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An introduction of Three-Dimensional Precipitation Particles Imager (3D-PPI)

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Thank you for carefully responding to all raised issues. The changes to the manuscript resolved many of these issues. However, a few questions remain or issues have not been resolved completely. In the following I am describing a few issues that I think still need attention.

Observation volume OV and effective OV

The effective OV is the intersection of the three individual OVs, which are 170mmx 125mm x 104mm. The intersection of the two OVs of Cam1 and Cam2 is a cuboid with the dimensions 104mm x 104mm x 125mm, i.e. it has the volume of 1352cm3. Intersecting this with the OV of Cam0 will result in the effective OV, which then must have a smaller volume. That means the volume that you provide with 1464cm3 is wrong. Alternatively, your description is wrong and the effective OV is not the intersection oif the individual OVs.

Rephrase: “the observation volume (OV) … is the interior rectangle of the observation volume of …”

- ‘Interior rectangle’ is wrong term to describe a volume
- It is not clear to use ‘observation volume’ to describe ‘observation volume’

Rephrase: “The cylindrical observation volume of the three telecentric lenses and LED lighting beams of 3D-PPI is illustrated in Fig. 2.”

- Does this refer to effective OV?
- Fig 2 does not show any observation volume (shows beams)
- No observation volume is cylindrical

Optical resolution / resolving power / smallest resolved detail

Thank you for adopting a better terminology. Pixel resolution and resolution (number of pixels of sensor) of the different cameras are important parameters in describing your instrument. I am missing another paramter describing the optical performance of your cameras, that is the resolving power achieved on images of Cam0-2 and on images of Cam3. You could determine it by calibration or by identifying the smallest features that can be detected on your images. I do not agree with a statement that the “smallest recognizable detail … is 0.0416 mm” (in response to my point 9). Of course, this is theoretically the best limit, however, it is not backed up by evidence. Can you show

images of snow particles with small details to illustrate the smallest features that can be detected (under optimal illumination and in-focus position)?
You seem to focus on “larger particles” (response to my point 9), but you don’t mention this clearly in the manuscript.

Removal of noise and smaller particles

You are rejecting features with Dmax less than about 0.2mm. I would recommend stating this limit in the Abstract/Conclusions (something like “…measure particles > 0.2 mm”).

You call it “removal of small noises from image”. I would rephrase this as I don’t consider ‘small noises’ a proper term, it sounds colloquial.

Prior to rejecting small features, you join connected regions that have their centroids separated by less than 4mm. This still fells like a large distance to me. I don’t understand why the centroid distance has been chosen here rather than the actual gap separating any two connected regions. The centeroid distnce depends on the size of the connected regions whereas the gap represents the size of a potentially undetected region of the particle. When joining small connected regions you accept a gap of almost 4mm. For larger connected regions, the accepted gap is smaller by roughly the average size of these connected regions. It would be good, after justifying better your joice of criterion, to show examples of particles resulting from joining connected regions. This could be done in Fig.7 by adding two or three such examples including a length scale for reference. A propoer description of what is shown now in the figure is missing (you indicate (in red numbers) detected particles, I think).

Pixel resolution

You determine the pixel resolution using ceramic spheres of known diameters, as described in Sect 3.2, which you call “Calibration of image binarization”. I still find it unclear how you describe the process.
You say that “we perform manual adjustments to mitigate the software’s misidentifification” sugesting that you use a software or algorithm. However, you state that the algorithm described in Sect 4 is not used. So, it is unclear what software or algorithm is used here.
I think, for the purpose of determining the pixel resolution, it would have been better, and easier to describe, to do a completely manual analysis of the images of the ceramic spheres, for example by adding best-fitting circles and determining their diameters in pixels.
I also still believe that taking images of a millimeter scale would have been better for the purpose. Aligning such a millimeter scale would not have been difficult with the required accuracy. Using a millimeter scale would have avoided the dependenc on the used algorithm and/or manual analysis (e.g. different thresholds result in over- or undersizing).

In fact, the use of spheres of know sizes is more suitable for testing an image processing algorithm. You actually do that in Sect 4.1 and Fig. 8. As a consequence, your Figures 6b) and 8 look almost identical, and it si difficult to see what difference there is between the two tests. In one figure you show error bars in the other not. What are the error bars in Fig 8? I guess they are related to that you image 20 spheres falling through in fornt of each camera. For Fig 6b, did you image one sphere for each diameter? Were these spheres dropped as for Fig 8?

For Fig.6b, I would suggest to plot the distance of two points (in mm) over the distance of these two points on the image in pixels (rather than the opposite as you are doing). Then you end up with fitting your data to the linear expression of the form Dmax = d*Px + e rather than, as you do now, Px = b*Dmax + c. In these expressions Dmax represents the actual size or distance in mm and Px represents the measured distance on the image in pixels. The fitting coefficients are d and b, respectively, and the intercepts are e and c, respectively. The resulting value for d is the pixel resolution. Whereas you take the inverse of the slope b. It is, however not generally true that d = 1/b, where d and b result from fitting the same data to the above two expressions. So, do the fit of Dmax = d*Px + e to your data in Sect 3.2 and then report d as pixel resolution. You likley get very similar results, but you avoid the confusion of how to comparer or convert your results properly to pixel resolution.

Fig 6b from one sphere (for each size), or the average of several images of spheres (at each size)?

Image processing algorithm – resulting errors

You use adaptive thresholding to binarize images. You also state (in the response to my point 14d) that "It has been tested that particles outside the depth of field cannot be clearly imaged and therefore cannot be detected." What does this statement mean? Are particles outside the DOF not properly binarized (because they are fuzzy, not in focus)? My question remains: How well-defined is the depth of field? The PSD values and OVs depend on it.

You state that "The average error for all spheres across different diameters is -0.048 mm." In your responses you explain that this error is "measured-true" and can be positive or negative. Taking the average of two errors where one is, for example, +5 and the other -5 would result in a zero average, which would wrongly describe the error. I think this is what happened when you report the very small "average error", it is a misleadingly small value, the average of larger positive and negative values. Consider another way to describe the errors and relative errors.

Horizontal speed

"The average value (consider positive and negative) of the horizontal velocity component..." What does that mean? Is this a suitabel average (see also error of image processing above).
It is not obviously clear that the horizontal speed corresponds to the East-West wind direction. Mention that installing the instrument facing south means that the horizontal speed seen by the high-speed camera Cam3 corrsiponds to East-West.

Size-dependent OV in Eq. 7

Excluding particles at the edge of the image means a reduction of OV that depends on particle size. You account for that in the modified eq (7). It now features Vj, the valid OV at the "jth moment". Vj has already been used in eq (6) for speed, potentially leading to confusion. However, what confuses me more is this "jth moment", not sure what that means. Should that not be "in the jth image"?