

Name of research institute or organization:

---

**Empa Materials Science and Technology**

Title of project:

---

National Air Pollution Monitoring Network (NABEL)

Project leader and team

---

Martin Steinbacher, Christoph Hüglin (project leader)

Project description:

---

The national air pollution monitoring network NABEL is a joint project of the Swiss Federal Office for the Environment (BAFU/FOEN) and Empa. The NABEL network was established in 1978 with initially 8 sites emerging from activities that started already in 1968 as contributions to international observations networks as part of WMO and OECD. Early activities mainly focused on sulfur dioxide and particulate matter. In 1990/1991 the NABEL network was extended to 16 monitoring stations that are distributed all over Switzerland. The monitoring stations represent the most important air pollution levels. The NABEL site at Jungfraujoch is a very low polluted site, representing a background station for the lower free troposphere in central Europe. Since in-situ measurements by Empa at Jungfraujoch started in 1973 as part of these programs, time series of nearly 35 years are now available for selected species.

The current measurement program at Jungfraujoch includes continuous *in-situ* analyses of ozone (O<sub>3</sub>), carbon monoxide (CO), nitrogen monoxide (NO), nitrogen dioxide (NO<sub>2</sub>), the sum of nitrogen oxides (NO<sub>y</sub>) and sulfur dioxide (SO<sub>2</sub>). The concentrations of methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), molecular hydrogen (H<sub>2</sub>), and sulfur hexafluoride (SF<sub>6</sub>) are observed in 30min intervalls. An extended set of halocarbons and a selection of VOCs (alkanes, aromatics) are measured with a time resolution of four hours. Daily samples are taken for determination of particulate sulfur. The concentrations of particulate matter < 10µm (PM10) are continuously observed as well as measured as 24-hour bulk samples.

Figure 1 shows some of the longest time series that are available for in-situ observations of air pollutants at Jungfraujoch. The time series of sulfate and SO<sub>2</sub> show steadily decreasing concentrations that well reflect the continuous emission reductions within this period. This was mainly achieved by the implementation of improved emission control technologies and the upcoming usage of gas instead of coal in the early 1980s and mainly the economic depression in Eastern Europe and the desulphurization of fossil fuels in Western Europe in the 1990s [1]. These measures led to a significant improvement in terms of environmental acidification but resulted in a stronger direct radiative forcing due to a smaller cooling effect of the particulate sulfate [2].

Particulate sulfate and TSP levels show a distinct seasonal pattern due to the seasonally varying vertical transport of polluted air masses from the boundary layer. The average TSP levels are in summer about a factor 4 higher than in winter when the Jungfraujoch is almost permanently decoupled from the planetary boundary layer and the measurement site is representative for the free troposphere. In addition, the

