

Follow, in yellow, my point-to-point answers to the comments of referee 2.

(Line numbers of the new version do not correspond with those in the Referee 2 comments)

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Double window

In Fig.3 “double window” seems to refer to the double window interspace (what you call “double window space” or “double window inter-space”).

In L. 193 “double window” has not been mentioned or defined earlier.

DS

There is a potential confusion because “DS” refers both to a surface (e.g. in Fig. 3 or when talking about the DS temperature  $T_s$ ) as well as to the sandwich of three glass layers. When “DS” is defined (L.200) it refers to the sandwich of three glass layers. This “DS” or sandwich is also referred to as “heated glass” (e.g. Fig. 3 or L.231), “electrically-heated glass” (L.200), “heating-glass” (L.250).

Throughout the updated text and figures, I evidenced that DS is just the outer surface of the electrically heated glass. I supposed it was straightforward also in the previous version, but I hope now is much clearer.

Heating and thermal control

- Instead of providing the specific heating power of  $1000 \text{ W m}^{-2}$  (L. 200/201), I would provide the actual heating power (in W), or provide both.

Done

- The “heated glass” is used to achieve sublimation (L. 202). It is unclear if the “DS temperature of (at least)  $3 \text{ }^\circ\text{C}$  above air temperature” (L. 205) refers to ICE-CAMERA and if this is temperature controlled using the DS “heated glass”. If yes, clarify in Sect.2.6. Do you consider  $3 \text{ }^\circ\text{C}$  or  $5 \text{ }^\circ\text{C}$ ?

$3^\circ\text{C}$  refer to a referenced paper carried out in DC, as stated in the text, in ICE-CAMERA we keep  $4\text{-}5^\circ\text{C}$  above air T

- What is a “ventilated resistance” (L. 230)?

Changed into ‘ventilated heater’

- L. 231, “eventually” is the wrong word: “disabling... during sublimation (see Sect. 2.7) when needed”.

changed

- L. 232: “200W wired thermostat”, I am unsure what the “wired” refers to.

Removed 'wired'

Fig. 8

If you want to keep Fig. 8, then several points should be addressed:

- "air" and "air" should refer to the outside air and the air in the double window interspace, respectively; change labels accordingly. Consequently, "Tair" is not the same as "Tair".
- Similarly, "Ts" is not the same as "Ts", one is the DS temperature, the other Ts is the temperature on the inside surface of the sandwich of three glass layers (surface towards the double window interspace).
- Radiative and convective/wind effects only apply to "k2" of the outside air. For explaining the cooling in principle, it may be sufficient to consider the outside-air k2; i.e. you may remove k2 of the double-window interspace.

Removed the fig.8 and summarized the discussion.

Explanation of sublimation and deposition periods

Consider rewriting L273-274 ("Once the heater is turned off, and after a cooling time of 20 minutes, the DS temperature comes back warmer than the air by about  $dT = 5^{\circ}\text{C}$ . The "sublimation period" is considered complete, and ice particles accumulate again on the DS, with no relevant sublimation ("deposition period" in Fig. 7).") more clearly, e.g:  
"Once the heater is turned off, and after a cooling time of APPROXIMATELY 20 minutes, the DS temperature comes back TO BE warmer than the air by ONLY  $dT = 5^{\circ}\text{C}$ . AT THIS POINT, THE "sublimation period" (OF APPROXIMATELY 30 MINUTES) is considered complete, and ice particles START ACCUMULATING again on the DS, with no relevant sublimation, I.E. THE "deposition period" STARTS."

Done, thank you!

Note that Fig 7 refers to an indoor test, but the text above to general outdoor behaviour (or an outdoor test) not shown in any figure. Thus, be careful when referring to Fig.7 to do it in an adequate way.

Note also that in Fig 7, "deposition" and "sublimation" do not bear a physical meaning.

text changed in order to meet these requests

Re: C) L 274-292 Adhesion of ice on DS

The two examples you provide in the explanations in L.291-295 give adhesion speeds (particles below these limits adhere) that are smaller than the settling speeds. Yet, you claim that this is

sufficient to explain adhesion of these smaller particles. My interpretation of these explanations is that particles settle at speeds faster than adhesion speeds and therefore should not adhere (without considering other effects).

Perhaps I am missing something or mis-interpret. In any case, it would be good to improve clarity.

I made a matlab code using the theory developed by the refenced paper on snow attachment to the glass and sedimentation speed papers (paper added to the references) , and compared the sedimentation speed of spherical particles with the sticking, critical speed. A discussion is added in order to clarify this topic.

In L.291, “decreases with particle diameter” leaves me wondering if you mean “decreases with DECREASING particle diameter”.

corrected

The “<<big>>” in L. 298 should perhaps better be called “large”.

