introduced (only later on in Sect 5, L347, it is mentioned what precision or "precise measurement" refers to. The effects of this theoretically higher precision are, however, not discussed in this study. If the authors consider this to be an important aspect of their study, then I would recommend to evaluate the consequences by using the same algorithm with differing pixel resolutions. As MASC measurements are only emulated here, the actual effects of the higher precision remain unclear (and are not part of this study and instrumemnt specific and related to questions such as if the increased precision is accompanied by a corresponding better optical resolution and accuracy).

4) Sect 5.1 and Figures 2 and 3:
The discussion of motion blur and its effects on accuracy seems to be wrong. It is correct that, considering a vertical particle motion during expeosure, the blurring affects both the upper and lower edge. However, the particle extension is not increased (blurred) upwards and downwards. At the start of the exposure, the particle has an upper and a lower edge. Both these edges are moving (blurring) downwards, i.e. blurring will not add extra pixel(s) above, only below. By incorretly assuming added pixels above and below, the authors seem to overestimate blurring by a factor of two.

5) The arteficial "cap" is not explained satisfactorily.
Instead, the value of the cap is translated in a certain perimeter stretching factor. However, the authors do not try to explain, why no smaller perimeter stretching factors exist. Assuming that (L. 442-443) only few particles have a smaller perimeter stretching factor seems wrong, I guess (from looking at Fig. 4.g) that there is not a single particle with smaller perimeter stretching factor.
The reason for this cap is likely to be found in effects of pixelation affecting the perimeter by artificially extending it, more noticeably for smaller particles (~0.5mm) than for larger ones.

Having said this, I need to remark that it should be discussed how the perimeter is determined.
L. 410-413: The pixelation effects should be considered.
Fig.7: Reformulating the discussion around the artificial cap may result in that Fig 7 is not needed. E.g., currently the whole discussion about it in L. 418-445 is difficult to understand and doesn't explain the cause of the cap.
Reconsider the usefulness of Fig.8.

6) Similarily, the apparent gap between aspect ratios around 0.9 and 1.0 is not explained properly (L. 375-376). It seems to stem from the fact that there is a minimum perimeter stretching factor that is above 1 in case a rectangle(square is fit instead of an ellipse/circle. There is no gap, but all particles with smaller perimeter stretching factor are simply "piling up at the aspect ratio of 1.0.

7) Using ellipses or rectangles that best fit the particle can be used to describe shape, they are, however, not sufficient as complete measurements of the particle's shape. The limitations of the evaluated algorithms could be highlighted better.

Other minor or technical issues:

Terminology:
Inconsistent use of terminology:
E.g. "tensor method" only used twice (L179-180 "hereaftyer referred to as the tensor method" and L242 "referred to here as the tensor method"), elsewhere "tensor-fitted ellipse" or "tensor-fitted ellipse method" or "tensor-fitted ellipse measurement"
Or: Inconsistent use of "resolution", not always used correctly. L100 "resolution" refers to the size on the particle that corresponds to one pixel. This is later more adequately referred to "pixel resolution" (e.g. L.269) or "pixel size" (L. 314).

Maximum dimension is not used in this study. The term "maximum dimension" is, however, used three times in the Conclusions. The authors likely wanted to refer to an ellipse- or rectangle-fitted dimension.

Sect 3.3:
Make it clear that the viewing planes are horizontal and that they are separated vertically by 6 mm (or 7?).
Discuss how the "piecing together" of the single line scans is carried out and what errors or accuracies are to be expected. Is the sentence in L. 517-519 ("highly accurate") true?
Provide information on pixels and pixel resolution (as done for PIP and MASC in 3.1 and 3.2).

L. 199-200 reformulate "made" (measurements are doen or carried out), e.g.

"... before the MASC measurements are emulated by using the same ..."

L.205: "a five pixel particle" is ambiguous as the PIP measured particle image and the emulated MASC image have different pixel resolutions. Use something like "a five PIP-pixel particle".

L. 214: "product of the particle fall speed and the camera observation frequency" seems wrong, should it be v/f?

Sect. 4.3: Specify that the tensor elements are mean values of the quantities (e.g. square of Delta y) for all particle pixels (or otherwise explain better eq. 1).

L. 377-378: Repeated use of "expected" and unclear when the increase in aspect ratio (or the period of lump graupel) is.

L. 389-390: "lack of a warm nose" and its implications should be explained if that is relevant for the discussion.

L. 399-401. While it seems intuitively obvious what the sentence tries to explain, it needs to be refromulated for correctness and clarity.

L. 402-403: remove last part of sentence ("note, extending the short...") to improve clarity.

L.473-476: reconsider the explanation, it seems that the example particle should move to the left while moving down to be compressed horizontally.

L.247 correct spelling: "eingenvalues"

L. 304 delete duplicate "both"