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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Ancient versus modern mineral dust transported to high-altitude alpine glaciers evidences saharan sources and atmospheric circulation changes" *by* F. Thevenon et al.

F. Thevenon et al.

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General comments The study of paleoclimate, and aerosol in this, and mineral dust specifically, is most useful to the community as well as interesting to read about. Thevenon et al. have done a proper analysis of the dust in CG ice core CG03. Some of their main conclusions are that the major dust events reaching the western Alps have been of saharan origin during the last millennium. Furthermore, that the last century has had larger dust depositions, due to changes in circulations patterns. I find that the laboratory work appear well performed, and that many conclusions are probable. How-

ever, the way that some of the text is written, and the way that the argumentation for some conclusions is done require more attention for a correct scientific text, as defined by ACP "Evaluation Criteria". Furthermore, as some conclusions are more solid than others, I would much appreciate if the authors detail the conclusions that are, based on their data, suggested wording: "further work will investigate...", "speculation", "an hypothesis can thus be formulated..." i.e. not-so-sure, as a help for the reader. Below follows the examples on these points in detail, and minor spelling corrections. I hope sincerely my comments will be a help to improve the quality of the article to even better.

Specific comments The title: - "evidences". Is this the properly chosen word here? It implies a much stronger meaning than the analysis in the paper shows, in my opinion. Contrast with this alternative formulation "Ice-core data during the last millennium shows mineral dust deposition from mainly saharan sources, changes can be attributed to circulation variability".

Reply: Changed to “reveals Saharan sources and long-term atmospheric circulation changes”

- At least I would require the title to define the time-frame. The dictionary has several meanings on "ancient", so the reader is not well-served (one being for instance "the earliest known civilizations and extending to the fall of the western Roman Empire in a.d. 476").

Reply: “over the last millennium” added in the title

Abstract: "...did not change significantly..." Could you please quantify that in some way? For instance by showing the percentile required to encompass the modern JFJ samples with the CG samples (and by choosing maybe the worst case of the most important parameter - or a combination of parameters (Nd and/or Sr , palygorskite, kaolinite/chlorite ratio etc ?)). Perhaps detail such an evaluation in the results section?

Reply: The sentence was “Isotope signatures demonstrate that the Saharan origin of

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the mineral dust transported to Alpine glaciers did not change significantly throughout the past centuries". This is a broad geographical indication, without any quantitative aspect. Figure 1 gives an idea of the variability of the source areas and the atmospheric transport for the few JFJ dust events. In addition to weathering/transport influence, the geochemical compositions of the geological sources are complex (Moreno et al., 2006).

"nort-central to north-western" is this a standard formulation for Sahara? Otherwise an alternative could be north-western quarter or similar?

Reply: "north-central to north-western part of the Saharan desert" is a geographical indication that corresponds to the sources of dust evidenced in Fig. 1.

"began ca. 20 years" This is difficult to understand. Is the date important, 1870? in that case write 1870 and remove the part "after the industrial revolution...". Is it important that is is exactly 20 years after? Is the industrial revolution what matters and 1870 not so much? The conclusion that the circulation changes depend on the industrial revolution 1850 (where? how?) is not very convincing, at least not in the way it is currently formulated in the abstract now. Please rephrase lines 15-20, into shorter sentences. Or do you mean, for instance, that the mineral dust deposited in the Alps is not mostly of a direct anthropogenic source the last century - but that is to most readers quite obvious?

Reply: Discrepancies between anthropogenic BC (increase about 1850) and natural mineral dust (increase about 1870) indicate two different processes and sources of insoluble particles, and that the excessive coal combustion (that produces minerals) at those times did not over exceed natural dust deposition. Changed to "Sustained high dust deposition, with larger mean grain size and Saharan fingerprint, began about 20 years after the Industrial Revolution in continental Europe (around 1850), suggesting that increased mineral dust transport over the Alps during the last century was primarily due to stronger spring/summer North Atlantic southwesterlies and drier winters in North Africa, rather than to industrial sources".

