Name of research institute or organization:

Empa, Swiss Federal Laboratories for Materials Science and Technology

Title of project:

National Air Pollution Monitoring Network (NABEL)

Part of this programme:

EMEP, GAW, ICOS, ACTRIS

Project leader and team:

Dr. Martin Steinbacher, Simon A. Wyss, Dr. Christoph Zellweger, Dr. Lukas Emmenegger, Dr. Christoph Hüglin (project leader)

Project description:

The National Air Pollution Monitoring Network (NABEL) is run by Empa jointly 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 WMO and OECD observation networks. In-situ measurements by Empa at Jungfraujoch began 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 throughout Switzerland. The locations of these monitoring stations are representative for the most important air pollution levels ranging from the urban 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), carbon dioxide (CO_2) and nitrous oxide (N_2O). These data are stored as 10-min averages. Molecular hydrogen (H_2) is semi-continuously monitored in 30-min intervals. An extended set of halocarbons, sulphur hexafluoride (SF_6) and a selection of volatile organic compounds (VOCs) (alkanes, aromatics) are measured with a time resolution of two hours. The concentrations of particulate matter < 10 µm (PM10) are determined both continuously and in 24-hour integrated samples. Daily samples are taken to quantify particulate sulphur.

In 2015, two multi-week intercomparison campaigns were performed at Jungfraujoch to assess the quality of selected continuous NABEL observations. From January 16 to March 2nd, the Finnish Meteorological Institute (FMI) operated a Cavity Ringdown Spectrometer and a Fourier Transform Infrared (FTIR) spectrometer which allowed collocated measurements of CO, CO_2 and CH_4 (see the respective contribution to the activity report 2015 by FMI). Moreover, O_3, CO, CO_2 and CH_4 measurements were also evaluated as part of an audit by the World Meteorological Organization/Global Atmosphere Watch (GAW) World Calibration Centre for Surface Ozone, Carbon Monoxide, Methane and Carbon Dioxide (WCC-Empa). The ozone analyzer at Jungfraujoch was compared against the WCC-Empa travelling standard with traceability to a Standard Reference Photometer. The travelling standard was used for the generation of a randomized sequence of ozone levels ranging from 0 to 90 ppb (see Figure 1). The results confirmed that the Jungfraujoch ozone measurements are fully traceable to international standards.

