Name of research institute or organization:

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

Title of project:

NO_y 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_y is the abbreviation of a family of tropospheric trace constituents containing nitrogen in oxidized form including nitrogen oxides (NO_x: $NO+NO_2$, being important primary pollutant mainly emitted by fossil fuel combustion and the compounds formed by oxidation of nitrogen oxides in the troposphere (including Peroxyacetylnitrate (PAN), nitric acid (HNO_3), particulate nitrates and other radical species). NO_x is an important precursor for the formation of ozone (O_3) which is a key compound of summer smog and an important greenhouse gas. PAN acts as an imporatnt reservoir species in tropospheric chemistry:

$$CH_3CO\text{-}O_2 + NO_2 \quad \Longleftrightarrow \quad CH_3\text{-}CO\text{-}O_2\text{-}NO_2 \text{ (PAN)} \qquad (1)$$

PAN can be formed in polluted air masses binding reactive nitrogen oxides (NO_2) and radical species. However, the reactive species can be released again from PAN by the backward reaction of equilibrium (1). This equilibrium strongly depends on temperature (cold temperatures favour PAN); if PAN is formed in the polluted planetary boundary layer and subsequently lifted into the cold upper troposphere then it can be transported over large distances, leading to intercontinental transport of NO_x.

NO_y is continuously measured by Empa at the Jungfraujoch observatory (3580 m asl., JFJ) since 1999; measurements at JFJ allow studying polluted air advected from the European planetary boundary layer as well as air of the lower free troposphere.

1. Measurement and Results

Measurements: After successful measurements of PAN from May to October 2008, technical problems occurred which were solved in May 2009. Since then the instrument at JFJ works well providing continuous measurements. The calibration of the instrument is done on regular intervals. The very sensitive instrument to measure **NOy**, NO (and O_3) was installed in summer 2009. The operation of the measurement system required the construction of an additional inlet for air sampling. This turned out to be a rather difficult task; the construction of the inlet system needed careful design and a search for a suitable place at the observatory. Several problems needed to be solved before reliable measurements were possible. The NO_y measurements are currenty under evaluation.

Results: Fig. 1 shows PAN measurements performed within this project in comparison with the data from earlier years. The mixing ratios were particularly large in May 2008 compared to 2009 (see Fig. 2) which is hardly attributable to changes in primary pollutant emissions and therefore most probably caused by the differences in prevailing meteorological conditions. The very high concentrations in May 2008 suggest advection from the polluted planetary boundary layer.

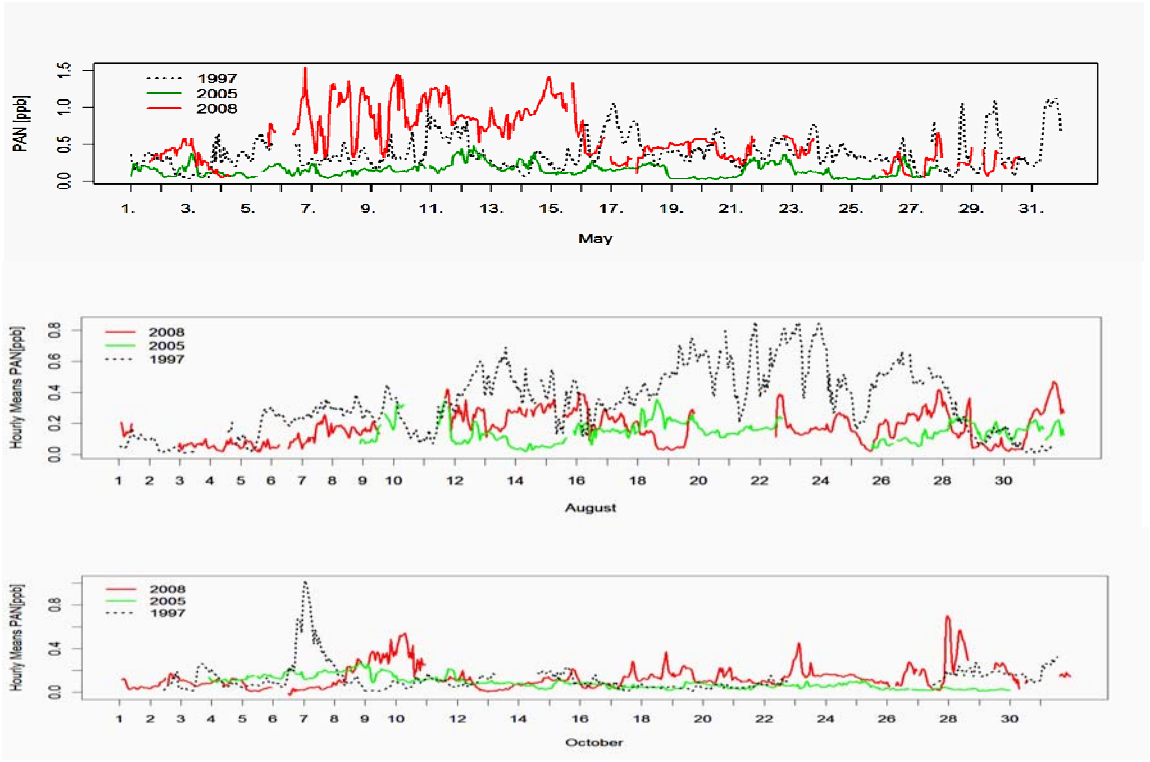

Figure 1: Selected measurements of Peroxyacetylnitrate (PAN) at Jungfraujoch in comparison with earlier measurements (1997: Zelllweger et al. (2003); 2005: Balzani Lööv et al. (2008)).

