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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The transport history of two Saharan dust events archived in an Alpine ice core" *by* H. Sodemann et al.

H. Sodemann et al.

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We are grateful to Referee 2 for valuable suggestions and pointing out parts of the paper requiring clarification. Our reply to the raised points is detailed below.

Major comments:

1.The Referee remarks that the aim of the paper is not clearly stated. This point has already been adressed in detail in the Reply to Review 1, and is therefore not restated here. Effectively, the aims will be reformulated much more clearly in the Introduction.

2.The Referee claims that due to transitions and common statements the paper is too long. While we will further focus the paper along the two core questions stated in the Reply to Review 1, we note that the paper should remain equally readable to both, researchers more interested in the physical processes and those who are working on the chemical implications of dust transport. Therefore, the paper will necessarily include a few statements that will appear obvious to researchers from one of the communities.

3.The Referee remarks that the meteorological discussion is too long. As has been detailed in the Reply to Review 1, the meteorological discussion yields important findings with respect to the conclusions of the paper. However, as the meteorology section was not conceived as an integral part of this study by both Referees, we make major changes to the structure of the paper, in order to tie the meteorological discussion closer to the interpretation of the chemical signal, and in order to shorten all discussion not directly related to the two core questions of this paper.

4.The Referee requests that chemical data in the ice core be confirmed by other measurements. The Jungfraujoch (JFJ) data shows that the March dust event was not as strong as at Piz Zupo (PZ), probably due to differences in the small-scale structure of the dust transport, topography, and mixing of air masses, which may lead to a complex spatial pattern of dust deposition in the Alpine area. For these data, we currently investigate whether they can be published in this paper, even though comparison with the data from PZ is limited due to spatial variability.

Unfortunately, no precipitation chemistry data are available from stations near PZ. Weekly bulk precipitation chemistry was measured (non-routinely) at the stations Robiei and Piotta for 9-15 October 2000. However, these data are not publicly available and therefore cannot be shown in this paper. We consider a detailed description of the precipitation chemistry from stations Robiei and Piotta with the ice core record beyond the scope of this paper, in particular as the bulk sample for one week would not allow us to extract more information on the timing of the event. We will include a comparison with the data described in Henning et al. (2003) where appropriate, but note also the

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difficulties associated with such a comparison (see Specific comments).

5.The Referee requests that an overview of the ice core dating should be given. More detail on the dating of the PZ core will be included (see Reply to Review 1). We cannot correlate depths in the ice core to specific months of the year as ice cores only record information when there is snowfall, which does not happen at regular intervals. At best we can give seasonal markers and then rely on other anomalous events such as those described in the paper to further tie the dating of the ice core record. See also specific comment below.

Specific comments:

P7501 L21: The time period corresponding to the sampling scheme varies as one goes down the core. The sampling scheme was chosen to provide at least 12 samples per accumulation year. In the case of the core section discussed here, a much higher resolution due to the high accumulation rate results. About 100 samples make up the section ascribed to the year 2000. Therefore, the time resolution per sample will probably range between several weeks to a few hours, depending on the frequency and intensity of precipitation events at the site. This will be included in the revised manuscript.

P7501 L23/24: Cations were measured using a 16 minute isocratic method with 20mM MSA eluent at 1 mL/min. Anions were analysed in 19 minute method involving gradient elution (concentrations between 0.25 to 24 mM NaOH) at 0.5 mL/min. Suppressed conductivity detection was used in both IC methods. The method used to determine the oxygen isotope ratio, δ^{18}O (defined as the relative deviation of the ^{18}O/^{16}O ratio of the sample from the international standard VSMOW) involved the pyrolysis of water to CO at 1450°C in a glassy carbon reactor (Saurer et al. 1998; Kornexl et al. 1999) and subsequent mass-spectrometric analysis of ^{12}C^{16}O and ^{12}C^{18}O (Delta Plus XL,

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Finnigan MAT, Bremen, Germany). This will be included in the revised manuscript.

Saurer, M., Robertson, I., Siegwolf, R., and Leuenberger, M., 1998: Oxygen isotope analysis of cellulose: An interlaboratory comparison. Analytical Chemistry 70(10): 2074-2080.

Kornexl, B. E., Gehre, M., Hofling, R., and Werner, R.A., 1999: On-line delta O-18 measurement of organic and inorganic substances. Rapid Communications in Mass Spectrometry 13(16): 1685-1693.

P7502 L22: Following the discussion in Bosc et al. (2004), the OC4 algorithm was proposed by O'Reilly et al. (1998); with revised numerical coefficients currently version 4 of this algorithm is in use (OC4v4). It provides the combined chlorophyll a and pheophytin a concentrations from a maximum reflectance ratio $\rho = \log_{10}(R_{rs}(\lambda)/R_{rs}(555nm))$, with R_{rs} being the remote-sensing reflectance at the sea surface, and $R_{rs}(\lambda)$ being the highest value among R_{rs}(443nm), R_{rs}(490nm), and R_{rs}(570nm). Chlorophyll a is the given by the empirical function Chl a $(mgm^{-3}) = 10^{0.366-3.067\rho+1.930\rho^2-1.532\rho^4}$. This will be included in the revised manuscript.

