Response to Reviewer 1

General comments:
This paper presents a meteorological database of blowing snow events for the Col du Lac Blanc study site a high-altitude experimental site located in Grandes Rousses range (French Alps). In-situ observations are obtained in four different automatic weather stations located within the study site. Additionally meteorological information is completed with SAFRAN model reanalysis. It is also described the methodology for obtaining blowing snow events and the data obtained with this methods are included in the database. The dataset described in this article has a great potential for many applications for studying snow dynamics on mountain areas. For this reason the manuscript should be published. Nevertheless there are some issues that must be addressed before its final publication.

We thank Reviewer 1 for his insightful comments. We answered below to all his points. His comments are in normal font while our answers appear in blue. Changes made to the original version of the paper appear in blue italic.

Major points:

1.- I encourage to include a new section explaining and describing Blowing snow data and the methods used (this is, change section 2.3 to section 3), since this probably is the most novel part of the paper. This section must clearly state from which AWS are the data. Sometimes it is difficult to follow this. Moreover Table 3 must be divided. You first present results obtained in section 2.3.2 with the particles thresholds. Afterwards you present a new "Table 4" with results shown in the two last rows of Table 3 since you are using there same method to compare the occurrence of drifting snow. This will help to understand the table faster for potential readers. I also miss some discussion about the fact that in Figure 4, when less data are available (percentage of valid data derived from SPC) more quantity of snow is detected and a higher percentage of time detected particles.

Following the recommendations of Reviewer 1, we added a new section 3 dedicated to blowing snow data. The content of this section has been modified following the comments of the three reviewers (see our answers to their different points). In particular, we improved the description of the 2 sources of blowing data: empirical database of blowing snow events and SPC measurements. Table 3 in the initial version of paper has been split into two tables. We hope that this revised presentation will help the potential readers. Concerning the last point, the percentage of valid data derived from SPC provides a confidence index in data (it is now indicated in Figure 4's legend). For example if we record data during only one day with snow storm throughout the season, we will obtain a low percentage of valid data (1%) with a high percentage of time during which particles are detected by SPC-S7 (100%) and a high quantity of snow (an average quantity of snow transported between 0.2 and 1.2 m per linear meter during 30 days (q*30) is calculated from the quantity (q) recorded during one day). As conclusion, there is no direct link between percentage of valid data delivered by SPC-S7 (which includes periods with and without blowing snow) with percentage of time when snow particles are detected by SPC-S7 (which only includes periods with blowing snow).

2.- I have missed some information about the climatic characteristics of the study site. As authors say, the experimental site has been operationally used since 1988. I think it is really interesting to provide an overview of the climatology observed in this site. For instance it could be included the mean annual and winter temperature, number of days with snow presence in the automatic weather station with the longest dataset, total annual precipitation:

The site has been operationally used since 1988 but was initially only dedicated to experimental campaigns dedicated to blowing snow processes and no continuous meteorological record of sufficient quality can be used to derive climatic characteristics of the site from 1988 to present. In the revised version of the paper, we included in Section 2.1 (Site characteristics) information on the winter climate of the site using the data available in the database to compute them. The revised paragraph is written as follows:

"The Col du Lac Blanc (CLB) experimental site is located at 2720 m a.s.l. in the Grandes Rousses mountain range (45.13°N, 6.12°E, Fig. 1) in the central French Alps. The mean winter temperature (December-March from 2000 to 2016) at AWS Lac Blanc (Fig. 1) was -6.1 °C. The study site covers an altitudinal range between 2700 and 2800 m a.s.l and can be viewed as a natural wind tunnel due to its orientation and the specific configuration of the surrounding summits. Indeed, the Grandes Rousses range on the eastern side and the "Dôme des Petites Rousses" summit on the western side channel the atmospheric flow according to a North-South axis (Fig 1). This characteristic of the site is particularly useful for studies on the effects of wind on snow redistribution. Over the winter period (December-March) from 2000 to 2016, the mean wind speed at AWS Lac Blanc was 4.9 m s^{-1} with a maximum wind of 38.3 m s^{-1} reached on 28 January 2006. Wind speeds larger than 10 m s^{-1} were recorded on average 10.2 % of the time in wintertime. Snow is typically present on the ground around the site (Fig. 2) from late October to early June. The mean winter snow depth (December-March) from 2000 to 2016 at AWS Lac Blanc was 1.88 m and presents a large inter-annual variability with a minimal value of 1.28 m in 2001/2002 and a maximal value of 2.83 m for winter 2003/2004. …." ." (68 in the revised manuscript)

