

Review of:

**Title: Saharan dust events in the European Alps: role on snowmelt and geochemical characterization**

My recommendation

**Major revisions** due to general and specific comments listed below.

The authors investigate the input of mineral dust (MD) on the geochemistry as well as the impact on snowmelt in the Aosta Valley, Italy at 2160m a.s.l. within the accumulation periods 2013/14, 2014/15 and 2015/16. The study investigate the evolution of snow melt off via in-situ observations, digital images, AWS data and modelling. Besides the investigation of a snow darkening index representative for MD on the snow surface, a geochemical characterization from MD affected and non-affected snow was presented as well. Authors observed a shortening of the snow season, concluding that MD accelerate snow melt-out dates.

The addressed topic is of interest for the Cryosphere community, but also for the climate modelling (e.g. surface albedo feedback) and remote sensing community (e.g. validation and calibration of satellite images).

General comments:

My major concern is the structure and the “red line” throughout the manuscript. The manuscript suffers from many repetitions and the text does not account to the corresponding headline. Therefore it is very hard to read and needs a lot of scrolling to other passages to follow the “story” behind. It would be of much help for the reader and hence also of much more interest if this would be revised and shortened rigorously (therefore major revisions). Authors should think of splitting the results from the discussion into separate section. The manuscript might get a bit more reader-friendly. Besides, citations seem to be sometimes randomly used whereas they are missing at points where there should be a quote. Authors should cite from recent to past or vice versa, but consistently throughout the manuscript. Details on the general comments raised above can be found in the specific comments below.

Specific comments:

P1 L18 change “snowpack in a...” to “snow packs at a...”

P1 L28 ff Aren't these the results from the comparison of Crocus model results without impurities vs. observations? Otherwise to which reference do the values of 38 days etc. refer?

P1 L34 Include also the importance on snow albedo feedback

P2 L7 remove sentence “These phenomena...”

P2 L13 “...dust lowers THE snow albedo...”

P2 L16 ff Which citation refers to which statement? One reference used twice in one sentence – maybe rewrite the sentence

P2 L22 remove “s” from “century<sub>s</sub>”

P2 L30 maybe also include Greilinger et al here

P2 L34ff remove “of the planet”, change “Thanks to..” to “Due to..”

P2 L40 "...precipitation and HENCE dust scavenging..."

P3 L40 define LAPs here

P4 L11ff "...was installed in 2009 measures air temperature (HMP45, Vaisala Inc.) and snow height (ultrasonic sensor SR50A, Campbell Scientific Inc.)."

P4 L18 – P5 L2 belongs to introduction

P5 L3 Include new subsection 2.2 RGB images or digital images or similar

P5 L6 rephrase "...and the same view scene was repeatedly captured" What would you like to say?

P5 L7 ..."format WITH a resolution of...AND three-color channels (red, green, blue)..."

P5 L9 Just as suggestion, it is always nice to refer to UTC. If you use local time, please specify time zone.

P5 L16 "Following Di Mauro et al. (2015) and Ganey et al. (2017) SDI was correlated...distribution of deposited impurities ~~from space~~..."

P5 L17 What do you mean with "and from hypospectral imagery of ice cores"?

P5 L24 "using THE SURFEX..."

P5 L25 "...estimation AS WELL AS numerical..."

P5 L28 "...and mass transfer between the snowpack and the atmosphere as well as the snowpack and the ground..."

P5 L31 "...snow properties, LAPs concentrations and..."

P5 L33 "...and accounts for...and impurities such as dust and black carbon."

P5 L34 "...TARTES was used to calculated SDI..." How was this done?

P6 L15 "...a few meters apart from the AWS."

P6 L16 "...from a pit at depths of..."

P6 L18 remove "successive"

P6 L20 "...particles between 2 and 60µm (equivalent spherical diameter)."

P6 L22 reference why you use 2.5G/cm<sup>3</sup>, Why exactly this number?

P6 L25-P7 L17 could be shortened, many passages not necessary. It is the Data and methods section!

P7 L23 "...in 'strong' events with dust deposition fluxes...and 'weak' events with lower concentrations."

P7 L36-P8 L2 removes paragraph, it is the Data and methods section!

P7 L10 remove first sentence

P7 L11 "...variables observed at Torgnon station and simulated with the Crocus model using..."