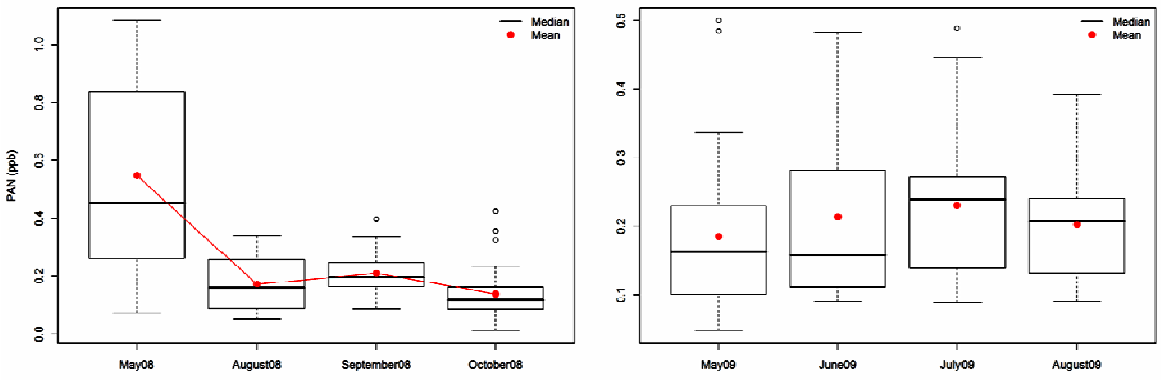

Figure 2 : Boxplot of PAN measurements at JFJ in 2008 and 2009.

For further analysis the PAN measurements were separated into different classes. PAN concentrations at JFJ vary depending on the history of air masses and the first goal of our study was to separate the air into two different categories; air masses with recent contact with the PBL and free tropospheric air. The main meteorological classes used in the analysis are Advective (abbreviated by A), Convective (abbreviated by C) and Mixed. The broad categories are sub categorized depending on the wind direction and speed at 500 hPa (Wanner et al 1998). The category "Convective Anticyclonic (CA)" is usually associated with low PAN mixing ratios in summer and autumn (see Fig. 3) suggesting that this class represents mostly free tropospheric air without recent contact with the polluted PBL

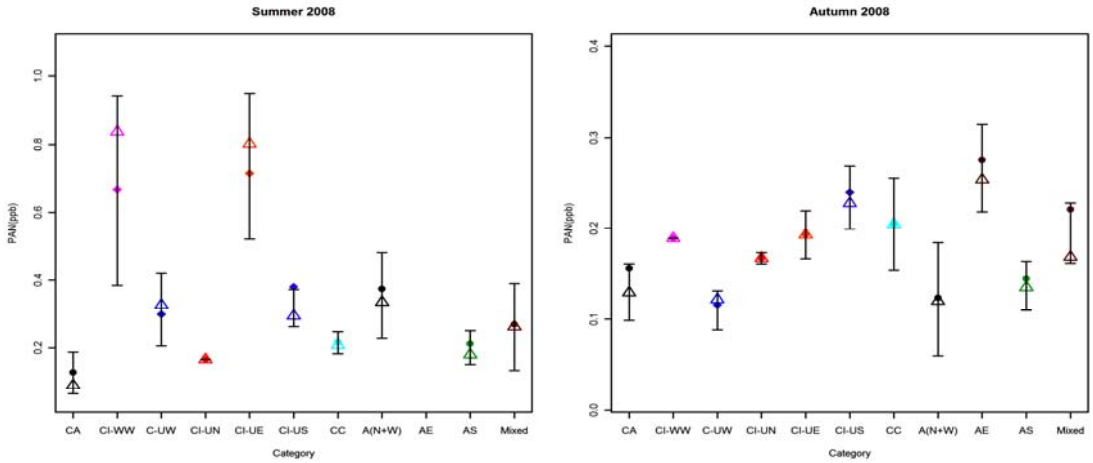

Figure 3: PAN measurement separated according to seasons using the Alpine Weather Statistics (AWS) (see Wanner et al., 1998).

2. Plans of the coming year

In the next year we will continue the field measurements of PAN and NO_y at JFJ. The data analysis and interpretation of the PAN and NO_y measurements (together with NO_x and other trace gases measured by Empa) will be continued. In the next step backward trajectory analysis will be used in order to learn more about the origin of the air pollutants transported to JFJ by long-range transport and how this is reflected in the composition of trace gases measured at JFJ. These results are particularly relevant in the context of intercontinental transport of air pollutants.

References

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Key words:

Atmospheric trace gases, free troposphere, planetary boundary layer, tropospheric chemistry, NO_y, PAN

Internet data bases:

http://www.iac.ethz.ch

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