

Name of research institute or organization:

**Institute for Atmospheric and Climate Science, ETH Zurich  
(IACETH)**

Title of project:

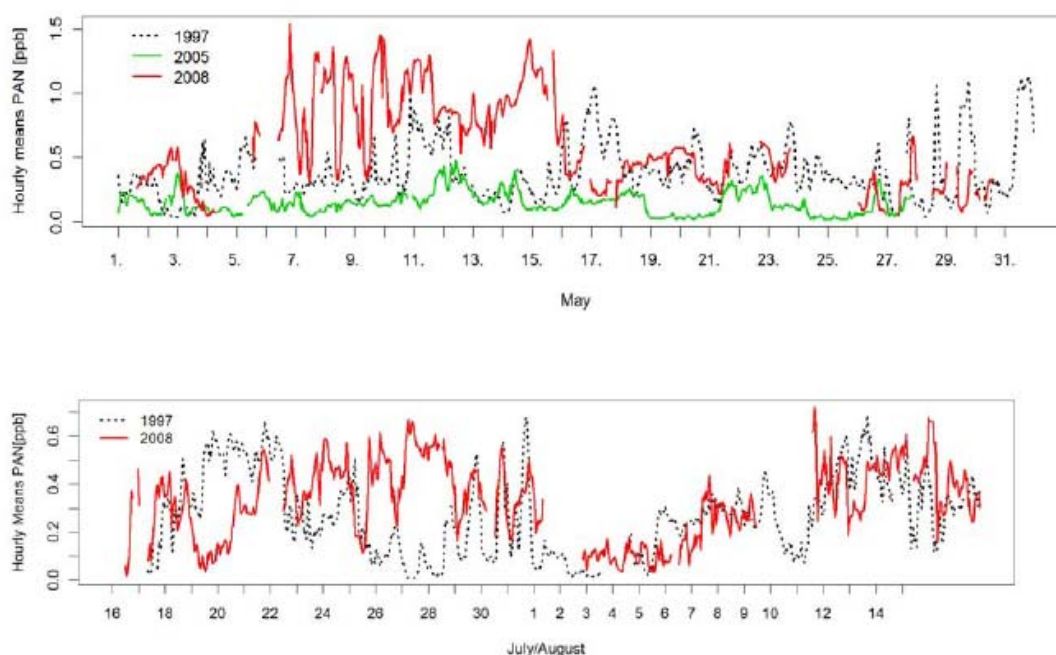
NO<sub>y</sub> at the interface of planetary boundary layer and the free troposphere from measurements at Jungfraujoch.

Project leader and team:

Prof. Johannes Staehelin, Project leader  
Shubha Pandey, Uwe Weers

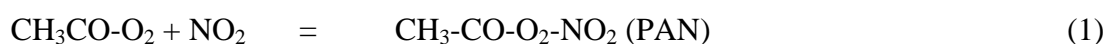
Project description:

NO<sub>y</sub> is the abbreviation of a family of tropospheric trace constituents including nitrogen oxides (NO<sub>x</sub>: NO+NO<sub>2</sub>, which are primary pollutants mainly emitted by fossil fuel combustion in the northern midlatitudes) plus compounds formed by oxidation of nitrogen oxides in the troposphere (including PeroxyacetylNitrate (PAN), nitric acid (HNO<sub>3</sub>), particulate nitrates and some others). NO<sub>x</sub> are important precursors for the formation of ozone (O<sub>3</sub>) which is a key air pollutant of summer smog and an important greenhouse gas.



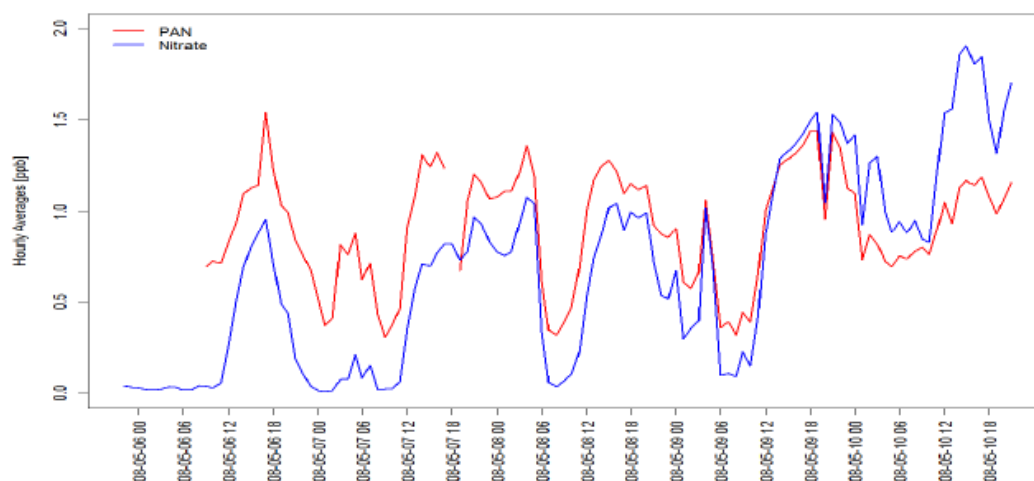
**Figure 1:** Measurements of PeroxyacetylNitrate (PAN) at Jungfraujoch in comparison with earlier measurements (see Zellweger et al., 2003, Balzani Lööv et al., 2008).

