Atmos. Chem. Phys. Discuss., 11, C669–C675, 2011
www.atmos-chem-phys-discuss.net/11/C669/2011/

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.

florian.thevenon@unige.ch

Received and published: 9 March 2011

- Page 860 10-12: Language problem: "during low rates of dust deposition"

Reply: Changed to "during periods of low dust deposition"

- 15: Language problem: "the greatest dust event". Do they mean the largest event and if so, how do they define the magnitude of dust events based on their data?

Reply: Changed to "the largest dust event": the surface of dust entrapped in this sample (about 10 centimeters weq) is almost equivalent to the total dust accumulated in the

ice record (about 40 meters weq).

- "dust event deposited around 1780-1790" Did the event last for 10 years? Is it due to the sampling resolution? Is the dating uncertainty 10 years? If so, why is the dating uncertainty that large if there is a distinct time marker dated at 1783 at 53.52 m. At which depth is the "greatest dust event" compared to the time marker? Older or younger? Or does the sample include the time marker? Language problem: "Higher dust deposition"

Reply: Changed to "Sustained high dust deposition" and to 1780 (instead of 1780-1790): In fact, this horizon is located just below the chronostratigraphic marker of the Laki fissure eruption (in 1783 in Iceland) that allows to date precisely this event around 1780. This artifact is also explained in Thevenon et al. (2009), p.8: "Although the apparent age (calculated by the age model) locates the highest concentration of Saharan dust between 1785 and 1790 (39.62 and 39.10 m weq), this horizon stratigraphically precedes the reference horizon of the Laki fissure eruption (apparent age of 1795, 38.81 m weq; Jenk et al., 2009), which began on June 1783 in Iceland".

16/17: "ca 20 years after the industrial revolution of 1850" Which industrial revolution is meant? Switzerland, Italy, England? What has the industrial revolution to do with the mineral dust? They do not show records of air pollution. Does that simply mean 1870?

Reply: The BC record, which is a record of air pollution, increases within "the Industrial Revolution in continental Europe (around 1850)", whereas sustained high dust deposition (in regards to preindustrial levels) occurs only after 1870. This different signals indicate two different sources of insoluble particles (anthropogenic BC and natural Saharan dust), and that the excessive coal combustion (that produces minerals) at those times did not over exceed natural dust deposition.

20: Language problem: "Meanwhile"

Reply: Changed to However

Page 861 5: “there is a lack of ice-core data about mid-latitude dust characteristics covering the preindustrial period” What about the ice cores drilled from KUP Heidelberg? Dust records are published by Wagenbach et al. 1996 and Wagenbach & Geis, 1989.

Reply: Changed to “there is a paucity of ice-core data”. The data from Wagenbach comes from the same site (the Colle Gnifetti glacier), and range from 1982 to 1936 for Wagenbach & Geis, 1989. To our knowledge, there is no similar continuous record of insoluble particles (characterized by mineralogy and geochemistry) over the last millennium in the Alps.

6/7: “evaluate European preindustrial atmospheric dust emissions” As far as I understand from the Abstract the emissions take place in the source region (Sahara) and the deposition takes place in the European Alps. So what is recorded in your archive? Emission or Deposition? From Europe or Africa?

Reply: Emission from Africa and deposition in Europe is recorded in this archive. Changed to: “in order to evaluate the atmospheric dust transported over Europe during preindustrial times”.

27/28: Although the authors state that the Southern Alps act as barrier to the transport of southwesterly dust laden winds from the Sahara they later use dust data from Jungfraujoch on the Northern face of the Alps as an analogue to Colle Gnifetti at the southern face. It is questionable if dust has similar source regions, transport histories for two such different study sites.

Reply: Sentence (lines 27/28) deleted. Jungfraujoch and the Colle Gnifetti are relatively close (70 km) in regards to the Saharan dust sources (more than 1000 to 2000 km) and the process of transport (SW winds linked to North Hemisphere atmospheric circulation). The present study (supported by mineralogical and geochemical data) furthermore demonstrates similar source regions and transport histories for both sites (as well as back-trajectory modeling or present-day satellite observations).

Page 862 1 This reference is wrong! Jenk et al. 2006 describe a different ice core, not Colle Gnifetti

Reply: Changed to Jenk et al., 2009.

12-15 “A previous study has demonstrated that the CG archive allows the reconstruction of changes in the dynamic of the southwesterly dust-laden winds from the Sahara, in relation to variability in large-scale atmospheric circulation patterns” This is a strong statement compared to the actual content of the mentioned paper. In Thevenon et al. 2009, the link between NAO and dust is drawn basically from literature (Prospero and Nees, 1986; Chiapello and Moulin, 2002). The low and varying sampling resolution of the ice core does not allow for a direct comparison with decadal-scale atmospheric circulation series.

