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The Cryosphere Discussions

Interactive comment on "Identification of blowing snow particles in images from a multi-angle snowflake camera" *by* Mathieu Schaer et al.

Anonymous Referee #1

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This paper presents a new method to automatically identify blowing snow particles in images from a Multi Angle Snowflake Camera (MASC) that was initially designed to study solid hydrometeors. The author developed an automatic classification task based on four selected descriptors that can make the distinction between blowing snow particles and precipitation particles. Mixed situations are also identified with an index indicating if the image is mostly composed of blowing snow particles or precipitation particles. At the end of their paper the authors present a few examples of application of their method in alpine and polar environment.

The subject of this paper is interesting for the community studying snow and its interactions with the atmosphere in polar and alpine regions. Indeed, in these regions, blowing snow events often occur with concurrent snowfall and the development of innovative

measurements methods is highly relevant to better quantify the interactions between falling snow, the surface of the snowpack and the wind field. My main comments about this study concern (i) the presentation of the feature selection for the classification and (ii) the analysis of results. These questions need to be clarified prior to publication in TC. They are listed below as general comments followed by more specific and technical comments.

General comments

Section 4.1 describes the selection of features used in the classification. The author use four categories of descriptors and mention in Sect. 4.1 which descriptor was finally kept within each category. However, the selection of the descriptors is only qualitatively described and only the final selection is given. The authors should better justify the choice of the descriptors based on quantitative results. Figures 5 and 6 could certainly help but they are never described in the text. It would be also interesting to associate the choice of the final descriptors with physical processes occurring during wind-driven snow transport. For example, the choice of the descriptors related to the size and shape of the particles can be associated with the fragmentation of particles (Comola et al. 2017).

Comola, F., Kok, J. F., Gaume, J., Paterna, E., Lehning, M. (2017). Fragmentation of wind blown snow crystals. Geophysical Research Letters, 44(9), 4195-4203.

The authors are presenting the results of their method in Section 5. This section contains 1 table and 5 figures for a total of 9 lines of text. I understand that this paper is centered around the description and evaluation of the identification method but the authors should provide a more exhaustive description and discussion of the results that they decided to show to illustrate the use of their method. For example, Figure 11 is quite interesting and should be analysed more in details by the authors. They could add on this figure the meteorological conditions (wind speed, precipitation) to better explain the transition from a precipitation event to a blowing event. The same apply

to Figure 12. Can the authors comment on the different particle size distribution? For blowing snow particles, how does it compare with particle size distribution measured with Snow Particle Counters (Sato et al., 1993)?

Specific comments

P 2 L 9: present weather have also been used to monitor drifting and blowing snow near the surface (Bellot et al. , 2011).

Bellot, H., Trouvilliez, A., Naaim-Bouvet, F., Genthon, C., Gallée, H. (2011). Present weather-sensor tests for measuring drifting snow. Annals of Glaciology, 52(58), 176-184

P 2 L 18-20: Naaim Bouvet et al. (2014) developed a automatic method to estimate the occurrence of snowfall as well as snowfall amount during blowing snow events using measurements from photoelectic sensors. It could be interesting to mention this study in the introduction since it dealt with topics similar to the ones presented in this paper.

Naaim-Bouvet, F., Bellot, H., Nishimura, K., Genthon, C., Palerme, C., Guyomarc'h, G., Vionnet, V. (2014). Detection of snowfall occurrence during blowing snow events using photoelectric sensors. Cold Regions Science and Technology, 106, 11-21.

P 4 L 4: the expression "exceptionally important" is rather unclear and the authors should provide typical values of the image frequency during blowing snow events.

P 4 L 15-16: we can expect different properties (size, shape and complexity) for the fresh-wind blown snow particles coming from the edges of the DFIR compared to more classic blown snow particles that have been exposed to transport in saltation and turbulent suspension. Can the author comment about it? In addition, the authors should comment on the potential deposition of blowing snow particles from the surrounding crests. Is it something that can be observed at the experimental site above Davos?

P 6 L3-7: The beginning of Section 3.1 contains a brief description of the MASC. Other technical details are provided at different places in Sections 1, 2 and 3. I recommend

the author to create in Section 2 a sub-section dedicated to the presentation of the MASC and summarizing the main characteristics of the instrument. In this subsection, it would be interesting to add more details regarding the MASC image frequency since it is used by the authors in their image classification method. What is the maximal frequency of the instrument? How does in depend on the particle concentration? To my knowledge, it is the first time the MASC is used to characterize blowing snow particles. It would be interesting if the authors can briefly compare the characteristics of the MASC and the Japanese Snow Particle Counters (SPC) (Sato et al., 1993) in terms of particle characterizations. The SPC can be currently considered as the reference device for blowing snow measurements (fluxes and particle size distribution).

Sato, T., Kimura, T., Ishimaru, T., Maruyama, T. (1993). Field test of a new snow-particle counter (SPC) system. Annals of Glaciology, 18, 149-154.

P 6 L 31-33: The authors computed quantiles and moments of the distribution of the considered feature. What are the typical numbers of particles on an image in the different situations: blowing snow, precipitation, and mixed situation?

P 9 L 11: the authors use the term "soft clustering" and the term "hard clustering" at P 10 L 24. These 2 terms can be indirectly understood when reading the text but I recommend the other to include in the text one or two sentences that clearly define these 2 terms.

P 10 L 9: it is not clear why the authors decided to remove exactly 80 data points (images ?) from the training dataset.

P 13 L 9-10: How do the authors justify the choice of having 10

P 13 L 15-17: The authors computed an index of mixing for each image as well as an index average among the 3 images with a given time identifier. Can the authors comment on the variability of the value of the index among the 3 images for a given time? Is their classification methods providing consistent results among the 3 cameras for a

given time? What are the reasons for the potential differences between the images?

P 13 Table 3: as mentioned later in the text (P 15 L 12-13), it would be really relevant for the reader to provide as well the percentages expressed in terms of time. The percentage in terms of images are difficult to interpret since they depends on the image frequency that changes with time.

Technical comments

Text

P 2 L11: the references should be written (Palm et al, 2011) and (Gossart et al., 2017)

P 10 L 4: the signification of the variables used in Eq 2 shoud be given in the text.

Figure

Figure 2: it would be interesting to show the period selected as blowing snow and precipitation on the upper graph of Fig. 2 Maybe add lines showing the median values of wind speed and MASC image frequency that were used to identify the different events.

Figure 2: please indicate at which height above the surface the wind speed is taken.

Figure 3: it is very difficult to identify the blowing snow particles due their size. Could the author insert a zoom over a specific region of the image containing blowing snow particles? It would be also useful to include a scale on the images to allow the reader to better estimate the size of particles.

Figure 4: a scale would be also useful on the images.

Figure 7: the labels and legends on the graphs are hard to read and should be made larger.

Figure 12: mention from which field campaign are taken these data.

Figure B1: It would be interesting to better highlight on the binary image the artifacts

mentioned the caption.

Figure B2: Mention which image is filtered and which one is binary?

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