Name of research institute or organization:

Eidgenössische Materialprüfungs- und Forschungsanstalt EMPA

Title of project:

National Air Pollution Monitoring Network (NABEL)

Project leader and team:

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Project description:

The national air pollution monitoring network NABEL consists of 16 monitoring stations and is operated by EMPA (Air Pollution/Environmental Technology Laboratory) under the supervision of the Swiss Agency for Environment, Forests and Landscape (BUWAL). The monitoring stations are distributed all over Switzerland and represent the most important levels of air pollution. The NABEL site at Jungfraujoch is a very low polluted site, representing a background station for the lower free troposphere in central Europe.

The measurement programme at Jungfraujoch includes the continuous measurement of the following gaseous pollutants: Ozone (O_3), carbon monoxide (CO), nitrogen monoxide (NO), nitrogen dioxide (NO_2), and the sum of nitrogen oxides (NO_y). In addition, a selection of VOC's (alkanes, aromatics) are measured with a time resolution of four hours. Daily samples are taken for determination of gaseous SO_2 and for particulate sulphur. Finally, 48-hours samples of total suspended particulate matter (TSP) are collected by use of a high volume sampler and analysed for total mass as well as for lead and cadmium concentrations (yearly means).

In a joint project with researchers from MeteoSwiss and Paul Scherrer Institute (PSI), the occurence of Saharan dust events (SDE) at the Jungfraujoch between March 2001 and December 2002 was analysed. SDE were detected by continuous measurement of the scattering and absorption coefficient of aerosols performed by PSI within the scope of the Global Atmosphere Watch (GAW) programme (Collaud Coen et al., 2003). The occurence of SDE detected with this new method was verified by visual inspection of the filter colour of TSP samples, and by analysis of back-trjectories of air masses. Moreover, the contribution of Saharan dust to the annual TSP at Jungfraujoch was estimated.

Analysis of back trajectories allowed to determine the potential source region for each of the identified SDE. Figure 1a shows the most important source countries. As expected, important potential source countries are situated in the northern and north-western part of the Saharan desert with the most cases counted in Algeria (34 out of 38 cases). Almost every SDE at the Jungfraujoch had the potential source region in Algeria. Figure 1b indicates the numbers of trajectory segments (i.e. the hourly trajectory time steps) counted in a $0.75° \times 0.75°$ grid superimposed over the domain. Again, it can be seen that the north-north-western part of Africa with Morocco, Algeria Tunisia and Libya is the most important source region of the Saharan dust detected at Jungfraujoch.

The direction of the air mass inflow to the Jungfraujoch was investigated by visual inspection of the trajectories and classifying them into four classes (Table 1).

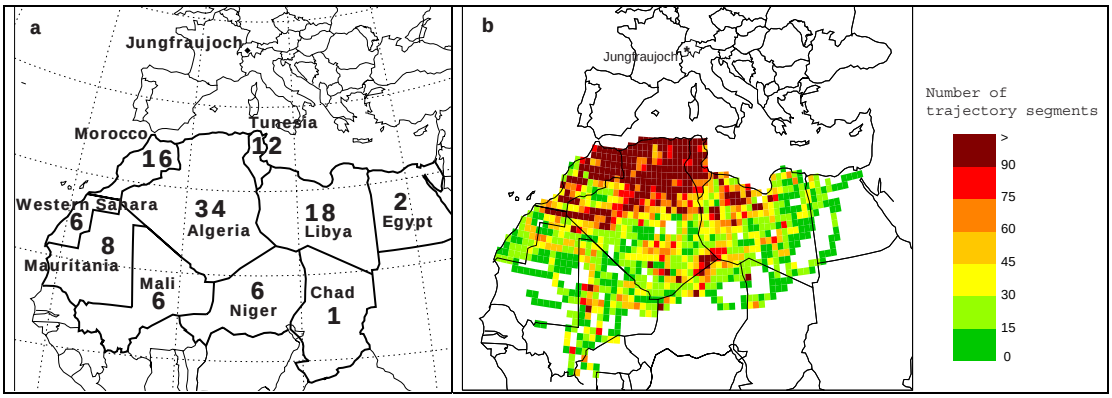

Fig. 1: The most important source countries of SDE detected at the Jungfraujoch. The numbers indicate the numbers of trajectories being situated at least once over the respective country in a vertical distance from ground of less than 150 hPa (a). Numbers of trajectory segments (hourly time steps) in a vertical distance from ground of less than 150 hPa in a 0.75°× 0.75° grid (b).

Table 1 : Inflow directions at the Jungfraujoch described by four sectors in % of total cases.

	0° - 90° (N-E)	90° - 180° (E-S)	180° - 270° (S-W)	270° - 360° (W-N)
All cases (38)	5	37	40	18
March – May (17)	12	47	29	12
June – August (9)	0	11	67	22
September – November (9)	0	33	45	22
December – February (3)	0	67	0	33

A statistical significance cannot be given because of the relatively small number of cases. Nevertheless, as expected, the inflow from the two southern sectors is the most important one in all seasons. This air mass movement is often associated with low pressure systems and their cold-fronts approaching Europe from the Atlantic. These weather patterns – often during South-Foehn events in the Alps - accelerate the air masses in front of the cold-front in northern direction towards the Jungfraujoch. Also the north-western inflow is not untypical for SDE. In these cases, the air moves from the Sahara towards the Atlantic, turns to the north and flows towards the Alps with prevailing westerly winds. Only two cases (5%) were found with an inflow direction from the north-eastern sector. This seems not to be a typical air mass path. In these cases, the air moves northward to higher latitudes before turning southward again and approaching the Jungfraujoch from north-east or east. These SDE also exhibited the longest travelling times of up to 8 days.