3.- If possible, I encourage manuscript authors to include in the database observations obtained during the whole study period and not only during winter period. This can be really interesting since can provide an evaluation of observations/model deviations on an annual time basis. Moreover I think that observations of the last two snow seasons 2016-2017 and 2017-2018 are quite valuable, so I encourage manuscript authors to, upload this information during the review process.

The Col du Lac Blanc experimental site has been designed to primarily focus on processes influencing the wintertime evolution of the snow cover. For this reason, continuous meteorological records are not available for the period outside the winter season. In particular, in summertime, instruments undergo revision and calibration (if necessary). SAFRAN outputs are provided during the whole study period to overcome this limitation.
We totally agree with Reviewer 1 that the last two snow seasons 2016-2017 and 2017-2018 are quite valuable. They will be available with the same doi as specified in Section 4. However we had not enough time to upload this information during the review process. The fact that the data acquisition at the site still continues is now also mentioned at the end of the introduction.

4.- The is mostly focused on data obtained with different environmental sensors. This way along the manuscript the model and the company (including a reference to their data) of sensors must be specified.
Sensors models and company are now specified in Table 1 in order to avoid repetition throughout the text.

Specific comments:

Line 15: Precise that "Grandes Rouses" is located in French Alps. Correction included.

Line 20: Precise the period in which the Snow Particle Counter acquired observations (2010-2016). Correction included

Line 28: Remove Gaillardet et al., 2018 reference. It is not appropriate to include a reference of an article submitted, even more if it is included in the abstract.
This article is now accepted. The reference for this paper was been removed from the abstract and is now included in the introduction.

Line 43: Maybe rephrase as: ": : :have joined their efforts to investigate the effect of wind transport on snowpack evolution." Correction included.

Line 44: "A high-altitude experimental site WAS set up: : :" Correction included.

Line 45: By inspection of Figure 2. I guess that the study area covers an altitudinal range of about 200-300m. Please include maximum and minimum elevations in the text.
The study area covers an altitudinal range of approximately 100 m between 2700 and 2800 m (Fig. 1c). It is now mentioned in the text.

Line 53-55: Change appropriately in regard to the major comment of including a new section for describing blowing snow data.
Correction included.

Line 60: Describe the locations of Grandes Rouses within the Alps and include the altitudinal range of the study site. We now mentioned in the text that the Grandes Rousses range is located in the central French Alps. Its exact location is shown on Fig. 1. The altitudinal range between 2700 and 2800 m a.s.l is also given.

Line 73: In table 1 and line 61, you provide the location of the automatic weather station on longitude, latitude; could you please also provide these coordinates on same coordinate system of the DEM available in the database?
The exact AWS locations are now also given in Table 1 in Lambert 93 coordinates, the same coordinate system as the DEM. We did not include them in the text when giving the general location of the Grandes Rousses range in lat/lon.

Line 130: Which is the "manual quality check" process? You remove outliers?
The procedure of quality control is now described for each variable in the revised version of the manuscript. Outliers were removed from the final datasets and replaced by nan values in the csv files.

Line138: Which young sensor? There are several products of this company. A Young 05103 wind monitor is installed at the AWS Lac Blanc. It is now explicitly included in Table 1.

Line 142: There is a final "." missed. Correction included.

Line 147: Include the company of PT100 wires. Correction included in Table 1

Line 149: You have already said that height changes during the course of the winter. Additionally you don't provide the snow free-height of these sensors. Remove this sentence.
As suggested by Reviewer 1, we removed the first sentence mentioning the changing measurement height during the winter. However, we decided to keep the second sentence since the snow-free height of each sensor is given in Table 1 (6^{th} column).

