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Comment on amt-2021-427

Anonymous Referee #1

Referee comment on "A comparative evaluation of snowflake particle 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-RC1>, 2022

amt-2021-427: Helms et al. 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)

In short: This study compares the different algorithms behind the measurement techniques of three digital video disdrometers: the Precipitation Imaging Package (PIP), the Multi-Angle Snowflake Camera (MASC), and the Two-Dimensional Video Disdrometer (2DVD) in observing snowflakes. The focus is on defining the uncertainties in the defined area influencing the equivalent diameter, and the aspect ratio. The authors quantify the motion blurring, in the case of PIP also the image compression, the shape-fitting measurements, and in the case of 2DVD, the estimate of the bounding box measurement when particle horizontal motion needs to be adjusted with an unskewing algorithm.

The topic is interesting and relevant for surface observations and the development of retrieval methods in global monitoring of snowfall. The study has novelty in the way it examines the measurement algorithms internal to the instruments, which typically are not transparent to the end-user of the data. The theory is clearly outlined with illustrative examples, and the conclusions are well-supported and valid. The manuscript is well written and provides a clear storyline, however, at least in my opinion, it leaves the reader questioning what is the magnitude/importance of these studied uncertainties in respect to the other uncertainties e.g. particles out of focus or only a fraction of particles observed, wind effects to particle fall velocity, miss-matching of particles, partially illuminated measurement space or limited observations of particles from only one plane projection, these are referred in several publications prior to this one. I would like to see more discussion on this topic and references to other related studies. My recommendation is to publish the paper after addressing this concern and some small remarks mentioned below.

Minor comments:

Line 11: "... PIP or 2DVD which provide similar precision once the effects of the PIP image compression algorithm are taken into account." This sentence is somehow unclear connected to the previous statement in lines 10-11 and is not clear for a reader who just reads the abstract. Please rephrase.

Line 41: "There are numerous examples of studies which rely heavily on either of these measures of particle size." The statement "numerous examples" follows only by two references, leaving for example relevant fields such as the snow model or satellite retrieval development unmentioned. I would like to see a broader scan of the research field, just mentioning applications and example references would be enough.

Line 64: "separate from the snowflake size," This is unclear. I don't understand how these mentioned studies are concerning only aspect ratio separate from size. Please rephrase.

Line 87: Altitude of the site?

Line 89-91: I would like to see more data of this event to support the assumptions of aggregation and lump graupels, e.g., time series of temperature, PSD, and mean fall velocity.

Line 336-8: "Even with a very fast fall speed of 4 m/s, the overestimation of the equivalent diameter for very large circular particles (diameter ~ 10 mm) is approximately two orders of magnitude or smaller than the actual equivalent diameter." Two orders of magnitude? This is not clear to me.

Line 339: "perfectly circular". Why assumed the particle to be circular, though written in lines 68-69 "aspect ratio is frequently prescribed, often with a mean value of 0.6 assumed (e.g., Matrosov et al., 2005)" and then without quantification stated that for the oblate particles "the relative (and absolute) effects of motion blurring on the area and equivalent diameter measurements will also grow". Please justify and elaborate.

Figure 4: Could you add the number of analyzed particles and a density plot would add information instead of a scatter plot.

Figure 6. Just to add more information about the particle habit, could the approx. fall velocity be added to the corner of the image? The colored fitted shapes, could the line be

slightly thinner or the image larger, it is now hard to see the lines in respect to the shaded image, they are all on top of each other.

Lines 404-406. As PIP is only seeing a plane projection of the particle, but here the particle is referred to as an ellipsoid, it is confusing whether in this perimeter stretching factor analysis, the computations are performed in 3D with ellipsoids and is it then assumed the same axes ratio in both directions or is it performed in the 2D projection. Could you please clarify this?

Paragraphs 408 – 445: I understood that this section provides explanations why the ellipse-fit in PIP has an arbitrary upper threshold close to 0.6, and why with the rectangular fit in PIP, there is a gap in aspect ratio between 0.9 and 1.0. However, it was not always clear, which "gap" the authors were pointing at. I would suggest that you would refer in the text (when addressing for the first time) to the image, where the "gap" is shown. E.g. in lines 436-438, I assume here the authors are referring to Figure 5b?

Figure 9. Same as Figure 4. It would be nice to see the number of analyzed particles and then rather a density plot than a scatter plot.

Lines 526-527: "and, as a result, the **maximum dimension** and aspect ratio measurements are unreliable; however, the PIP variables other than the ellipse and rectangle dimensions appear to be reliable" I assume here it is referred that the PIP-fitted **maximum dimension of an ellipse** is unreliable and not that the observed maximum dimension is unreliable. Please clarify.

Lines 528-530: "As the present study has demonstrated, the PIP imagery can be reprocessed and reliable measurements of **maximum dimension** (the previous comment) and aspect ratio can be made via the application of an alternative ellipse-fitting algorithm, such as the MASC or tensor-based algorithms." In the manuscript, it was described that the AVI file contains only the first 2000 frames from the 10 - minute section, and with 380 frames per second, this translates to 5.3 seconds of data. It is unclear that can an end-user reprocess the whole data volume or just the sample frames in the AVI-files? Could this be elaborated?