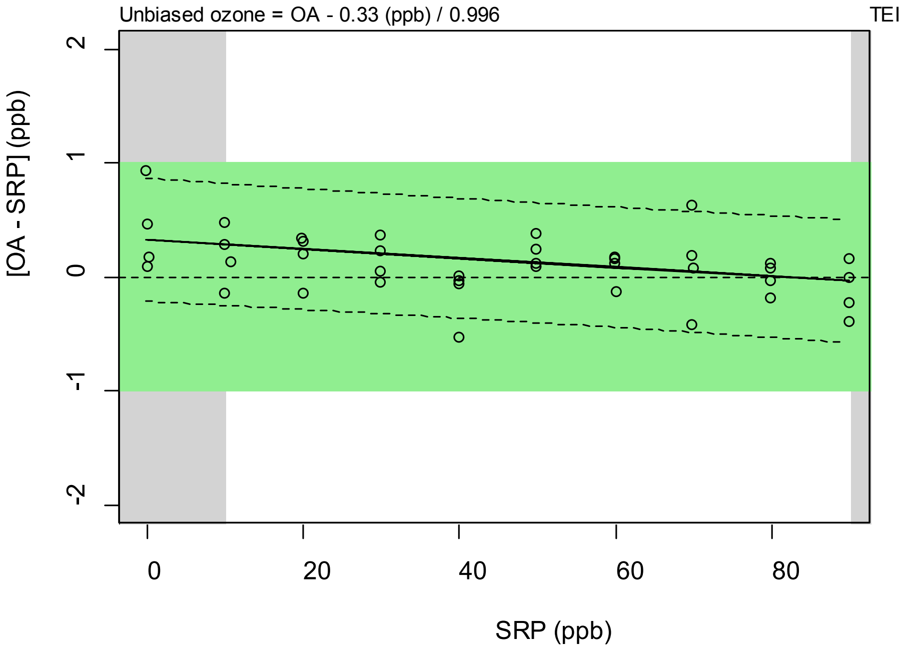

Figure 1. Comparison of the NABEL ozone analyzer (OA) with respect to the Standard Reference Photometer (SRP) as a function of mole fraction. The white area represents the mole fraction range relevant for Jungfraujoch, whereas the green range corresponds to the GAW data quality objectives. The dashed lines around the regression line illustrate the Working-Hotelling 95% confidence bands.

The CO, CO_2 and CH_4 performance was assessed by analysis of WCC-Empa travelling standards measured with the NABEL equipment and the verification of the resident calibration gases with the WCC-Empa instrumentation. Moreover, parallel measurements for CO, CO_2 and CH_4 using a travelling instrument were made from March 19 to May 29. Next to the reference gases comparison, this 10-week campaign provided additional information on the overall performance of the measurements at Jungfraujoch including the air sampling and data evaluation processes. The results showed an agreement well within the GAW compatibility goals for all audited species (see Figure 2).