Reply: It is well established for decades that that Saharan dust is transported by SW winds associated to north hemisphere atmospheric circulation. However, because of the low sampling resolution, there is no tentative of comparison with decadal-scale atmospheric circulation series (NAO) in Thevenon et al., 2009 and in this paper that both present long-term variations (with sampling resolution depending of the dust abundance).

Page 865 Results show evidences that the dust deposited at CG and JFJ of Saharan origin, a fact that is well known for decades (see Haeberli 1977, De Angelis & Gaudichet 1991, Wagenbach et al. 1996).

Reply: This is the first time that such old Saharan dust has been quantified by optical technique, and characterized in detail by mineral and geochemical data (especially Sr/Nd isotopes) that can now be used as reference for deciphering Saharan dust in other climatic archives. In this study, we furthermore put in perspective the results in regards to the dust deposited over Greenland during the LGM.

24/25 Is not the structure of light colored (dust depleted) versus dark colored (dusty)

”layers” an artifact of the varying sampling resolution throughout the ice core. The number of your total data points (around 35) is not significantly higher than the number of major dust events recorded at this ice core site over the last 400 years. In not “layering” determined from how the sample boundaries are defined. You did not choose an equidistant sampling (either in space or time).

Reply: An equidistant sampling would have lead to varying sampling resolution through time, because of the very important thinning of this ice core (and an equidistant sampling in time is not possible for the same reason). Here, the sampling resolution primarily depends of the amount of insoluble particle entrapped in the ice core: The depleted dust-core sections were merged, in order to obtain a few micrograms of dust, because of the limits of detection of the analytical methods used. That is the reason why, the dust depleted samples are covering more time (e.g., filters on Figure 3 in Thevenon et al., 2009). Conversely, a much higher sampling resolution was possible in the dusty ice parts.

Page 866 29 How do this data compare to available high-resolution records of Pb and other heavy metals from the same ice core site (Barbante et al., 2004, Schwikowski et al. 2004)

Reply: The data are compared to very high-resolution analyses (PAHs that show a similar behavior to heavy metals) recently published on the same ice core by Gabrieli, 2009) on p.869, lines 2-9.

Page 867 What is the difference between your back-trajectory modeling approach compared to the previous attempts of Schwikowski et al. 1995, Collaud Coen et. al. 2004, Sodemann et al. 2006. who all calculated back-trajectories for JFJ and the Alps?

Reply: In our study, air-mass back-trajectories were calculated using the Hysplit model (Draxler and Rolph, 2003: p. 867, lines 14-15) for our sampling dates.

Page 868 Figure 3 does not show error bars of the isotopic data (from Figure 2 one can

conclude that the error for certain samples is in the range of 0.05-0.1 for 87Sr/86Sr.

Reply: The error (x 10-6) are given in Table1.

8-12 The conclusion that isotopic data from Colle Gnifetti ice core should suggest the African origin of dust in Greenland or the presence of dust from Gobi at Colle Gnifetti is not supported by the data. Overall the isotopic data shows a strong scattering of all data points. Only the data from Antarctica differs distinctly. Moreover the data for certain areas is only constrained by few data points (in fact it is one data point for the Gobi desert). Any attempt to suggest source regions of dust from Figure 3 is therefore questionable.

Reply: Changed to: it is meaningful to note that a dusty layer recently deposited over CG glacier carries the isotopic signature of the Gobi desert (Fig. 3). Interestingly, in addition to the mixing of dust from Asian sources (Gobi sand and China loess), a possible contribution from African sources (Saharan dust) to the aeolian dust deposited over Greenland during the last glacial period cannot be definitively ruled out from the isotopic fields of dust reported on Figure 3.

13/14 Kang et al. 2003 link highly resolved mineral dust records from Alaska, Himalaya and Greenland to atmospheric circulation pattern in the Northern Hemisphere. They draw no conclusion concerning Saharan dust transported to Alpine glaciers.

Reply: Changed to: The comparison of the mineral dust records from three Northern Hemisphere ice cores (Alaska, Himalayas, and Greenland) with instrumental sea-level pressure series of spring over the last century, reveals consistent relationship between atmospheric circulation patterns and the long range transport of mineral dust (Kang et al., 2003).

Hypotheses of a links between dust deposition and winter drought conditions over Northern Africa (and an eventual link to circulation pattern) as “suggested” (Lines 14-25) by the authors should therefore be tested by comparing well established highly

resolved ice core dust data until the very recent past (Al, Ca, Fe) directly to instrumental and proxy data of North African drought or winter NAO.

Reply: This is a different field of research, on the soluble material at much higher resolution, (which does not allow mineralogical and Sr/Nd isotopic analyses of insoluble material). In the last sentence of the manuscript, we mention this work, done on the same ice core that should be soon published.

26-29 and Page 869 1-13 The content of these results does not fit very well to the context of the general paper.

Reply: This last paragraph gives an overview of the pollutants record over the last decades, by comparing our results (BC and 13CBC) with recent ones; but also with the pollution trend after 1975 that is not included in our record.

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