Diameters

corrected

L.460 “Particles below 3600  $\mu\text{m}^2$  in bounding-box surface, 73 pixels minimum size (equivalent to approximately  $D < 60 \mu\text{m}$ )”:

- “D” is ambiguous, use  $D_s$  or  $D_f$  (assuming a spherical particle, I think you want to refer to  $D_s$ , which would be equal to Feret width and Feret length);

corrected

- “73 pixels minimum size”: I would avoid “size” as you seem to refer to an area of 73 pixels;

corrected

- It is unclear what the limit for processing is, 3600 $\mu\text{m}^2$  bounding box or 73 pixels area?

corrected

L. 449 In one occasion you use “Feret size”: should be Feret width and length?

Removed the ‘ Feret size’ from sentence

L420-422 define  $D_f$  and  $D_s$ , where  $D_f$  is the “Feret-box surface-equivalent diameter”. Later , in

L.715 you talk about “the bounding box equivalent diameter ( $D_f$ )”; I would be consistent.

corrected

L.716-717 “For comparison, a round particle is expected to have a ratio of  $D_s/D_f=0.78$ .”:

SHOULD BE (accord. to def. in L420-422)  $\sqrt{\pi/4}$ , approx. 0.89, and not 0.78!?

Corrected the error, THANK YOU!

Overlapping particles

Sect 4.1.4, 3): Could these artificially created copies of the “same segmented image” be detected and thus avoided as an issue?

Added a sentence for this. Also, a sentence about the duplicated detection of the same , non overlapping particles was added.

Positive bias of confusion matrices

L. 545-550: The text modified in response to my previous review is unclear and leaves my comment not properly discussed. It is unclear what “This process has been repeated three times recursively...” means exactly. Is the enlarged training dataset used to create a new CNN, which is then used to classify the previously discarded images (wrongly classified by previous CNN version)? It seems that this enlarged “image training data set” is used for consecutive training and testing. Data used for testing should be independent from training, but here it seems that the test data (or a large part of them) were part of training the CNN (or classified by a previous version). I see the risk of introducing a positive bias by effectively preventing (to a large extent) data that may be classified wrongly by the trained CNN because wrongly classified particles are excluded in this process of enlarging the training and test dataset. I don't see how “these images should be considered as ordinary, supervised training images” adequately discusses this.

I rewrote the whole description of this iterative process, evidencing that misclassified particles were also properly re-labeled and so re-used in the next CNN training. In fact, especially after the first CNN training (based on a very limited data set) a lot of bullets were misclassified as columns, rosettes as irregular rosettes, etc.. These images were properly re-labeled to be used for the next CNN training. In any case, I must say that most of the choices involved in the development of CNNs (network structure, training parameters, etc.) are traditionally arbitrary: I describe the method I used for my personal application. The CNN must work with my particular instrument, with its particular illumination, image resolution, etc, and has not a widespread application. Moreover, it will be changed in the next future for including more classes of particles as the statistical base increases.

Discussion about importance of sublimation (Re comment on L624/5, 632/633 in previous review)

L647-649, “This result suggests that sublimation on the DS during the deposition period is less important than the natural variability of precipitation intensity in determining the number of particles detected during the acquisition.”: I am not sure that you can draw a conclusion like

this based on the evidence you are mentioning. In addition, the following sentence, which should confirm this, is confusing as you seem to refer to lower (colder temperatures) as “temperatures above the median” and warmer temperatures as “in the lower temperature range”.

Also L 654-655 suggests that “sublimation does not affect dramatically the number of particles”. Again, this cannot be concluded from the results. Contrarily, one must expect that sublimation affects the number of particles (see Fig.9b in Sect 3.2) for smaller particles and at warmer temperatures.

Similarly, the statement in L 691-692 cannot be concluded from the measurements. The resulting size distribution in Fig. 23 may very well be affected by sublimation (and would have been different, with larger and/or more particles, without sublimation). If plates were observed at -50degC or warmer (temperature information is missing in the discussion) then the observed plates may be deposited at the end of the deposition period, shortly before the scan. Particles deposited earlier would have been completely sublimated if less than 200um in size (see Sect 3.2).

Likely, the discussion cannot be improved to support the author’s claims. Rather, it should be acknowledged that sublimation cannot be excluded or quantified easily. In addition to particles potentially disappearing due to sublimation (L731-732), particles may also appear smaller than their size during precipitation and when deposited. Statements such as in L738 (“apparently without dramatic losses of small particles for sublimation”) cannot be deduced from the presented observations.

I changed the related sentences according with the referee comments.

Other issues:

Resolution of the ICE-CAMERA

Your clarifications refer to the pixel size in the scanned image, but not to the optical resolution.

Can anything be said about the optical resolution? (What are the smallest details/features that can be seen on the images?)

added the Nyquist criteria

Use of “adverse”

L 307, “The adverse effect is an accelerated natural sublimation of deposited particles.” As in the previous review, I have a problem with this sentence and think it is bad language and therefore difficult to follow.

changed

Section numbering

Sect. 4.1.1 is missing?

Renumbered the sections, thank you!

Eventually

L 628, “eventually” is the wrong word.

corrected

Data set or dataset

You use “data set”, data-set”, and “dataset”. In one place also “data store”, unclear if you mean dataset there or something else.

Changed to ‘dataset ‘everywhere’