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1. Intro p 862 l 6: "documented Saharan dust sources" How? I suppose you mean by the XRD (table 2)? It would be beneficial to state here.

Reply: Changed to “potential dust source areas and polar ice core records”. The dust characteristics encompass the mineralogy, elemental and isotopic composition (Sr and Nd).

- It would be beneficial to explain specifically which samples from JFJ were deemed to be of Saharan origin and how they were evaluated in the results or methods section.

Reply: The backward trajectory analysis has allowed to identify the Saharan origin for most of the JFJ samples. The results are presented in Figure 1 and summarized in Table 3.

3.2 Should not the equations be numbered and improved in formatting?

Reply: Equations are numbered for each spectrum (e.g., CG 1780), as a function of the intensity (Y axis) for the different peaks of selected minerals (mica, kaolinite, chlorite), with the same nomenclature than Figure 4. Results are expressed as ratios. We choose this semi-quantitative method because most of the samples contain small amount of dust.

This section should be expanded on, perhaps you can explain a bit more thourough the methodology, and include relevant references.

Reply: More details about this method can be found in Adatte et al. (1996), reference added.

See comment on fig.4 below. 4. Results

p 865 l 17: Higher EFs for Pb and Cs U are indications of anhtropogenic influence according to that section. This must be detailed, and shown specifically for what time-frames, and be compared with also atmospheric as well as the crust concentrations (EF).

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Reply: This part has been removed

p 866 l 20-24: The text states the similarity between Saharan dust in literature and the analysis shown from the paleodust, for "dusty"layers with Dp > 1.5 _m, concerning the Sr and Nd. - The authors need to show the dusty layers more easily to the reader (as well as the "light-colored" the authors mention later). When I draw a line through 1.5 _m, in figure 2 panel "mean mineral size" ,and read the corresponding time periods for events larger than this, would that be ALL dusty layers?

Reply: “the dusty CG ice-core layers (>100 mm2 of dust/kg)” are shown with filled circles and the “light-colored layers (<30 mm2 of dust/kg)” by empty circles, as a function of their isotopic composition on Fig. 3. The information about the size comes from Fig. 2. We changed the value to 1 um in the text, which encompasses all the dusty layers (>100 mm2 of dust/kg).

In lines 24 and the next paragraph you try to explain this. But it becomes slightly confusing: perhaps "saharan dust samples analyzed in literature" should be inserted in line 18-19?

Reply: Changed to “African dust sources analyzed in the literature”

Then, on p 867, l 1-5 you write that the conclusion for the reason to lower Sr last century is "intercontinental dust background properties ... and/or anthropogenic". Here the conclusive wording is not warranted, I would advice to formulate a hypothesis and to work to verify that with more data onwards.

Reply: We hypothesis that dilution and low accumulation time may explain the depleted geochemical values (e.g. Sr) in depleted dust core-sections of CG and in short-time deposited samples at JGF research station, respectively. Concerning the anthropogenic impact, we added a correlation diagram on Figure 6 showing the negative correlation (r2 = 0.4) between changes in Sr isotopes ratios and EFPb after 1910.

Then on p 867 l 5-13 the authors write that the aerosol surface area correlate positively

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with Sr, as well as with the "dusty layers" (fig 6). - Please mark and define the "dusty layers" for a reader to identify. - Moreover, it is not always the case that the surface area correlates with larger particles (for instance from fig 2 year 1690 and 1660 they anticorrelate), and it is possible that the surface area is generated by smaller numerous particles. Has this been considered?