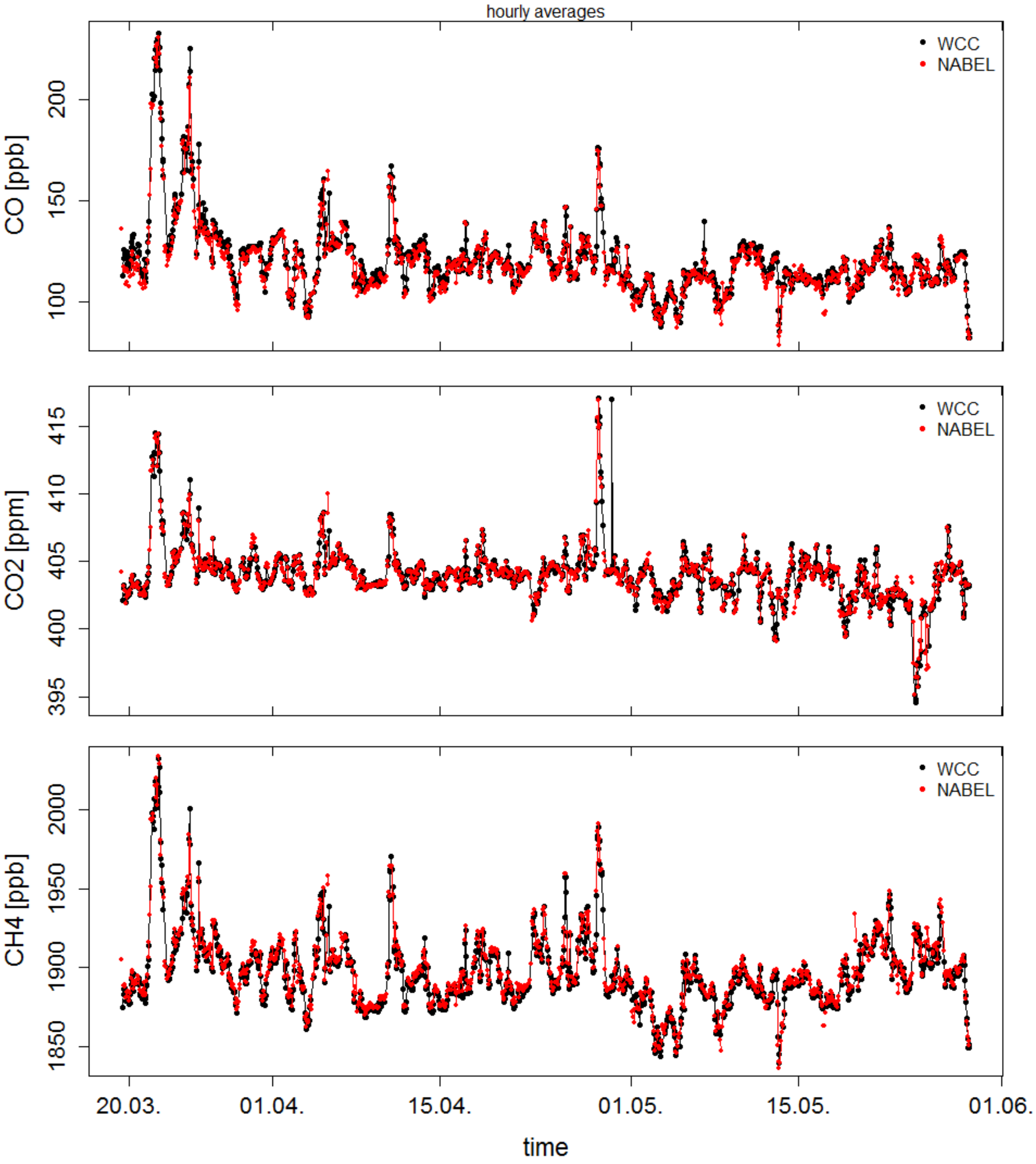

Figure 2. Time series of CO (top), CO_2 (middle) and CH_4 (bottom) mole fractions from March 19 to May 29, 2015. Data measured with the NABEL equipment are shown in red; data from WCC-Empa are shown in black.

In late 2014, new options to quality control the continuous Jungfraujoch measurements arose from the implementation of measurements at the Jungfrau East Ridge station. The former telecommunications station at 3705 m asl, approximately 1 km Southwest of the Sphinx station, is now equipped with instrumentation for continuous NO, NO_2, CO, CO_2 and CH_4 observations. Parallel measurements for East Ridge and Sphinx are available for the whole year of 2015. The additional measurements provide useful information on the representativeness of the observations at the Sphinx observatory and also allow identifying episodes when the Sphinx measurements are influenced by local (mainly touristic) activity which is occasionally the case, especially in summer. Measurements at East Ridge are rarely contaminated, and the impact of local sources is easily identifiable. Certain differences between the measurements at Sphinx and East Ridge can also be explained by the distance between the sites and the higher elevation (125 m) of the East Ridge station. For the less reactive gases CO, CO_2 and CH_4, the agreement is particularly good in winter when both

Sphinx and East Ridge are nearly always above the atmospheric boundary layer (see Figure 3). In contrast, clear differences can be observed in summer, e.g. when the influence of boundary layer air is less pronounced at East Ridge than at Sphinx (see Figure 4). Summertime differences are particularly visible in the CO_2 records when the intrusion of boundary layer air, which is often depleted in CO_2 due to the biospheric CO_2 uptake at lower altitudes, leads to lower mole fractions at Sphinx (see August 5 and 6). Sometimes, arrival times of the advected air masses can also be shifted by a few hours as it can be seen in the CO record on August 3rd.