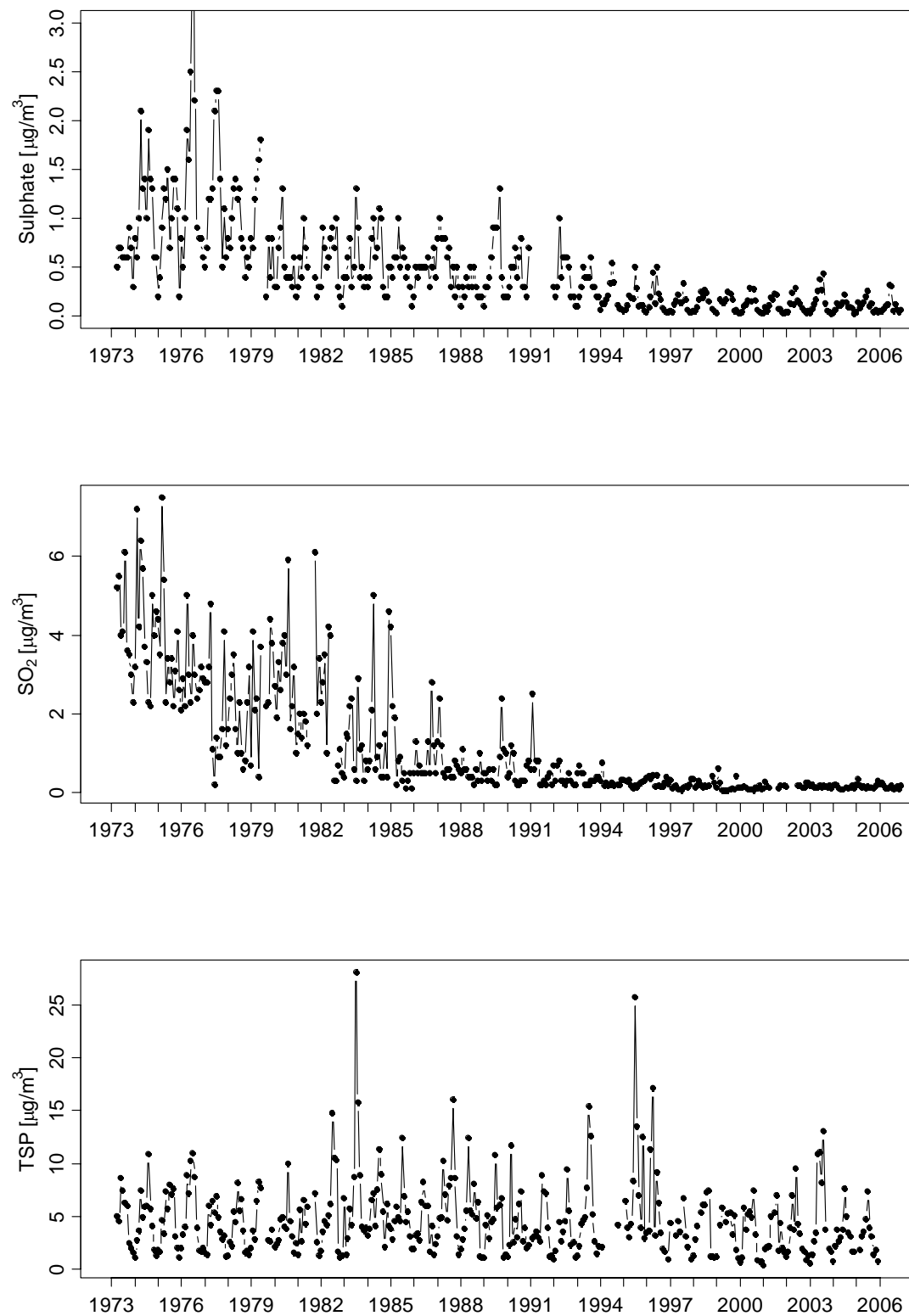


Figure 1: Monthly means of particulate sulfate, sulfur dioxide and total suspended particles (TSP) at Jungfrauoch.

frequency of Saharan dust events (SDEs) is very low in winter [3], whereas SDEs can significantly contribute to the TSP level at Jungfraujoch during the warmer seasons. In contrast to SO<sub>2</sub> and sulfate, TSP concentrations only decreased slightly over the investigated period. Nevertheless, TSP trends are negative for all seasons, although the trends are only significant for average summer and fall values (95% confidence level). This trend analysis indicates continuously decreasing TSP levels of both, the free troposphere as well as the air masses that are transported from the polluted boundary layer to the Jungfraujoch.

- [1] Vestreng V., Myhre G., Fagerli H., Reis S., Tarrason L., 2007. Twenty-five years of continuous sulphur dioxide emission reduction. *Atmospheric Chemistry and Physics* 7, 3663-3681.
- [2] Marmer E., Langmann B., Fagerli H., Vestreng V., 2007. Direct shortwave radiative forcing of sulfate aerosol over Europe from 1900 to 2000. *Journal of Geophysical Research* 112, D23S17, doi: 10.1029/2006JD008037.
- [3] Collaud Coen M., Weingartner E., Schaub D., Hueglin C., Corrigan C., Henning S., Schwikowski M., Baltensperger U., 2004. Saharan dust events at the Jungfraujoch: detection by wavelength dependence of the single scattering albedo and first climatology analysis. *Atmospheric Chemistry and Physics* 4, 2465-2480.

Key words:

---

Air quality, long-term monitoring

Internet data bases:

---

<http://www.empa.ch/nabel>

[http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg\\_luft/luftbelastung/index.html](http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg_luft/luftbelastung/index.html)

Collaborating partners/networks:

---

Bundesamt für Umwelt (BAFU)/ Federal Office for the Environment (FOEN)

Global Atmosphere Watch (GAW)

Labor für Atmosphärenchemie, Paul Scherrer Institut

Meteo Schweiz

Scientific publications and public outreach 2007:

---

### **Refereed journal articles**

Steinbacher, M., M.K. Vollmer, B. Buchmann, S. Reimann, 2008. An evaluation of the current radiative forcing benefit of the Montreal Protocol at the high-Alpine site Jungfraujoch, *Science of the Total Environment*, 391, 217-223.

