Name of research institute or organization:

Empa, Swiss Federal Laboratories for Materials Science and Technology

Title of project:

Continuous measurement of stable CO_2 isotopes at Jungfraujoch, Switzerland

Part of this programme:

ICOS

Project leader and team:

Dr. Lukas Emmenegger, project leader
Dr. Béla Tuzson

Project description:

In-situ, continuous, and high precision isotope ratio measurements of CO_2 are performed using a quantum cascade laser absorption spectrometer (QCLAS). The three main CO_2 isotopologue mixing ratios ($^{12}C^{16}O_2$, $^{13}C^{16}O_2$ and $^{12}C^{18}O^{16}O$) are directly and simultaneously measured with one-second time resolution since December 2008, providing the first long-term, continuous time series for a remote location. The obtained time-series (see Figure 1) contain information about the CO_2 source- and sink processes and their dynamics at local, regional and continental scales and, thus, allows us to gain unprecedented insight into the temporal and spatial characteristics of atmospheric CO_2.

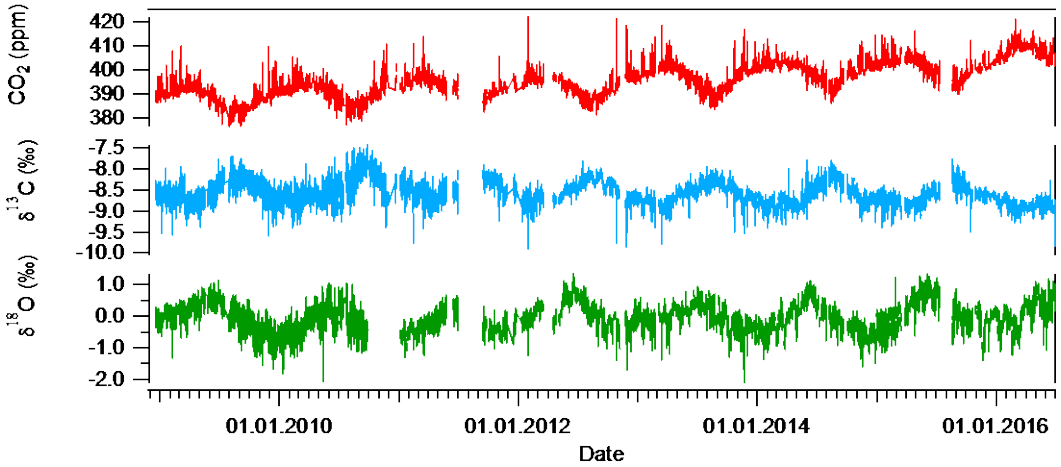

Figure 1. Overview of the data (one hour average) recorded since December 2008. The yearly cycles of CO_2, and isotopic ratios of $\delta^{13}C$ and $\delta^{18}O$ are easily observed, while the individual pollution events appear as sharp spikes.

An analytical precision better than 0.03 ‰ for both $\delta^{13}C$ and $\delta^{18}O$ for an averaging time of 10 minutes is routinely achieved. However, this can be only guaranteed for stable operating conditions. Rapid changes in the laboratory temperature have been seen to induce apparent changes in $\delta^{13}C$ and $\delta^{18}O$ of up to 1 ‰, while slow temperature drifts are taken accounted for by reference gas measurements every 15 minutes. Figure 2 illustrates situations, where sudden, periodical, and strong changes of the temperature in the Sphinx laboratory cannot fully be corrected in the measured isotope ratio values, whereas the effects of slow temperature drifts are completely removed by the measurement and calibration procedures.

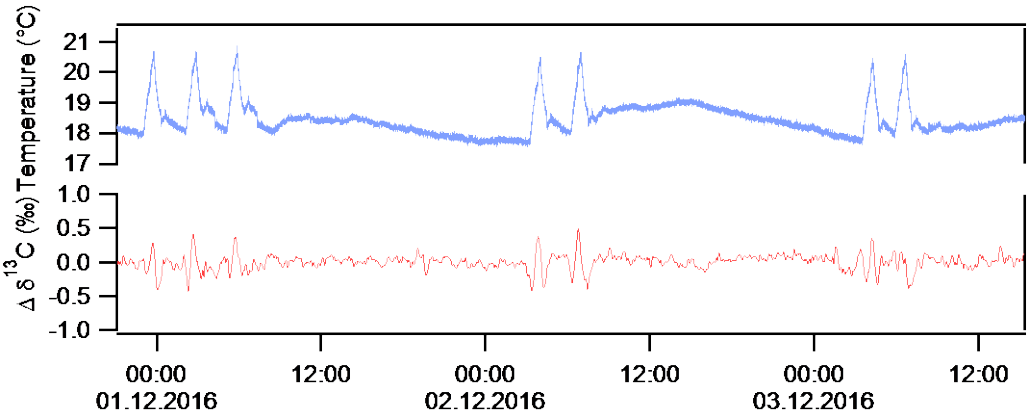

Figure 2. Effect of ambient temperature variations on the measured isotope ratio. Slow drifts are well compensated for, while fast and large changes create significant disturbances in the retrieved isotopic ratio.

Key words:

Isotope ratio measurements, carbon dioxide, laser spectroscopy, quantum cascade laser

Collaborating partners/networks:

ICOS – Integrated Carbon Observation System
RINGO - Readiness of ICOS for Necessities of integrated Global Observations
Max Planck Institute for Biogeochemistry, Jena, Germany
University of Berne, Switzerland

Scientific publications and public outreach 2016:

Conference papers

Emmenegger, L., S. Reimann, D. Brunner, M. Vollmer, S. Henne, Measurements and Modelling for GHG emissions estimation, IG3IS Side Event, EGU General Assembly, Vienna, Austria, April 19, 2016.

Emmenegger, L., Trace gas measurements at Jungfraujoch, GAW-CH Spring Meeting, Zürich, Switzerland, April 6, 2016.

Emmenegger, L., B. Buchmann, C. Hüglin, S. Reimann, M. Vollmer, M. Steinbacher, Sherlock und die Sphinx, The Swiss Society for Meteorology SGM, Zürich, Switzerland, June 3, 2016.

Emmenegger, L., J. Mohn, E. Harris, S. Eyer, E. Ibraim, B. Tuzson, Frontiers of QC Laser spectroscopy for high precision isotope ratio analysis of greenhouse gases, EGU General Assembly, Vienna, Austria, April 17-22, 2016.

Steinbacher, M., S. A. Wyss, B. Tuzson, F. Conen, G. Martucci, T. A. Berhanu, M. Leuenberger, L. Emmenegger, The Swiss Contribution to Atmospheric Observations in ICOS RI – the class 1 candidate station Jungfraujoch, Swiss Global Change Day, Bern, Switzerland, April 12, 2016.

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