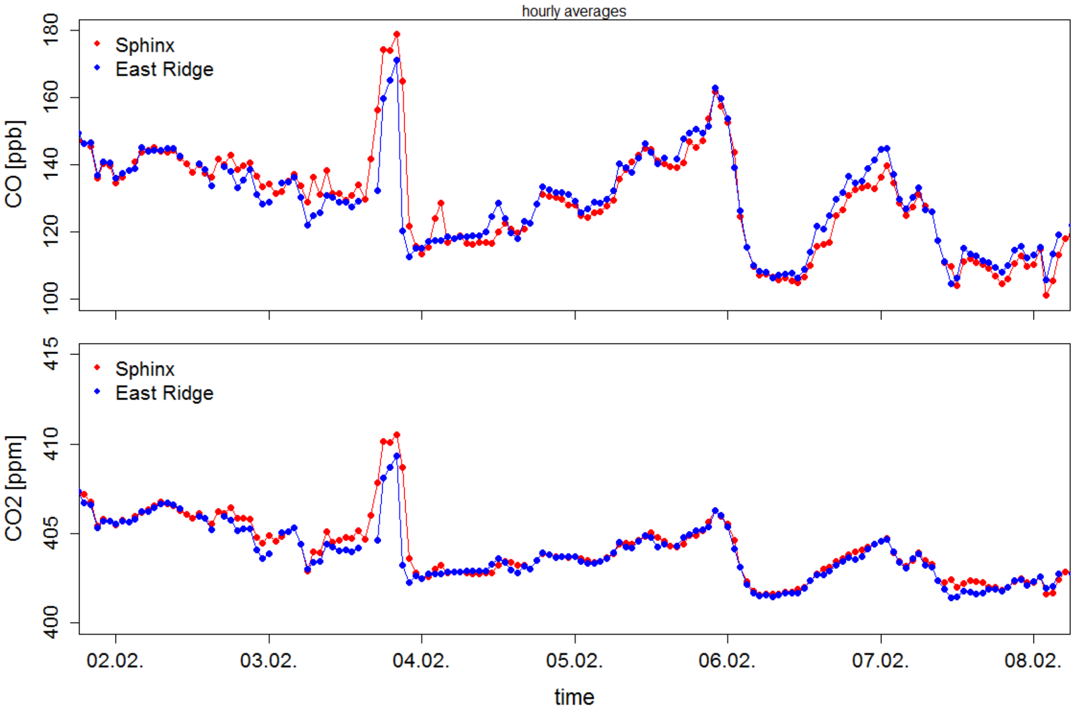

Figure 3. 6-day time series of CO (top) and CO_2 (bottom) mole fractions measured at the Sphinx observatory (red) and the East Ridge station (blue) in February 2015.

NO mole fractions are usually very low, close to or below the detection limit, at both sites. Absolute levels of NO_2 are difficult to compare as different instrumentation is used at Sphinx and East Ridge. While a photolytic converter is used at Sphinx to convert NO_2 to NO prior to analysis, a heated molybdenum converter is used at East Ridge. Molybdenum converters do require only little maintenance which is beneficial at a site like East Ridge where access is strongly restricted. However, it is known that molybdenum converters are also sensitive to other oxidized nitrogen species, and thus overestimate NO_2 concentrations (Steinbacher et al., 2007). A reasonable agreement was found for NO_x (i.e. the sum of NO and NO_2) measurements at East Ridge and NO_y (the sum all oxidized nitrogen species) measured at Sphinx (see Figure 5). Concurrent patterns in the time series point to larger scale phenomena, while specific features only observed in one of the time series are likely caused by local processes.