Line 152: Please, include model and company of the ultra-sound snow height sensor. I also suggest giving a small explanation about how these sensors work.
Model and company of the ultra-sound snow height sensors are now indicated in Table 1. The following sentences were added to describe how the sensors work:
"These sensors determine the distance to the snow surface by sending out ultrasonic pulses and listening for the returning echoes that are reflected from the surface. The time from transmissions to return of an echo and the speed of sound in the air are then used for obtaining the distance measurement. Since the speed of sound in the air varies with air temperature, a correction of the distance calculation is carried out using the air temperature measurements previously described." (L 152 in the revised manuscript)

Line 155: The surface area of the ultra-sound sensor observation may variate depending on snow height. Please clarify and quantify maximum and minimum surface area values.
We added the following sentence to quantitatively describes how the surface area observed by the sensor changes as a function of snow depth:
"The beam angle is 30° which gives an observed surface area of 8 m^2 for a sensor mounted at 6 m above a snow-free ground (the average sensor height at AWS Muzelle and Lac Blanc, Table 1). This

area decreases down to 0.9 m^2 when the snow depth reaches 4 m." (L 157 in the revised manuscript)

Line 157: Include the company of SHM30 sensor. The name of the company is now indicated in Table 1.

Line 164: In the abstract you said that you provided SAFRAN reanalysis and here it is said that you provide SAFRAN analysis. Please clarify.
We thank for Reviewer 1 for identifying this inconsistency. Since we provided outputs form the SAFRAN reanalysis, we modified the text accordingly.

Lines 164-176: I see quite interesting to include SAFRAN model outputs. If I am right, this is not a 2D model. Please explain how you obtain the data for Col du Lac Blanc.
Indeed, SAFRAN is not a 2D model. It is a meteorological application that uses a conceptual representation of the topography by elevation bands for specific mountainous area known as "massifs". The following sentences were added:
"They are available per 300-m elevation bands for areas known as massifs (23 in the French Alps) which were defined for their climatological homogeneity (Durand et al., 1993). To obtain SAFRAN data at the elevation of CLB (2720 m a.s.l), we used a weighted-average of the data from the Grandes Rousses massif for the elevation bands 2700 m and 3000 m." (L 170 in the revised manuscript)

Line 173: You say SAFRAN is considered as the reference precipitation in Col du Lac Blanc; however this is a model and could have errors. Please discuss this issue and provide an estimation of potential bias of this model (even if it is for a different study area) in the Alps.
SAFRAN is a meteorological analysis system which combines for each massif a climatological precipitation gradient with all the measurements of daily precipitation available in the massif using optimal interpolation. For the Grandes Rousses, in mid-winter, 6 stations are used for the analysis covering an altitudinal range between 1350 and 2350 m. The main sources of uncertainty in the precipitation analysis are: (i) the quality of the precipitation measurement potentially affected by wind under catch, (ii) the shape of the climatological precipitation gradient, especially at high-elevation where no station are used in the analysis. The precipitation analysis at the elevation of Col du Lac Blanc is affected by these two sources of uncertainties. Previous studies compared SAFRAN seasonal snowfall and measurements of winter mass balance for the St Sorlin glacier located in the Grandes Rousses range between 2650 and 3400 m (Gerbaux et al., 2005; Dumont et al., 2012; Reveillet et al., 2018). They reported an underestimation of SAFRAN seasonal snowfall ranging between 33 and 42 %. In the revised version of the paper, the section on the SAFRAN analysis has been rewritten as follows:

"SAFRAN data at CLB are provided for all the meteorological variables required to run continuously a land surface model at CLB without data gap for the entire time period.. SAFRAN data includes 2-m wind speed, 2-m air temperature and humidity, incoming longwave and shortwave radiation and snowfall and rainfall amount at an hourly time step. Using SAFRAN data for driving a land surface model at CLB requires accounting for several limitations of this dataset, in the interpretation of the results, especially for solid precipitation and wind speed and direction. Directly measuring solid precipitation at CLB has been abandoned for several years, because of the strong undercatch under windy conditions (e.g. Kochendorfer et al., 2017) which could not be addressed adequately in-situ. Instead, SAFRAN data are used for solid precipitation, which uses observations at neighboring sites.
Note however that the accuracy of the SAFRAN precipitation data is known to be limited at high elevation such as CLB, because of the restricted number of stations incorporated into the analysis above 2000 m (only 2 in the Grandes Rousses range) and the potential influence of wind undercatch at these stations. Gerbaux et al. (2005), Dumont et al. (2012) and Reveillet et al. (2018) compared SAFRAN total solid precipitation amounts at the annual scale and observed winter mass balance of the St Sorlin glacier (2650 m -3400 m) located in the Grandes Rousses 5 kilometres away from CLB. They found an underestimation of SAFRAN winter precipitation ranging between 33 and 42 %. At CLB, the underestimation is expected to be less since glacier are generally preferential accumulation areas for a given elevation.

