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Atmospheric Measurement Techniques Discussions

Interactive comment on "Numerical simulations and Arctic observations of surface wind effects on Multi-Angle Snowflake Camera measurements" *by* Kyle E. Fitch et al.

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The subject of the well written and structured paper is well within the scope of AMT as it provides new tools and data for the correct use of an (already established) instrument for snowflake measurements called "Multi-Angle Snowflake Camera“ (MASC). For this purpose, the authors use a combination of numerical simulations based on an Euler-Lagrange approach and field based measurements. The main findings are guidelines for the correct usage of the above mentioned MASC, which I consider a substantial contribution to further investigations of snowfall measurements.

Event though the article is quite good in my opinion and I would not argue with the main

findings, I have some remarks. (Disclaimer: Please note that I am not an expert in precipitation measurement and my expertise mainly is in fluid and particle dynamics and the simulation thereof. So if there are points regarding especially the meteorological topics that I did not get right, please do not hesitate to object/improve.)

Major remarks:

1) The description of the CFD simulation setup should be a bit more detailed: What is the total number of cells? (Table 1 seems to give a wrong information about this, as the cells would be much larger as they seem in Figures 1(c)-1(e)) Have there been any examinations on grid independency? Please specify the boundary conditions. Please justify why potentially important forces acting on particles in turbulent/shear flows are neglected (lift force, pressure gradient force) Where are the starting positions of the particles? (could be included e.g. in one of the figures 1(c)-1(e))

2) Furthermore, I would suggest using more particles and particles of different size and shape according to the different riming classes seen in the measurements. And, as the influence of turbulent wind on the collection characteristics is examined, a model for turbulent dispersion should also be included. The finding that fall velocity is reduced with increasing wind speed could maybe have been made without the particle simulation part by just looking at the fluid velocities inside/above the collection area. If so, the particle simulations might as well be left out and more detailed particle simulations would be something for further work.

3) As in principle the dependence of the collection efficiency on particle dynamic properties is investigated, I would suggest to include some thoughts on and references to general particle dynamics. Namely, there is the particle Stokes number, defining the ability of particles to respond to sudden changes in the carrier fluid's velocity. It is proportional to the product of particle density and the square of the diameter. Aggregates with comparatively low densities would have a low Stokes number, indicating that they follow the flow better than more dense aggregates. Additionally, bodies moving through

fluids tend to orient in a manner that the drag is maximised. For oblate particles this would mean that their "plane" is oriented perpendicular to the flow direction. With these two principles a lot of the paper's findings can be explained quite well.

4) Regarding the orientation of particles: As non-spherical particles tend to arrange themselves in some preferential angle to the flow, the concept of determining their orientation seems questionable even for medium wind speeds between 1.5 m/s and 5.0 m/s, as the flow above and inside the measurement region seems to be heavily influenced by the device. What are the authors' views on this?

Minor remarks:

Section 1:

L46f: suggested change from "characterize" to "were used to characterize" or similar

L58f: Isn't the collection region cylindrical or circular, not ring-shaped?

L58ff: I would suggest to include some information about the different parts' positions in Fig. 1a)

L70ff: Maybe the number of references can be reduced, where possible?

L90f: also include influence on riming degree among "fall speed, fall orientation, and size distribution"?

Section 2:

Please specify more clearly: It seems that first a steady state simulation with simple-Foam is done, and afterwards particles are tracked through a "frozen" flow field, but it is not actually mentioned.

L96: Which solver? Maybe simpleFoam should be mentioned here already.

L100: simpleFoam instead of simpleFOAM

L115: Please specify the drag coefficient function.

L115 & L117: Re should be Re_p

Fig. 2: I would suggest writing "wind directions" instead of "wind vectors". What cross-section is meant? Maybe the plane for the arrows? Please specify. A more detailed view of the results inside/around the measurement section would be nice, as it would be possible to examine the wind speed there more detailed. Is it possible to show some exemplary particle path lines? (additional images could be included as supplementary material)

Fig. 3 and Fig. 4: Please indicate where the data is sampled.

L130: "in the k-ω-SST closure model"

Section 3:

L137: "the angle between D_max and the local horizontal" should be "the angle between the major axis and the local horizontal"

L143: Is the average of the three images the best guess for the actual orientation angle? How "stable" is the detection of orientation angles for rimed particles, as they might have no clear major axis?

Fig. 6(b) might be dropped in my opinion

L171: Why were the PDFs adjusted with a Gaussian kernel and how do the original data look?

Table 3: In the regime of U_sfc <= 5 m/s: Are the data for smaller U_sfc also contained in values for larger U_sfc? (e.g. is the data of U_sfc <= 0.5 m/s also in U_sfc <= 1.0 m/s?)

L187f: If something different is simulated, then it should not be compared to that. There seems to be a significant difference between the measurements and the simulations. Please include some discussion about this difference.

Fig. 10: The low fall speed mode seems to be less prominent (U_sfc <= 1.0 and 1.5 m/s) or even vanishes (U_sfc <= 0.5 m/s) for aggregates. Is there any explanation for this?

Section 4:

As metioned above, please include some discussion of the simulation results and how they compare to the measurements.

As mentioned in major remarks, I suggest including some of these thoughts:

Falling objects tend to orient in maximum drag conditions, which matches the findings here. (compare L196ff)

As aggregates seem to have smaller fall velocities than particles of the other two categories, they should be oriented more vertical to orient in maximum drag conditions when experiencing the same horizontal wind speeds. This again matches with the findings. (compare L201)

Aggregates are more prone to get blown away by the surface winds as they have comparatively low Stokes numbers and high surface-to-density-ratios in comparison to more rimed particles. (compare L205ff)

L236: “enhanced are reduced” should read “enhanced or reduced”

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