The NABEL measurements of 48-hours averages of TSP were used to estimate the contribution of Saharan dust to the TSP mass concentration at the Jungfraujoch. The contribution of Saharan dust (SD) to the 48h-TSP mass concentration at the Jungfraujoch was determined for the identified SDE. Thus, the non-SD fraction of 48h-TSP samples that are affected by SD is estimated and subtracted from the total 48h-TSP mass concentration. The Saharan dust fraction of 48h-TSP samples that are affected by SD is estimated with a local linear regression model. Figure 2 shows the

measured 48h-TSP mass concentration, the local linear regression function, and the estimated non-SD fraction for all TSP samples that are affected by SD.

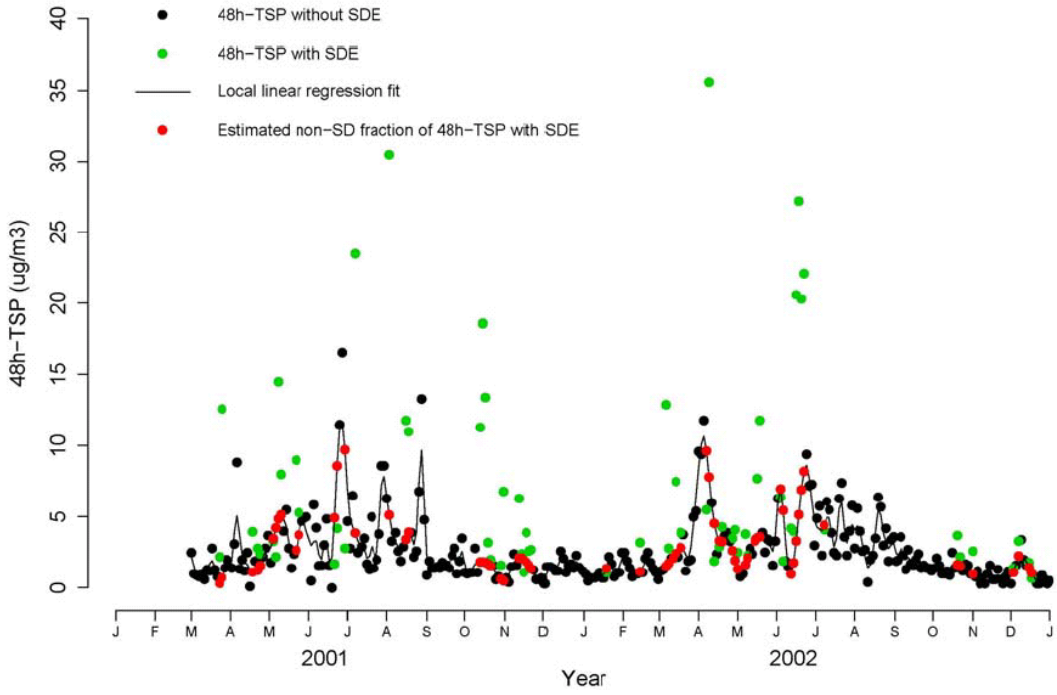

Fig. 2: Measured and estimated 48h-TSP mass concentration between 1 March 2001 and 31 December 2002 at the Jungfraujoch. Shown are the measured values for samples that are not affected by Saharan dust (black dots), and for samples that are identified as being affected by Saharan dust (green dots). The line is the estimated local linear regression function. The red dots are the estimates for the non-SD fraction of 48h-TSP samples that are affected by SD.

The annual average contribution of Saharan Dust to long-term TSP at the Jungfraujoch can be estimated as the arithmetic mean of the determined SD contribution to 48h-TSP. For the time period from 01.03.01 to 31.12.02, the average contribution of SD to TSP is 0.8 $\mu g/m^3$ ($\pm$ 0.2 $\mu g/m^3$), the mean TSP level during this time period is 3.4 $\mu g/m^3$. For 2002, the annual mean contribution of SD to TSP is 0.7 $\mu g/m^3$ ($\pm$ 0.2 $\mu g/m^3$), the annual mean TSP mass concentration in 2002 is 3.4 $\mu g/m^3$. In 2002, the annual contribution of Saharan dust to TSP at JFJ is therefore about 21%.

Key words:

Air pollution, long-term measurements, Saharan dust, back-trajectories, total suspended particulate matter

Internet data bases:

http://www.empa.ch/nabel
http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg_luft/luftbelastung/index.html

Collaborating partners/networks:

Bundesamt für Umwelt Wald und Landschaft (BUWAL)
Global Atmosphere Watch (GAW)
Labor für Atmosphärenchemie, Paul Scherrer Institut
Meteo Schweiz

Scientific publications and public outreach 2003:

Refereed journal articles

Colaud Coen, M., E. Weingartner, D. Schaub, C. Hueglin, C. Corrigan, M. Schwikowski, U. Baltensperger, Saharan Dust Events at the Jungfraujoch: Detection by wavelength dependence of the single scattering albedo and analysis of the events during the years 2001 and 2002, ACPD **3** 5547-5594, 2003.

Data books and reports

Technischer Bericht zum Nationalen Beobachtungsnetz für Luftfremdstoffe (NABEL), EMPA, 2003.

NABEL, Luftbelastung 2002, Schriftenreihe Umwelt Nr. 360 Luft, Bundesamt für Umwelt Wald und Landschaft, Bern 2003.

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