

Reply to reviewers' comments on "History of desert dust deposition recorded in the Elbrus ice core" We would like to thank both reviewers for their comments that help us to improve and clarify the manuscript.

Please note that this is a companion paper of another manuscript submitted to ACP <https://www.atmos-chem-phys-discuss.net/acp-2019-402/> Preunkert et al., "The Elbrus (Caucasus, Russia) ice core glaciochemistry to reconstruct anthropogenic emissions in central Europe: The case of sulfate."

Some additional text was added to this manuscript as suggested by the reviewer of the Preunkert et al. paper (see section 4.3). Figure 5 was changed following the recommendation of one of the reviewers as well.

Reply to

Anonymous Referee #2 (RC2) Received and published: 2 July 2019

This paper presents a very interesting dataset from a deep ice core extracted from Elbrus in 2009. Several variables are measured and the record shows interesting trends in dust deposition in the Caucasus. The paper is generally well written and fits the aim and scope of ACP. I suggest it can be published after some minor revisions mainly related to the structure of the paper. In fact, often results and methods are mixed together. More details on the statistical data analysis should be added in the Methodology section. Hereafter, my specific comments on the paper.

pg1-ln23 Please define the acronyms (PDO, SOI)

Done

pg1-ln25 Further information regarding anthropogenic activities will be helpful here

If we understand correctly the reviewer asked to provide more details on whether the anthropogenic activity contributed to the increasing trend of Ca²⁺. Text was revised. Sentence added "It was shown that the increase of Ca²⁺ concentration in the ice core cannot be attributed to human activities, such as coal combustion and cement production."

pg2-ln4 Please add some references and examples regarding the usage of satellite data for dust monitoring

references added (e.g. Chudnovsky et al., 2017; Gautam et al., 2009; Li and Sokolik, 2018)

pg2-ln15 please correct: "proxy data are fundamental"

done

pg2-ln26 please correct: "the caucasus is a natural trap"

done

pg2-ln28-29 not clear, please rephrase

Changed to «The absence of melt water infiltration near the summit of Elbrus ensures the preservation of a climatic record in an ice core.»

pg3-ln18-21 This is more an "abstract-like" sentence. I don't think is necessary to introduce the results in this Section

Accepted. Moved to section 4.1

pg4-ln1 here is not clear how you separate winters and summers, please add details

The details of ice core dating are provided in the next section. (3.2.). We moved the paragraph about the sampling resolution to this section.

pg4-ln10 "Dating the ice core"

Done

pg4-ln15 Remove "Susanne" from the reference

Done

Section 3.3 I think that this section should be reshaped. Important methodological descriptions are introduced here, but they are mixed up with the results. This does not help the reader. I suggest to move all the methodological information to Section 3.1 and to create a new paragraph in Section 4 where the authors introduce the structure of their results.

Taken into account. We removed this section and moved part of the text to Section 4. The second paragraph was deleted.

p5-ln31 here other impacts of dust in the cryosphere should be mentioned. For example the impact on snow and ice melting through snow-albedo feedback (see. Gabbi et al. 2015 Cryosph.; Di Mauro et al. 2019 Cryosph.)

Taken into account.

Following sentence was added: Deposition of light-absorbing impurities (in particular, black carbon and dust) plays an important role in changes of the snow and glaciers and may enhance the response of the mountain cryosphere to climate changes via snow-albedo feedbacks (Gabbi et al., 2015; Ginot et al., 2014; Mauro et al., 2017; Skiles et al., 2018)

pg6-ln13 are there other studies focusing on these peaks? If yes, please add some references.

We're not aware of other studies of these dust peaks in Caucasus. Comparison to other records are presented in section 4.5

pg6-17 the trend analysis should be described in the Methods. Further details on the statistical analysis should be added. How the authors checked the significance of trends? They used a parametric or non-parametric methods?

Taken into account. For correlation analysis we used Pearson's correlation and correlation significance was checked using a t-test. The t-test has been also used to quantify the significance of linear trends. A new section (3.3) on climate data analysis was added.

pg6-ln28 here the authors may reference to recent large dust transports happened in spring 2018.

