Name of research institute or organization:

**Empa, Swiss Federal Laboratories for Materials Science and Technology**

Title of project:

# National Air Pollution Monitoring Network (NABEL)

Project leader and team:

Dr. Martin Steinbacher, Dr. Christoph Hüglin (project leader)

Project description:

The National Air Pollution Monitoring Network (NABEL) is run by Empa in joint collaboration with the Swiss Federal Office for the Environment (BAFU/FOEN). The NABEL network was established in 1978 with initially 8 sites emerging from activities that started already in 1968 as contributions to international observation networks as part of WMO and OECD. In-situ measurements by Empa at Jungfraujoch started in 1973. Early activities mainly focused on sulphur 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 from kerbside to remote free tropospheric background. The NABEL site at Jungfraujoch is a very low polluted site, representing a background station for the lower free troposphere in central Europe.

The current measurement program at Jungfraujoch includes continuous *in-situ* analyses of ozone ($O_3$), carbon monoxide (CO), nitrogen monoxide (NO), nitrogen dioxide ($NO_2$), the sum of nitrogen oxides ($NO_y$), sulphur dioxide ($SO_2$), methane ($CH_4$) and carbon dioxide ($CO_2$). The concentrations of $CH_4$ are also measured in 24 min intervals along with nitrous oxide ($N_2O$) and sulphur hexafluoride ($SF_6$). Molecular hydrogen ($H_2$) is semi-continuously monitored in 30-min intervals. An extended set of halocarbons and a selection of volatile organic compounds (VOCs) (alkanes, aromatics) are measured with a time resolution of two hours. Daily samples are taken for determination of particulate sulphur. The concentrations of particulate matter < 10 μm (PM10) are continuously observed as well as measured as 24-hour integrated samples.

The NABEL activities have several objectives such as

- the observation of air pollution levels and comparison with air quality standards,
- the long-term measurement of air pollutants for trend determinations and the control of success of air quality reduction mechanisms,
- the contribution to international programmes like the European Monitoring and Evaluation Programme (EMEP) or the Global Atmosphere Watch Programme (GAW) of the World Meteorological Organisation (WMO),
- the provision of information to the public about present air quality, and
- the role of a research platform and user lab.

Highest quality standards have to be applied to meet these goals leading to very demanding requirements for standards, calibrations, traceability, instruments, as well as data handling and standard operational quality control procedures. Special attention has to be paid to time series homogeneity, in particular when looking at atmospheric composition trends. Thus, thorough evaluations and intercomparisons have to be made especially when implementing novel measurement techniques.

After the successful implementation of spectroscopic techniques for the continuous in-situ observations of methane ($CH_4$) and carbon dioxide ($CO_2$) in 2010 (see HFSJG activity report 2010), further systematic tests were performed making use of the simultaneous water vapour observing capability of the Cavity Ringdown Spectrometers (CRDS). For this purpose, two CRDS analyzers were installed at Jungfraujoch. One of it was equipped with a drying unit to remove humidity prior to

