The Cryosphere Discussions

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Comment on tc-2021-260

Anonymous Referee #1

Referee comment on "The statistics of blowing snow occurrences from multi-year autonomous snow flux measurements in the French Alps" by Zhipeng Xie et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-260-RC1, 2021

This study presented here aims to present the spatiotemporal variations in blowing snow occurrence in the French Alps and to explore the potential links with ambient meteorological conditions using long-term meteorological data and FlowCapt measured snow mass flux. This analysis might help to improve model simulations of blowing snow, as local measurements and satellite-based retrievals are linked. Nevertheless, the study is not placed in a broader context, which does not show me the applicability of this study in other studies. I have three main concerns about the study.

First, the authors say the regional characteristics of blowing snow occurrence are investigated, but the blowing snow measurements are not connected with the local topography and the available other observations such as snow depth and precipitation. For example, it doesn't make sense to state that the minimum frequencies of blowing snow days are observed in September, without connecting it to the terrain. It is very likely that most of the stations barely have snow in September in the French Alps, especially at altitudes <2000 m, which is supported with Fig. 10. If the authors are willing to improve this point it is needed that they show other metadata of the stations, such as the type of vegetation, exact altitude and the topographical features such as sheltered or exposed areas and relate these to the observed snow flux. Also, Fmor is often highlighted as the station with the maximum values, but this should be explained with the features of the station.

Second, an extensive review of the FlowCapt sensor is missing. The research in this study should be related to previous work with such a sensor. More information is needed on reliability and applications of the sensor. Furthermore, I am also not sure about the reliability of the FlowCapt sensor if it got partly covered by snow. This study also is contradictory at this point. L124 states that the sensor can monitor snow drift as long as the sensor is partially exposed, but in L146/147 it is said that the measurements suffer from changes in this exposed length. The reliability of the sensor had already been discussed in other literature. For example, Lehning and Fierz (2008) stated that the FlowCapt measurements have to be regarded as an index measurement rather than a precise flux measurement. It should therefore be doubted whether it is useful to

distinguish between 0.1, 0.5 and 1 g $m^{-2}s^{-1}$.

Third, it is needed to distinguish between a discussion and conclusion. The study lacks of a discussion and the study is not placed in a broader context. This makes the study not useful for other studies, as numbers are presented that apply to nine stations at the French Alps, without relating it to local topography. Already from observations during fieldwork, we know that blowing snow occurs very frequently, and the quantitative use of FlowCapt sensors, as already said, is questionable.

Detailed comments:

L39: palys must be plays

L41: which effects of snow cover on the ground thermal regime are meant?

L47/48: can you please add some examples of climatological and hydrological effects on changes in snow distribution?

L49/50: please add references to these two statements.

L53: Li and Pomeroy, not Pomeriy.

L60: aclanche must be avalanches

L62: please consider replacing heat fluxes by energy fluxes.

L69: 2) physically based snow models

L70: please add some more recent references, such as Liston et al (2007) or even more recent physically based snow models (e.g. SNOWPACK).

L73: despite sharing a similar overall spatial pattern

L82: observations instead of observation

L83: spatiotemporal patterns

L86: please provide examples of where the measurements are done, even though they are sparse

L87: and uneven distribution. And do you mean the FlowCapt observations with near-surface measurements?

L88: accurate information is not a good statement here. In other studies, it was already stated that the FlowCapt sensor are an indicator of snow flux and not of precise measurements. Do you maybe mean other accurate information? Which?

L92: transport, with (the comma is placed wrong)

L101: in France and please elaborate on what these ISAW stations are. Where are they used for and what kind of data do they provide? Since when are measurements available?

L104/105: please mention or show which years are used in this study. A Gantt chart with available data per station would be a valuable addition. Also please state over how many years the data is averaged.

L116: compoled? Do you mean resampled to an hourly resolution?

L117: please consider using abbreviations for the meteorological variables, as these variables are repeated here from L106-108.

L123: what is meant with large climatic range?

L124: I want to know more about the functionality of the sensor if it is partially exposed. In general and as stated above, more information is needed about the FlowCapt sensors.

Fig. 1: please provide the elevations at an higher resolution and/or a table with the exact elevation of the station and its expositions.

L134: the air temperature (space missing)

L135: what is meant by ranges? Please also consider using abbreviations for wind speed and direction or otherwise remove the second time 'wind'.

L136/137: how often does it occur that the wind speed and direction remain unchanged? Is this a measurement error?

L139: a SR50 is a snow depth sensor. Please mention it. The paper would also benefit from a figure that compares precipitation, snow depth and snow drift observations, as these are strongly related.

L141: the months without snow are not the same from year to year. Please compare and display the snow flux observations with the snow depth and only discard months without snow. Show the statistics of the amount of months with snow. Therefore it is also needed to show which years measurements were available (see L104/105).

L143: outlier observations. Please use observations instead of measurements throughout the manuscript.

L145: why do you discard periods with positive air temperatures?

L148: please elaborate more on these inaccurate snow depth observations. How inaccurate are the snow depth observations compared to the uncertainty of the FlowCapt sensor?

L159/160: which values were used by Amory (2020) and how much do they differ from what is used in the French Alps? Do these thresholds make sense, if we keep in mind that the FlowCapt sensor only indicates snow drift and is not very accurate in its quantitative assessment?