Wind speed is generally underestimated by SAFRAN CLB due to the influence of the surrounding topography which is not included in the conceptual representation of the topography in SAFRAN. It is recommended to replace SAFRAN wind speed and direction by the observations collected at CLB when running a land surface scheme at CLB, as described in Vionnet et al. (2013).”

Line 195-204: These sentences are difficult to follow, please rephrase. For instance when you say: “Positive values of the difference: : :.” I think you are describing the method you refer before as “This indirect method: : :” but this is not clear.
This part of the paper has been rewritten to be easier to follow:
« Periods of ground snow transport were then identified at an hourly time step from an analysis of the recordings from the snow depth sensor. Positive values of the difference between the maximum and minimum snow depth recorded over an hour and associated large values of its standard deviation are characteristic of the presence of snow particles between the sensor and the surface of the snowpack. Snow particles in motion above the snowpack surface create indeed interference in the ultrasonic signal. This indirect method to identify blowing snow occurrence was developed and tested over fifteen years of observations at Col du Lac Blanc. » (L 212 in the revised manuscript)

Line 203: How did you complete the analysis for the period 2000-2004 without the webcam? Maybe you could explain that the results obtained for the period 2004-2016 were evaluated with a visual inspection of webcam images.
The sentence has been modified based on the recommendation of Reviewer 1:
“The results obtained for the period 2004-2016 were evaluated with a visual inspection of webcam images, in particular to improve the identification of blowing snow events with and without concurrent snowfall.” .” (L 218 in the revised manuscript)

Line 204: Change “recorded” by “included”. Correction included.

Line 225: Why 917 kg m^{-3} density value?
The snow particles blow as rounded grains, not snowflakes. Indeed, the saltation process will quickly round the edges of original snow crystals and the grains become well rounded and are assumed to be spherical. The accuracy of mass flux measurement depends on blowing snow characteristics. Thus the particle density is set to the ice density and is equal to 917 kg m^{-3}. Blowing snow accompanied by snowfall contains not only spherical particles but also variously shaped particles including snow crystals and snowflakes, and its size distribution extends to a larger range.
Explanation is now included in the revised manuscript *(L 245 in the revised manuscript)*
“They blow as rounded grains, not snowflakes. Indeed, the saltation process quickly rounds the edges of original snowflakes and the grains become well rounded and are assumed to be spherical. The accuracy of mass flux measurement depends on blowing snow characteristics. Thus the particle density is set to the ice density and is equal to 917 kg m^{-3}.”

Line 228: Here you use the acronym SPC and not anymore SPC-S7s as you did before. Please be consistent along the manuscript when you refer to this device.
The term “SPC-S7” is now used throughout the text.

Line 240: Include A, z and m values you used to estimate mean horizontal flux and its vertical interpolation.
All available data (i.e. at different heights z) are used to estimate the mean horizontal flux at 1-m and its vertically-integrated value. A and m are not constant over time and are calculated at each 10-min time step. It is now specified *(L 265 in the revised manuscript)*

Line 220 and 238: include a reference for mathematic equations (1, 2: : :). Numbering included.

Line 251: I guess this is the power law you introduce in line 238. Use a number to refer this expression. Correction included.

Line 263 to 264: When you present “kg” of snow, specify that you are showing snow mass transport variable.
We are not sure to clearly understand the comment and we replace “quantity of snow transported” by “blowing snow transport quantities….”

Line 266: “: : :to keep in mind that SPC, which detects each particle, is able to: : :” Correction included.

Line 267: This is discussed in next section in several paragraphs: Correction included.

Line 278: You already showed the 50% if time and the 6245 kg of mass on previous section. This is redundant. You can remove it here. It has been removed.