O'Reilly, J. E., Maritorena, S. Mitchell, B.G., Siegel, D.A., Carder, K. L., Garver, S.A., Kahru, M., and McClain, C., 1998: Ocean color chlorophyll algorithms for SeaWiFS. J. Geophys. Res., 103(C11): 24937-24953.

P7507 L15/16: Including a figure which shows the seasonal variation of NH_4^+ and $\delta^{18}O$ would require a discussion of a longer section of the ice core, and further increase the size of the paper (which according to the reviewer is already too long). The seasonal variation of chemical species for ice core dating has for instance been used by Eichler et al. (2000) and Preunkert et al. (2000). The requested information is included in the Palmer et al., manuscript in preparation, which will be attached to the answer letter to the editor. The references will be cited in the revised manuscript.

Eichler, A., Schwikowski, M., Gaggeler, H. W., Furrer, V., Synal, H. A., Beer, J., Saurer,

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M. and Funk, M., 2000: Glaciochemical dating of an ice core from upper Grenzgletscher (4200 m a.s.l). Journal of Glaciology 46(154): 507-515.

Preunkert, S., Wagenbach, D., Legrand, M., and Vincent, C., 2000 : Col du Dôme (Mt Blanc Massif, French Alps) suitability for ice-core studies in relation with past atmospheric chemistry over Europe. Tellus 52B(3): 993-1012.

P7505 L19-P7508 L1: These ions were omitted from the Figure to provide clarity, as their behaviour is similar to other ions shown in Figure 3. H^+ shows the acidity of the ice and hence reflects NO_3^- and MSA records, with a peak during the March event. K^+ is very similar to Mg^{2+}, and $C_2O_4^{2-}$ behaves again similar to Mg^{2+}. Instead of inserting this information to the Figure, it will be mentioned in the revised manuscript.

P7508 L4: Winter conditions are typically noted by low concentrations of trace ions in the snow. Typical values below about -20 permil for $\delta^{18}O$ during winter, and above about -15 permil during summer, with significant inter-annual and short-term variability superimposed (Eichler et al., 2000; Preunkert et al., 2000).

P7508 L7: A detailed comparison of the specific chemical composition with measurements from JFJ would require a discussion of the small-scale variability (on spatial scales of 10s to 100s of kilometres) inherent to dust events, which is at the limit of resolution of our meteorological data. Furthermore, we cannot definitely tie together data from the JFJ and the PZ ice core, as the ice core data is not a continuous record of atmospheric conditions as is the case at the JFJ. In this paper, the JFJ data are rather used as a link due to the common preservation of atmospheric events.

P7508 L18-21: See answer to major comment 4. The locations of the two stations have been included to Fig. 1.

P7509-7515: See reply to major comment 3.

P7517 L27: Will be changed accordingly.

P7518 L1-2: This statement resulted from misinterpreting Fig. 5 from Hinz et al.

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(2005), and will be restated to “In particular, slightly higher class abundances of particles rich in iron oxides (particle class ‘mineral 2’, Fig. 8 in Hinz et al., 2005) were noted on March 23.”.

P7518 L8-17: We will strongly shorten this paragraph in the revised paper, see also reply to major comment 2.

P7519 L21-23: A detailed comparison with Henning et al. (2003) with respect to the specific chemical composition would require a discussion of the small-scale variability (on spatial scales of 10s to 100s of kilometres) inherent to dust events, which is at the limit of resolution of our meteorological data. We note that pollution signals are apparent in the data shown by Hinz et al. (2005) and Henning et al., (2003), but consider a detailed comparison beyond the scope of this paper. A note to this end will be added to the revised manuscript.

P7520 L19/Fig. 12: The vertical axis title will be changed to ‘pressure’. In order to avoid overloading the Figures, we will not add a height axis. As a rough estimate for the conversion of the pressure axis into altitude, 800 hPa correspond to 1900 m asl, and 500hPa to about 5500 m asl. This will be noted in the Figure caption.

P7521 L6-10: We regret the misinterpretation and will correct the statements in our paper accordingly. We repeated the back-trajectory analysis for the JFJ site, and note differences with respect to the timing and magnitude of modeled dust transport at the two sites, and potential wet deposition prior to arrival. This gives closer agreement with the dust event timing detected in Hinz et al. (2005), but further complicates a direct comparison of the JFJ data with the ice core record from Piz Zupo.

P7525: We will add a statement to this end to the method discussion (Section 7).

Table 1: We will add a similar line for the October event.

On behalf of all authors

Harald Sodemann

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 7497, 2005.