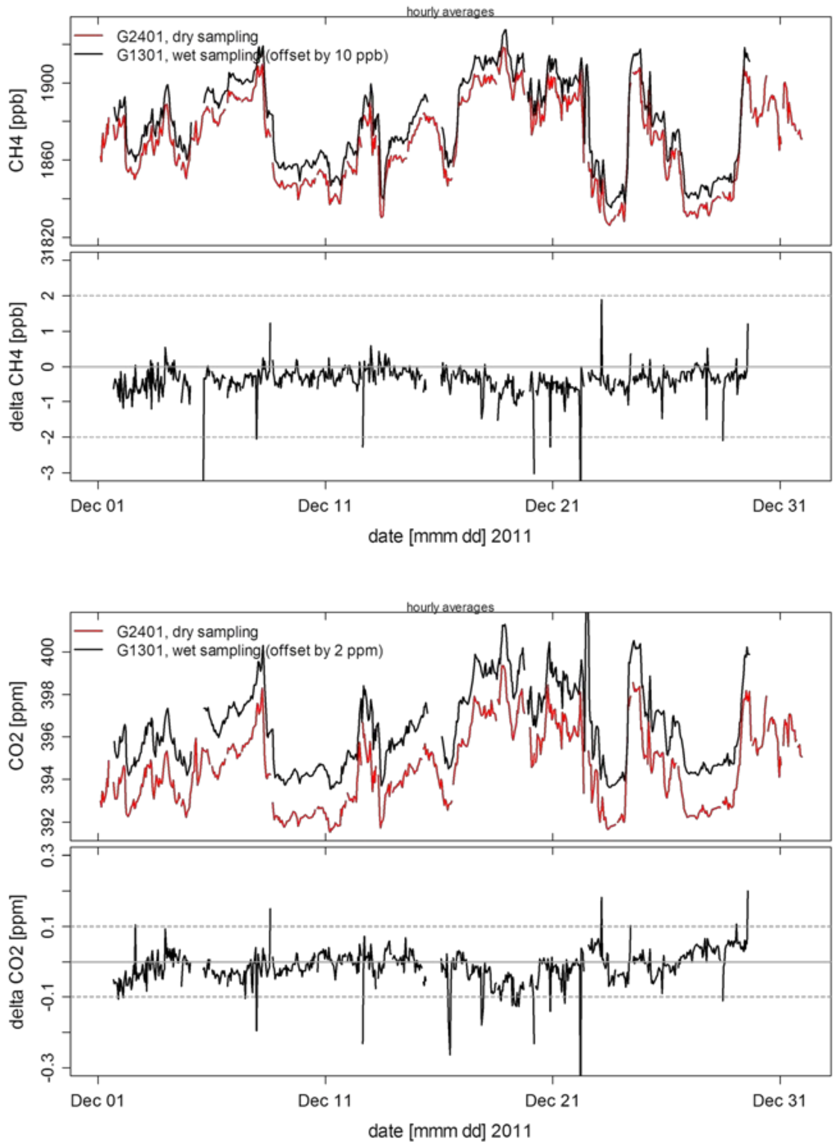


***Figure 1****: Time series of hourly averages of $CH_4$ (top plot) and $CO_2$ (bottom plot) dry air mole fractions at Jungfraujoch, measured with two CRDS analyzers in December 2011. The sample measured with instrument G2401 was dried prior to analysis while G1301 sampled unaltered humid air and dry air mole fractions were corrected according to the simultaneously recorded $H_2O$ readings of the G1301 analyzer. G1301 data were offset by 10ppb ($CH_4$) and 2ppm ($CO_2$) for the sake of readability. The lower panels display the G1301 to G2401 difference. The dashed grey lines illustrate the WMO compatibility goals of 2ppb ($CH_4$) and 0.1ppm ($CO_2$).*

analysis while the other analyser measured at ambient humidity. For the latter, dry air mixing ratios were determined by application of a humidity correction accounting for dilution and pressure broadening effects. The comparison (see Figure 1) showed a nearly perfect agreement of the observations, both for $CH_4$ and $CO_2$. This test confirmed that the CRDS technique allows sampling the fully unaltered humid gas stream and subsequently determining dry air greenhouse gas mixing ratios using the $H_2O$ signal of the analyzer. Consequently, a simpler gas flow setup upstream of the analyzer can be deployed that is less prone to artefacts, leakages and malfunctions.

CO observations with CRDS were commenced in fall 2011 next to the current non-dispersive infrared (NDIR) analyzer. The comparison shows a good agreement with all features similarly observed by both techniques (see Figure 2). However, a small bias of about 5ppb in non-compliance with the WMO compatibility goal of 2 ppb is observed. The reason for the slight offset is still under investigation. It might be caused by calibration issues or unconsidered instrumental features. A cross-calibration of the different calibration standards is still pending. Nevertheless, these first results reveal the superior performance of the CRDS compared to the NDIR technique in terms of noise. This exercise will turn into a longer term feasibility study of CO observations with CRDS aiming at replacing the current instrument by a laser spectrometer based instrument type in the future. It is envisaged to also test other laser spectrometers such as quantum cascade laser equipped analyzers in the near future.

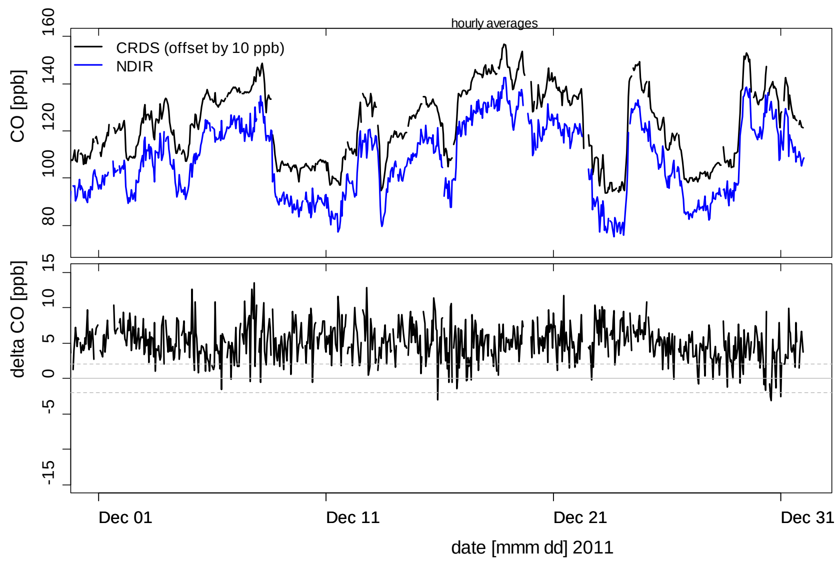


***Figure 2**: Time series of hourly averages of CO dry air mole fractions at Jungfraujoch, measured with CRDS and NDIR analyzers in December 2011. CRDS data were offset by 10ppb for the sake of readability. The lower panel display the CRDS to NDIR difference. The dashed grey lines illustrate the WMO compatibility goal for CO of 2ppb.*

Key words:

atmospheric chemistry, air quality, trace gases, long-term monitoring

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 (BAFU)/ Federal Office for the Environment (FOEN)
Global Atmosphere Watch (GAW)
Labor für Atmosphärenchemie, Paul Scherrer Institut
MeteoSchweiz
Climate and Environmental Physics, University of Bern

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