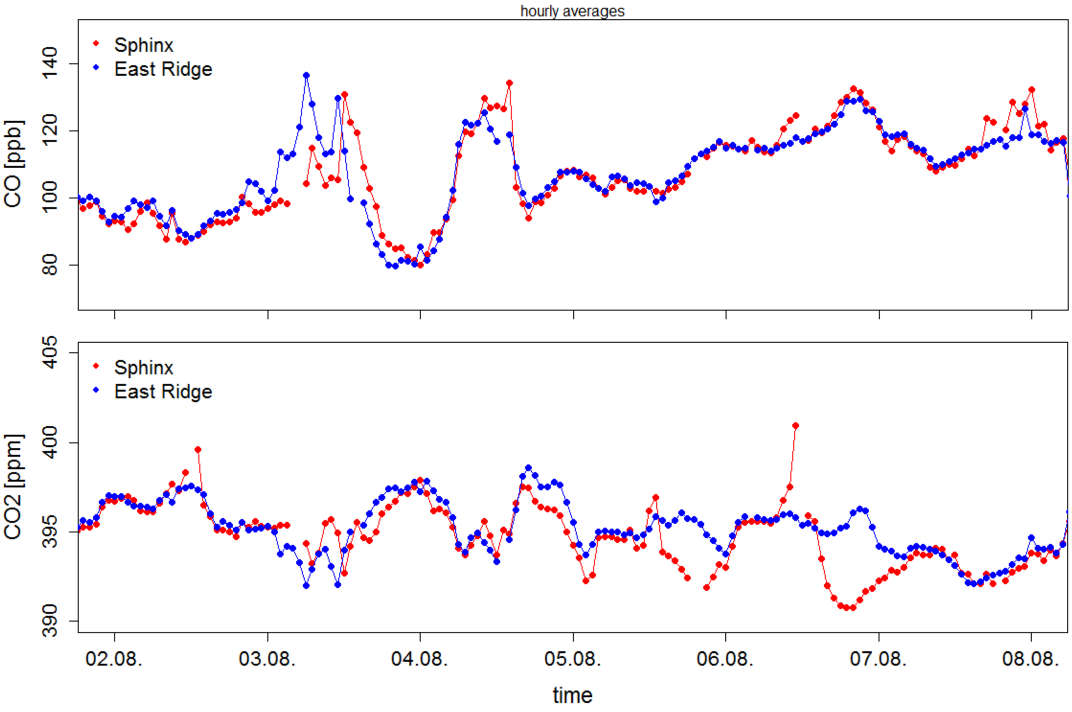

Figure 4. Same as Figure 3 but for 6 days in August 2015.

The comparison of the two data sets shows that the measurements at East Ridge are highly valuable for quality control, filtering and interpretation of the data recorded at the Sphinx observatory. Therefore, measurements are planned to be continued also in 2016.

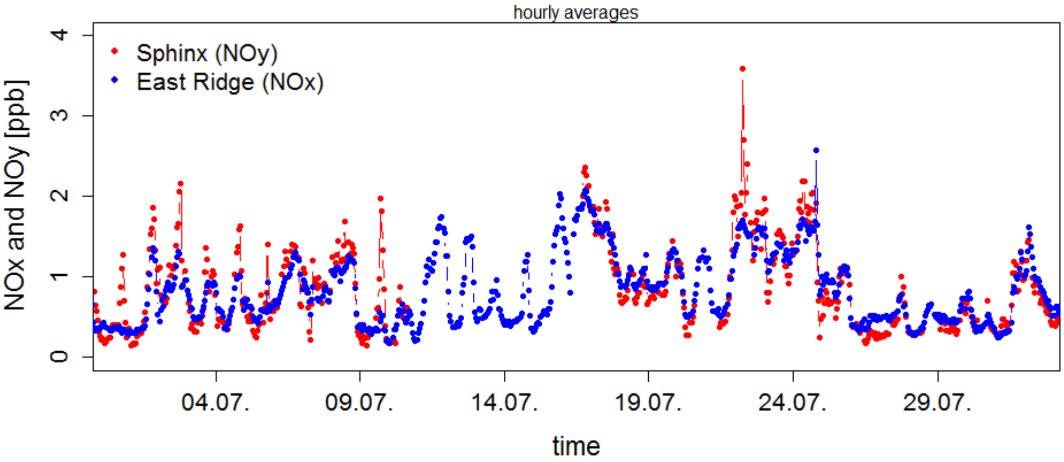

Figure 5. Time series of NO_y mole fractions at Sphinx (red) and NO_x mole fractions at East Ridge (blue) for July 2015.

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Key words:

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

Internet data bases:

http://empa.ch/web/s503/nabel
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Collaborating partners/networks:

Bundesamt für Umwelt (BAFU) / Federal Office for the Environment (FOEN)
Belgian Institute for Space Aeronomy, Brussels
Institut d'Astrophysique et de Géophysique, Université de Liège
Labor für Atmosphärenchemie, Paul Scherrer Institut
MeteoSchweiz
Climate and Environmental Physics, University of Bern
GAW – Global Atmosphere Watch
EMEP – European Monitoring and Evaluation Programme
ICOS – Integrated Carbon Obervation System
InGOS – Integrated non-CO2 Greenhouse gas Observation System
ACTRIS – Aerosol, Clouds, and Trace Gases Research Network

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