Fig. 2+3: the timescale of these figures (and the other figures showing the months) is very confusing. Please add a broken axis between May and September and use a scatter plot instead of a line.

Sect. 3.1: the mentioning of the minimum and maximum for specific stations is only interesting if it is related to another parameter, such as the local topography or extreme wind values.

L193: please refer to which Fig. XX after Fche

L197: what is found in the study of Guyomarc'h et al?

Fig. 3: how are events counted that overlap two months? E.g. a blowing snow event start 31 January and lasts until 2 February. Where is this assigned to? Fig. 3 can be removed in my opinion, as it does not provide a lot of additional information if Fig. 2 and Fig. 4 are displayed.

L200: BSD frequency is very vague. Please decide if you want to show the amount of blowing snow events (including its duration) or the amount of days that blowing snow occurs.

L202: please refer to Fig. 4 after the numbers.

L203: please relate the highest and lowest frequencies to the local conditions at the stations.

L207: please prove and show why/how the significant spatial variability was related to the local ambient conditions.

L211: Fmor and Fcmb stations

L211: how can an event be a fraction of a number? Is it averaged? Please provide information over how many years this average is calculated.

L213: only small variations

Fig. 4: please provide information on how the frequency of BSD is calculated. Is it BSD/#days? Also add the broken line to the x-axis.

Fig. 5: add the broken line to the x-axis. Add title above the Fig. (0.1, 0.5 and 1 g $m^{-2}s^{-1}$) and provide more information on 5ghi in the caption.

L233: 76.99% (significancy) and blowing instead of blwoing

L234: this sentence is very unclear. High or low magnitude? Accounting 88.4% of the time? What do you mean with both magnitudes accounting?

L241: fluxes

L247: Seasonal variability (capital letter)

Sect. 3.2: to which months do you assign the events that overlap two months? See comment at Fig. 3.

Fig. 6: this is a very unclear figure. The grey dots are related to the months. Again, please do not connect these points as the summer months are missing. Furthermore, as I've already mentioned my concern about the reliability of the FlowCapt sensor and the thresholds, I would remove this figure. If you are really willing to keep the figure, please add it as scatterplot to Fig. 5.

L271: the low value in May at Fber is probably related to very small amounts of snow in May. Please validate this with snow depth and precipitation data. Otherwise, mentioning this station as station with the largest variations is not adding much information to your manuscript.

Fig. 7: caption: increasing mean wind speed (WS) and 0.1 and 1.0 g $m^{-2}s^{-1}$, respectively. In the labels m/s must be m s-1 and also show wind speeds of 0 m s-1. If this is not possible, elaborate more on the chosen threshold of 3 m s^{-1}.

L294: wind speeds in Figure 7 (space is missing)

L295: these high wind speeds also lead to blowing snow. Even though they are rare, please add them to the study and elaborate the magnitude of these events.

Fig. 8: this should not be a line plot, as the summer months are missing. Please consider making a scatter plot such as Fig. 5.

L304: high wind speeds (space was missing). How high are relatively high wind speeds?

L307: relatively strong inter-particle bonding. This is an interesting statement, but please prove it.

L308: how do you know about snow compaction? Please prove this with literature or observations.

L309: low and (space is missing)

L310: how do you know this is 'likely caused'? Please prove this statement.

L312: is this snow wetness measured? How do you know this? I'd rather say high water content of the snow.

L316: this statement does not fit in the context of your results and it should be supported by other literature.

Fig. 9: please elaborate in the text further about the differences between NoSF and SF. It is not entirely clear in both text and figure.

Fig. 10: hard to understand. Please represent the data in a graphical way. Anyways, this plot also shows why blowing snow in September is the least frequent, as we often do not have snow. Caption: unavailable and rarely occur.

L343: the frequency of blowing snow with concurrent snowfall was significantly lower. But how are the measurements handled during snowfall? Again, more information is needed about how the sensor works. I can imagine it won't work during snowfall and thus the frequency seems to be lower. Second, what is significant in this context?

L373: closely related to large-scale atmospheric circulation and local topography. Please add references to this statement.

Fig. 11: Do these wind roses display the frequencies? The scale of the axis is different (between 30 and 50) for the different stations. Please make this equal.

Sect. 3.4 about wind: it is concluded that wind direction is not an effective factor to estimate the occurrence of blowing snow. But this is concluded while no comparison has been made with the local topography, because that surely influences the blowing snow.

Sect. 4: this section is called summary, but the study would strongly benefit from a discussion to place the results in a broader context and to be critical about its own results. A proper conclusion should follow the discussion.

L406: of course September has the least amount of blowing snow days, as there is barely snow in September (Fig. 10). This is not a proper conclusion or a new finding where the community can benefit from.

L418: snow event in terms of

L431: please provide a direct link to the data set

References:

Lehning, M., & Fierz, C. (2008). Assessment of snow transport in avalanche terrain. Cold Regions Science and Technology, 51(2-3), 240-252. https://doi.org/10.1016/j.coldregions.2007.05.012

Liston, G., Haehnel, R., Sturm, M., Hiemstra, C., Berezovskaya, S., & Tabler, R. (2007). Simulating complex snow distributions in windy environments using SnowTran-3D. Journal of Glaciology, 53(181), 241-256. doi:10.3189/172756507782202865