Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-176

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Referee comment on "Reconstruction of the mass and geometry of snowfall particles from multi-angle snowflake camera (MASC) images" by Jussi Leinonen et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2021-176-RC1, 2021

The study presents a novel methodology to retrieve snowflake mass and geometrical properties from the simultaneous observation of the snow particle by multiple viewing angles. The authors developed a GAN algorithm to address this problem. It is worth noting that this is no trivial challenge since the shape of snowflakes is highly irregular.
Finding a methodology for the automatic estimation of snowflake mass, on a single particle level is still an area of active research since it poses significant challenges. The problem is also very relevant for many applications ranging from microphysical studies of snow to remote sensing simulations. For this reason, I consider the study of great interest for an AMT publication.
The paper is logically structured and easy to follow. The graphics are clear and the text is well written.
The methodology is well described and made easier to apply by other researchers thanks to the open code and data sharing.
The limitations of the proposed methodology are appropriately discussed and the application example helps to illustrate the relevance of the study.

I did not find any major flaw in the paper and I certainly recommend it for publication after minor revisions. I will take this opportunity to list a few minor comments that I hope will help the authors refining their work.

The thing that puzzles the most is the fact that the GAN is trained with model data. This point is appropriately discussed at line 155 and following, but I am still thinking about how this affects the results presented in table 4. It appears to me that the exponent of the power-law fit for the mass-size relation is always approximately 2 and only at very high degrees of riming (75-100%) it significantly deviates from this value. This is coherent to what was already shown in Leinonen and Szyrmer (2015) where the model predicts that riming mostly affects the prefactor of the mass-size relationship, while the exponent is not affected. In that study, a completely different growth model (i.e. rime growth, model C) is needed in order to affect the exponent of the mass-size relation. Because of that, I am suspicious about the fact that this result might be a consequence of the model employed.

On the other hand, it seems that there is some evidence to support the idea that the exponent of the mass-size power law should vary more continuously between the unrimed aggregates b=2 and the 3D scaling b=3 (see e.g. Mason et al 2019 Retrievals of Riming and Snow Density from Vertically Pointing Doppler Radars, figure 1 and equation 8).
In my view, when snowflakes grow by riming they increase mostly in mass (fill-in theory and Seifert et al. 2019) and will start increasing in size more and more while their rime mass fraction increases. In my view, the smallest particles should reach this limit first, hence their size would start increasing earlier than one of larger aggregates, thus the exponent b of the m-D power low starts increasing. This conceptual view comes from the idea that the riming degree of single particles is not constant inside a snowflake population.
If I understand correctly (please correct me if I am wrong), snowflakes coming from various particle populations (different times/ weather events) are stratified according to their riming degree in Table 4. If the logic of my previous paragraph is valid, the m-D fits derived in Table 4 are not well representing natural snowflake populations because, in general, one should assume a size-dependent riming degree.
My additional questions related to this point are: How do the results of Table 4 compare with those of Mason et al. 2019? How confident are you in the quality of the used riming model to represent real physics? Is it possible that the results are affected by a biased model? Can you elaborate on which improvements to the snowflake model might be needed in order to make it producing snowflakes whose mass scale with exponents in between 2 and 3?

A few more specific comments:

Line 141: I guess also the orientation of the particle matters for the simulated silhouette. In other parts of the paper, the orientation of the particle is discussed as a source of uncertainty. I wonder if it would be possible to constrain orientation by means of hydrodynamic models and exploit it to constrain also the GANs retrieval

Line 185. I guess that also the surface properties of ice (roughness mainly) are needed in order to simulate the interaction of light with the snowflake and that is also something that the used model does not provide.

Line 191. I guess there is a typo PhotoTOnic

Section 4.1 The used apparatus seems very expensive and has significant limitations nonetheless (max size, fragile material). Maybe the authors can give some indications on which are the technical specifications for a 3D printer suited to replicate the experiment.

Line 202 Is the fall speed impacting the measurement capabilities of MASC? I guess the material used for 3D printing has a different density with respect to ice and thus a different fall speed.

Line 255. In Equation 2, if I got it right, m^i is the same quantity as m_i in Eq.1 just with the voxel identifier i shifted from subscript to superscript. If that is the case I would suggest using the same notation in both cases (I have a personal preference for subscripts)