P8 L15 "In Figure 3d ..."

P8 L16ff Remove sentences "Strong and weak..." as well as "ALADIN CLiamte..."

P8 L17 You found a good agreement between the qualitative information, but how about the quantitative?

P8 L27 Please be more explicit why results before explain the large different in snow melt out dates.

P9 Figure3 I personally have difficulties to read and interpret Figure 3d and especially Figure 3e. Maybe explain in more detail in the text (and/or legend) what is the shaded area and what is the colored (reddish, yellowish) area?

P9 Table1 It would be also nice to show the correlation with the Crocus model without impurities

P9 L12 "...8.5µm for snow samples collected at 20cm and 40cm depth, instead..."

P9 L15 Remove the sentence "At the bottom..."

P9 L16 Authors say that results are comparable with other studies. Please give some numbers what others found, not only the citation.

P9 L17 "Samples shown in..."

P10L8 – P11L27 Please work through the whole section. Parts of the text are already mentioned before, conclusions drawn here are not obvious for the reader. Where exactly do I see the marked change in snowmelt rate and the induced earlier snowmelt in Figure 3e? Here you also mention already some conclusions. It is the Results and discussion section!

P13 Figure5 "...data are also shown (black line)."

P13 L10 "In the upper part of Figure 6 ..."

P14 L1 "In the lower part of ..."

P14 L5 Why are you sure that the red line is IN the pit? Couldn't this be also a shadowing effect of e.g. an uneven surface? Why should the February event be visible only in the area of the pit?

P14 L14 Which non-linear model? Explain and describe the model of Di Mauro et al. 2015 shortly.

P14 L24-L31 repetition and extensive discussion (maybe start a separate discussion section related to the sections in the results.

P14 L32- P15 L2 Belongs to the introduction

P15 L3-L7 is an outlook, move to summary

P15 L8-L18 another discussion block

P15 L20-L26 move to introduction

P15 L27 “The analysis of the elemental composition allowed...”

P15 L28 Is the threshold of definition of major and minor components referring to > or < than 1% of the average crust composition set by the authors? Reference?

P16 Table2 state somewhere in the legend or in the plot that SH1 is the dust affected and SH2 the clean snow! This would help the reader. Otherwise readers have to go back to the Methods section to check this. What are the value in the brackets? Why are some elements given in % mass fraction and others in µg/g? This makes it difficult to compare.

P17 L1 “Concentrations of major elements normalized to the upper continental crust composition are shown...”

P17 L9 “...see in Figure 7c.”

P17 L13 For Fe this is even more than 30 times if I am not mistaken.

P17 L23 remove the sentence “This is related to...” This is discussed again few lines below

P17 L27 remove “not with the first one”

P17 L35 Actually it is not the Ca which is affecting the pH but the related Carbonate! Include here the Carbonate discussion from L23

P17 L37 remove the bracket

P17 L35-P18L3 maybe rephrase the whole paragraph, difficult to see what the authors like to say

P18 Figure7 What is the y-axis in Figure 7b? Remove the sentence “They are intended here...” from the legend. Remove “..., presenting anomalously high normalized concentrations;” Remove everything after “...listed following...” What is meant with “incompatible elements (with respect to Fe)? Indicate here also the nomenclature of SH1 and SH2 to be consistent throughout the manuscript.

P18 L16 include sentence “They are...” already in the first sentence of the paragraph in line 13.

P18 L23 Remove the sentence “Given the position...”

P19 L1-L10 repetition to earlier passages

P19 L12 What does this “incompatibility degree with respect to Fe” reveal? Why use this measure?

P19 L13 Remove the sentences “As in the case...” until “low normalized concentrations.” Repetition!

P19 L33 The content of the next section is not a conclusion but a summary! Please set the conclusion you draw based on your work more explicitly.

P19 L38 “...11days, respectively.”

P20 L3 See also <http://www.aagr.org/article/detail/AAQR-18-03-ACPM-0116> to confirm the Sahara dust event. Include citation.

P20 L9 But the fingerprint of the local sources plays also a role. Please state this here in the text.

P20 L20 Maybe you find something in here <https://onlinelibrary.wiley.com/doi/abs/10.1034/j.1600-0889.49.issue1.4.x>