Line 291: I guess these conclusions came from table 3 since Figure 4 does not show the empirical method. Remove Figure 4 reference.
Correction included

Line 299: I find quite surprising that the occurrence of wind-induced snow transport is closer to 30% of the time. Has been shown this value before? Where?
It is not so surprising if we consider that snowfall events with light wind are also recorded by the SPC. Higher transport frequency with seasonal variation have been observed in Adélie Land (Trouvilliez et al., 2015 http://dx.doi.org/10.1016/j.coldregions.2014.09.005)

Line 301: You mean the empirical method with SPC data? Please clarify.
Empirical method systematically refers to Empirical database of blowing snow occurrence. In the new version, we used the same name throughout the text to avoid confusion.

Line 316: Include mean snow depth value during the 2010-2016 time period.
It is now included in text:
“The mean snow depth value during the 2010-2016 period was 1.99 m.“ (L 349 in the revised manuscript)

Section 4, data availability: The database must include a metadata file for each AWS that includes all variables of each file, their units and the location of the station. Moreover I think it is not necessary to include the doi of each single station, for SAFRAN reanalysis and for the DEM all these links can be easily found following the link: http://doi.osug.fr/public/CRYOBSCLIM_CLB/CRYOBSCLIM.CLB.all.html
It was already done in the original version but not easy to find if the reader use only the link http://doi.osug.fr/public/CRYOBSCLIM_CLB/CRYOBSCLIM.CLB.all.html as suggested by the reviewer. That’s why we prefer to include the doi for each single station. But we fully understand reviewer’s viewpoint and for greater clarity, dois are now presented in a new table (Table 4).
The metadata are clearly described when accessing the doi for each dataset and includes the variables of each files, their units and the location of the station.

Concerning the DEM, it must be provided DEM on a single file and not in 14 separate files. The research group knows in detail the study site characteristics and any incoherence coming from alignment errors of the separate files can easily be detected, what it is not the case for potential users of the DEM. If necessary the spatial resolution of the DEM can be reduced to 0.5 m or 1 m grid cell size. X, Y and Z units and column names must be included in xyz files. Also a metadata diles of the DEM must be included.
The DEM is now provided as a single file with a spatial resolution reduced to 1 m to be easy for the user. The metadata for the DEM are described when accessing the corresponding doi.

Figures and tables:

Figure 1: Please include in c) panel the “Dôme des Petites Rouses” triangle and the point that marks “Col du lac Blanc” from b) map. I also encourage manuscript authors to draw dashed lines on c) map showing the area covered in picture of Figure 2. This would really help to potential readers to understand the characteristics of the study site.
Figure 1 has been modified following the recommendations of Reviewer 2. We also include the following suggestions made by Reviewer 1. The “Dôme des Petites Rouses” triangle is now shown on map c) whereas the point that marks “Col du lac Blanc” has been removed from map b). Instead, the location of the four AWS is shown on map b). A blue dashed line depicts the approximate contour of the area covered by the picture shown in Fig. 2. The legends of Fig. 1 and 2 have been modified accordingly.

Figure 5: I guess that the different circles of wind roses show the frequency of the different events. Please clarify.
The different circles shows the frequency and the values of frequency are given on the graph.

Maybe it is more interesting to provide the wind rose for AWS Col (same of (b) wind rose) since you are showing the fluxes obtained in this station.
The wind rose for AWS Col is now provided and is consistent with the rose showing blowing snow fluxes.

Table 2: Please group first column when same station is described. It will be easier to understand the table.
In the revised version of the manuscript, we merged Table 1 and 2 as recommend by Reviewer 2 and group the first column when the same station is described.

Table 3: For the second column of the table, put “Threshold” in the first cell and not for each single cell. Units of the different variables are not appropriately included; in some cases the occurrence of drifting snow presents the%in others not. Similarly Kg of snow mass transport are not provided. Please be consistent along the table. Moreover there is a mistake and the 2p/cm2/min threshold is a 20p/cm2/min threshold as introduced in line 248. In the last row of table 3: You say that it is shown the “Total quantity of snow transported” however I think it is the occurrence of drifting snow. Moreover I see a bit confusing that you show in this row the results obtained with the method presented in section 2.3.1 with the SPC data without introducing this before.
The new section 3 has been rewritten and all the comments suggested by Reviewer 1 taken into account.

Supplementary material: Line 20: Remove one “of” right before 500*500.
Sentence has been removed.