Reply: The sentence was “Fig. 6 plots the aerosol surface, and the mica and chlorite contents against 87Sr/86Sr values to illustrate changes in the Sr radiogenic composition with increasing aerosol deposition and clay characteristics. Higher 87Sr/86Sr ratios are found within the dusty layers...” . In this context, the generic term “dusty layers” makes reference to samples enriched in dust, i.e. the higher aerosols surface represented on Fig. 6. In this figure 6, we choose to separate the samples as a function of their deposition time (pre- and post- 1910), not as a function of their size. Fig. 3 gives an idea of the variation of Sr with the dustiness. - p. 867 l 5-13 was making reference to the general correlation shown on Fig. 6. We agree, when the surface area do not covary in Fig. 2 with larger particles, it is because the surface area is generated by smaller numerous particles; and the grain size may influence dust mineralogy and chemistry (Moreno et al., 2006).

Furthemore I have difficulty in finding how the surface area for the ice core samples are measured, and it would be proper for the reader to see that, as that connects the linear x-axis of the top panel (JFJ) with the bottom log-scale (ice core) for panel "PM10 / total aerosols" in fig 2!

Reply: This axis has been reported on Fig.2

The above mentioned section is: hard to read and to understand much due to the structure. Many figures are referenced all at once. Perhaps readibility, and the arguments, and following conclusions would be easier, if each figure was introduced with proper explanation sequentially? fig 2 - fact; fig 3 - fact -literature; fig 4 - fact - conclusion etc.

Reply: The paragraph “4 results and discussion” has been restructured in different

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parts that facilitate the reading. 4.1 Trace element, 4.2 Mineral, 4.3 Sr/Nd, etc. However, it is true that the figures are showing complementary, but also similar information that allow to demonstrate the Saharan origin for JFJ and CG samples. For instance on p.8: “the geochemical and mineralogical composition of the dust deposited at CG during the last centuries are quite similar to the composition of the dust collected in 2008 and 2009 at JFJ (Fig. 2, 3, 4 and 5), suggesting an overall similarity in aeolian dust sources through time”. There is no redundancy or confusion here, but a similar conclusion that can be inferred from different figures and proxies (trace elements, isotopes, Xray diagrams), supporting our interpretation.

p 868 l 12-24: This is a very interesting part of the paper, and could with advantage be expanded on with a few sentences explaining to a less specialist reader...this is the part of the paper where the shown results actually connect with the circulation. My comment is simply; it is based on the assumption from one paper Kang et al 2003. How sure where they, and on what timescales, as you compare periods of a hundred years or less?

Reply: The paper of Kang is cited because it presents “dust records from three Northern Hemisphere ice cores (Alaska, Himalayas, and Greenland)...reveals consistent relationship between atmospheric circulation patterns and the long range transport of mineral dust”. However, mineral dust from ice cores is broadly used to reconstruct atmospheric circulation pattern. In this paper, we do dot expanded this part, because this thematic is discussed in my former manuscript (Thevenon et al., 2009), based on the total aerosol surface and grain size. However, the new results of this paper which demonstrate the Saharan origin furthermore confirm the importance of SW winds and atmospheric circulation patterns. It is important to understand that the relatively low resolution of the present record does not allow to reconstruct seasonal reconstruction as in Kang et al., but longer term variations and trends.

Technical corrections Table 2 and 3 - a reader would appreciate to have also the sample names (64, 66, 68,70 : : : E, F, G: : :) in these tables.

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Reply: Sample names have been added to tables 2 and 3.

Fig 3. I cant separate the sample 1200-1300 AD from the yellow box named N and W African sources in the print-out. Where is what? They are BOTH circles with a cross in?

Reply: The sample 1200 to 1300 AD is represented in Figure 3 and in the legend as a black circle with a cross in. Its isotopic fingerprint fits with those from N and W African source, Sahara dust in Atlantic sediments, and Sahara dust collected in Caribean.

Fig 4. From that data (top panel) it appears as if P is present at JFJ (although the peak is not labelled)?

Reply: P added on (top paned) Fig. 4.

And a question on method: is it even remotely possible that in the lower panel, that the peak labelled Micas 003 could be actually Quartz 101?

Reply: There is Quartz and mica in this sample, and the peak of quartz comes before the mica. The particularity of this sample is the great abundance of mica, which is visible by its different peaks (Mica 001, 002, and 003).

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 859, 2011.