PAN is an important reservoir species in tropospheric chemistry:



PAN is formed in polluted air masses binding reactive nitrogen oxides ( $\text{NO}_2$ ) and organic radicals which can be released again by the backward reaction of equilibrium (1). This equilibrium strongly depends on temperature; if PAN is formed in the polluted planetary boundary layer and subsequently lifted into the cold upper troposphere it can be transported over large distances, leading to intercontinental transport of  $\text{NO}_x$ .

$\text{NO}_y$  is continuously measured by Empa at Jungfraujoch since 1999; the concentrations show an increasing tendency which is surprising keeping in mind that during the last ten years  $\text{NO}_x$  emissions in Switzerland and the surrounding European countries are rather decreased. PAN has been measured at JFJ in several campaigns in the last years showing decreasing concentrations, which is puzzling because PAN also significantly contribute to  $\text{NO}_y$ . The PAN instrument (belonging to Empa) was repaired, tested and calibrated and successfully installed at the observatory of Jungfraujoch. The measurements of PAN in May, July and August 2008 are shown in Fig. 1 (because of technical problems some measurements are not available) together with measurements from earlier years, indicating very large variability. The large variability in ambient air concentrations is attributable to differences in the origin of the air masses.



**Figure 2:** Diurnal variation of PAN and particulate nitrate (courtesy of PSI) from 6. to 10. May 2008.

In Fig. 2 the diurnal variation of PAN is compared with particulate nitrate. In this period a high pressure system prevailed in Switzerland and PAN measurements showed exceptionally high concentrations. The strong diurnal variation with late afternoon peak suggests formation of PAN and particulate nitrate in the polluted planetary boundary layer of the Swiss plateau and subsequent transport of the compounds to measurement site by convective transport.

In the next year we intend to continue the measurements of PAN at JFJ together with  $\text{NO}_y$  measurements performed with our instrument, which uses a converter outside

the instrument in order to check the possible effect of HNO<sub>3</sub> deposition in the instrument operated by Empa. The interpretation of the measurements will be continued making use of backward trajectory analysis and chemical filters for separating the different air masses such as free tropospheric air and air from European planetary boundary layer.

### References

Zellweger, C., J. Forrer, P. Hofer, S. Nyeki, B. Schwarzenbach, E. Weingartner, A. Ammann, and U. Baltensperger: Partitioning of reactive nitrogen (NO<sub>y</sub>) and dependence on meteorological conditions in the lower free troposphere, *Atmos.Chem. Phys.*, 3, 779-796 (2003).

J.M. Balzani Lööv, S. Henne, G. Legreid, J. Staehelin, S. Reimann, A.S.H. Prévôt, M. Steinbacher, and M.K. Vollmer: Estimation of background concentrations of trace gases at the Swiss Alpine site Jungfraujoch (3 580 m asl), *J. geophys. Res.*, 113, doi:10.1029/2007JD009751 (2008).

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### Key words:

Atmospheric trace gases, free troposphere, planetary boundary layer, tropospheric chemistry, NO<sub>y</sub>, PAN

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### Internet data bases:

<http://www.iac.ethz.ch>

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### Collaborating partners/networks:

Christoph Zellweger, Dominik Brunner (Empa); Ernest Weingartner (PSI)

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### Scientific publications and public outreach 2008:

#### Refereed journal articles and their internet access

(Note, that these publications were part of the earlier project “Carbonyls and PANs at the Jungfraujoch and related oxidation processes at the boundary layer/free troposphere interface”)

Balzani Lööv, J.M., Henne, S., Legreid, G., Staehelin, J., Reimann, S., Prévôt, A.S.H., Steinbacher, M., Vollmer, M.K., Estimation of background concentrations of trace gases at the Swiss Alpine site Jungfraujoch (3 580 m asl), *J. geophys. Res.*, 113, doi:10.1029/2007JD009751, 2008.

Legreid, G., D. Folini, J. Staehelin, J. Balzani Lööv, M. Steinbacher, and S. Reimann: Measurements of organic trace gases including oxygenated volatile organic compounds at the high alpine site Jungfraujoch (Switzerland): Seasonal variation and source allocation, *J. geophys. Res.*, 113, D05307, doi:10.1029/2007JD00863 (2008).  
<http://iac.ethz.ch/edit/pub/edit.php>

### Conference papers

Shubha Pandey, J. Stähelin, D. Brunner, M. Steinbacher, C. Zellweger “PAN measurements at high alpine observatory, Jungfraujoch”, IGAC 2008, 7 September – 12 September 2008, Annecy, France. (Poster presentation)

Staehelin, J., Peter, T., Trace gas measurements at Jungfraujoch to study intercontinental air pollutant transport and tropospheric ozone trends, Bern, Switzerland, 26. November, Spawning the Atmosphere measurements of Jungfraujoch, SANW

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