Reimann, S., M.K. Vollmer, D. Folini, M. Steinbacher, M. Hill, B. Buchmann, R. Zander, E. Mahieu, 2008. Observations of Long-Lived Anthropogenic Halocarbons at the High-Alpine site of Jungfraujoch (Switzerland) for Assessment of Trends and European Sources, *Science of the Total Environment*, 391, 224-231.

Cozic J., B. Verheggen, E. Weingartner, J. Crosier, K. Bower, M. Flynn, H. Coe, S. Henning, M. Steinbacher, M. Collaud Coen, A. Petzold, U. Baltensperger, 2007. Chemical composition of free tropospheric aerosol for PM<sub>1</sub> and coarse mode at the high alpine site Jungfraujoch, *Atmospheric Chemistry and Physics Discussions*, 7, 12145-12184.

Zanis P., A. Ganser, C. Zellweger, S. Henne, M. Steinbacher, J. Staehelin, 2007. Seasonal variability of measured Ozone Production Efficiencies in the lower free troposphere of Central Europe, *Atmospheric Chemistry and Physics*, 7, 223-236.

### **Conference contributions**

Steinbacher, M., M. K. Vollmer, S. Henne, D. Brunner, B. Buchmann, S. Reimann – Non-CO<sub>2</sub> Greenhouse Gas Mixing Ratios at Jungfraujoch, Switzerland; Influence of Air Mass Origin, 14<sup>th</sup> WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases, and Related Tracer Measurement Techniques, Helsinki, Finland, September 10 – 13, 2007.

Reimann, S., M. K. Vollmer – On the usage of VOCs for determination of processes in the background atmosphere, 4<sup>th</sup> ACCENT T&TP Barnsdale Expert Meeting, Barnsdale, UK, November 05 – 07, 2007.

Reimann, S., M. K. Vollmer, D. Folini, M. Steinbacher, A. Manning, S. O'Doherty – On the use of continuous atmospheric measurements at background sites for the assessment of regional sources of greenhouse gases in Europe, 8th International Conference on Emissions Monitoring, Duebendorf, Switzerland, September 05 – 07, 2007.

Reimann S., M. K. Vollmer, M. Steinbacher, D. Folini, M. Hill, B. Buchmann – Long-Term Monitoring of Greenhouse Gases at Jungfraujoch, Climate Change Committee Working Group I Meeting, Ispra, Italy, March 08 – 09, 2007.

Folini, D., S. Ubl, P. Kaufmann – Modelling passive tracer transport to the high Alpine site Jungfraujoch, 6<sup>th</sup> International Conference on Urban Air Quality, Cyprus, March 27 – 29, 2007.

Cui J., Siegrist A., Kunz M., Sprenger M., Staehelin J., Steinbacher. M – Stratospheric intrusion and transatlantic transport events at Jungfraujoch in 2005: comparison and validation of FLEXPART and LAGRANTO; 2<sup>nd</sup> ACCENT symposium; Urbino, Italy; July 23 – 27, 2007.

Dils B., Demoulin P., Folini D., Mahieu E., Steinbacher M., Buchmann B., de Maziere M. – Ground-based CO observations at the Jungfraujoch: Comparison between FTIR remote sensing and NDIR In Situ Measurements; 2<sup>nd</sup> ACCENT symposium; Urbino, Italy; July 23 – 27, 2007.

Zanis, P., A. Ganser, C. Zellweger, S. Henne, M. Steinbacher, and J. Staehelin – On the seasonality of ozone production efficiency at Jungfraujoch in the Swiss Alps for undisturbed free tropospheric conditions, 2<sup>nd</sup> ACCENT Symposium, Urbino, Italy, July 23 – 27, 2007.

### **Data books and reports**

BAFU 2007: NABEL Luftbelastung 2006. Messresultate des Nationalen Beobachtungsnetzes für Luftfremdstoffe (NABEL). Umwelt-Zustand Nr. 0726. Bundesamt für Umwelt, Bern. 139 S.

Address:

---

Empa  
Laboratory for Air Pollution/Environmental Technology  
Ueberlandstrasse 129  
CH-8600 Dübendorf

Contacts

---

Martin Steinbacher  
Tel.: +41 1 823 4654  
Fax: +41 1 821 6244  
e-mail: [martin.steinbacher@empa.ch](mailto:martin.steinbacher@empa.ch)  
URL: <http://www.empa.ch/nabel>