Accepted. the sentence was added «Recent major long-range dust outbreak event over North Africa, eastern Mediterranean, and Caucasus occurred on 22 and 23 March 2018 (Solomos et al., 2018)».

pg7-ln28 here the authors should briefly describe the possible impact of this increase of dust concentration. For example, earlier snow melt at lower altitude, (more) negative mass balance of glaciers, higher frequency of avalanches etc.

Declined. This topic is out of the scope of this paper. We do not calculate and radiative forcing neither discussing potential impacts of dust on snow and glaciers. This needs a separate detailed study. Answering to the previous comment a sentence was added to the section 4.1. "Deposition of light-absorbing impurities (in particular, black carbon and dust) plays an important role in changes of the snow and glaciers and enhance the response of the mountain cryosphere to climate changes via snow-albedo feedbacks (Ginot et al., 2014; Gabbi et al., 2015; Di Mauro et al., 2017; Skiles et al., 2018)."

pg7-ln28 is this increase reflected in ERA-interim data? Please add details on it. ERAinterim data are referenced only in the caption of Figure 9. Please add details on how and why you used this dataset.

Done. Text revised. A new section (3.3) on climate data analysis was added.

pg8 ln2: add a comma after Sahara.

Done

pg8-ln12 add this in the methods. How it was calculated, from which data? SPEI 3 was the most correlated with Ca²⁺, you tried other indices? why the average of three months results in a higher correlation?

Text was revised. A paragraph was added to the new methodology section 3.3.

The Standardised Precipitation-Evapotranspiration Index (SPEI) was used as a drought proxy (Vicente-Serrano et al., 2010). It was showed that this index is preferable among the other drought indices to investigate the relation of dust emission to droughts (Achakulwisut et al., 2018). We considered SPEI calculated over 1, 2, 3, 6 and 12 month. The time series of SPEI were obtained by averaging over the regions of interest.

We only report the highest correlation which was found for the SPEI3. We can only speculate that the persistent drought for three months may result in a higher dust emission. But this is rather bold statement. All the drought indices show an increase in dryness of the regions. Which is our main message.

pg8-ln33 "number of days", of what?

Noted. The number of dust days

pg9-ln12 not clear. Please rephrase.

Done

pg9-ln22-23 these indices were never introduced. Acronyms are not defined. Add this information in the methods section. Describe why you selected those indices.

Section 3.3. was added to the methods. Description of the data used added.

pg10-ln26 Add brackets to "Dai (2011)"

Done

pg10-ln26 Define SST

Done

References: De Angelis and Gaudichet 1991, De Angelis et al. 1997 and De Chatel 2014 are not listed in alphabetical order, please correct.

Done

Figure 1: This map needs a legend. Colors are derived from hysplit backward trajectory but they are not clear to the reader, who cannot interpret them without a legend. I suggest to create a new figure with a clear evidence of possible dust sources. Furthermore, a map depicting the location of the drilling site on Elbrus could be useful.

Taken into account. Figure 1 was revised. We don't see the necessity in adding the additional figure since the location of Elbrus is shown on Fig. 1.

Figure 2: describe in the caption what's in the different panels

Done

Figure 4: delete "RAW DATA" from the legend. Please mark the zoom the in upper

Done

Figure 7: please add the labels to both plots

Done

Figure 10: is this a piece-wise regression? How the authors identified the break? This is important since the detection of the break strongly influences the correlation they show with SPEI. Here the authors show the Pearson's coefficient r , whereas in Figure 7 they show R^2 . I suggest to use R^2 across the whole manuscript.

Taken into account. SPEI data are available from 1901. The linear trend for the Ca²⁺ data was calculated for the same period.

We tend to decline the reviewers suggestion to use R^2 across the manuscript. Since we present the strength and the direction of the linear relationship between two time series the r is a common choice. r is a common measure of similarity between time series. On contrary R^2 is normally used to

show how well the model follows the data. On figure 7 we report the scatterplot and linear regression of two chemical species and so R^2 is commonly used for such plots. We do not see inconsistency here.

References:

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