

Name of research institute or organization:

Empa – Swiss Federal Laboratories for Materials Testing and Research

Title of project:

Continuous measurement of stable CO₂ isotopes at Jungfraujoch, Switzerland

Project leader and team:

Lukas Emmenegger, project leader
Bela Tuzson
Brigitte Buchmann

Project description:

A recently developed instrument employing direct absorption spectroscopy was installed on the high altitude research station Jungfraujoch (3580 m a.s.l.) for *in situ* and continuous measurements of $\delta^{13}\text{C}\text{-CO}_2$ and $\delta^{18}\text{O}\text{-CO}_2$ isotope ratios. The spectrometer employs a novel quantum cascade laser at 4.3 μm as light source, combined with thermoelectrically cooled IR-detectors. This design allows for cryogen-free operation, thus facilitating long-term and unattended operation. Spectra of $^{12}\text{C}^{16}\text{O}^{16}\text{O}$, $^{13}\text{C}^{16}\text{O}^{16}\text{O}$ and $^{12}\text{C}^{18}\text{O}^{16}\text{O}$ are acquired in a 76 m astigmatic multipass cell at a pressure of 60 mbar.

The QCL spectrometer has been running since September 2008. It delivers real-time measurements of the main CO₂ isotopes. The CO₂ mixing ratios and isotope ratios are in excellent agreement with flask sampling, followed by well established NDIR and IRMS analysis. Detailed data analysis was performed for a three month winter period starting in February 2009.

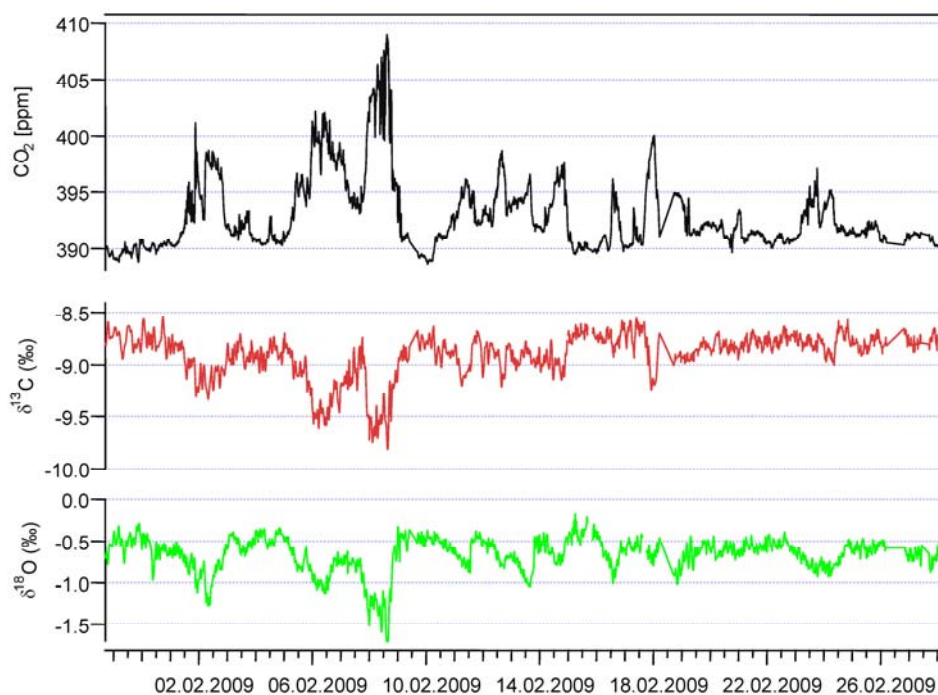


Figure 1: Time series of CO₂, δ¹³C-CO₂ and δ¹⁸O-CO₂ during February 2009, measured at Jungfraujoeh by QCLAS. Marked patterns in CO₂ mixing ratios are related to changes to CO (not shown) and CO₂ isotope ratios.

During this period, various pollution events were identified based on changes in the relation between CO₂ and carbon monoxide (CO) mixing ratios (Figure 1). Each of these events show significant changes in δ¹³C-CO₂ and δ¹⁸O-CO₂ which can be used to determine CO₂ source signatures using the Keeling intercept method.

Key words:

Isotope ratio measurements, laser spectrometry, quantum cascade laser

Collaborating partners/networks:

IMECC - Infrastructure for Measurements of the European Carbon Cycle
University of Bern, Climate and Environmental Physics
ETHZ - Inst. for Quantum Electronics
Alpes Lasers SA

Scientific publications and public outreach 2009:

Conference papers

Emmenegger, L., Mohn, J. and Tuzson, B. (2009). Development and application of quantum cascade laser spectroscopy for CO₂ and N₂O isotopes in environmental research, Atmospheric Sciences Seminar, September 25, University of Harvard, USA.

Mohn, J., Tuzson, B. and Emmenegger, L. (2009). Advances in infrared spectroscopy for conducted and diffuse emissions, Conference on Emissions Monitoring, September 23-25, Stresa, Italy.

Mohn, J., Tuzson, B., Guggenheim, C., Vollmer, M. K. and Emmenegger, L. (2009). High precision and site selective N₂O isotopomer analysis at ambient concentrations. Field Laser Applications in Industry and Research, September 6-11, Garmisch-Partenkirchen, Germany.

Tuzson, B. and Emmenegger, L. (2009). Recent advances in CO₂ isotope ratio measurements using quantum cascade lasers. 8th international carbon dioxide conference, September 12-19, June 13-17, Jena, Germany.

Tuzson, B., Mohn, J. and Emmenegger, L. (2009). Applications of QCL based spectrometers for isotope ratio measurements in environmental research. 7th International Conference on Tunable Diode Laser Spectroscopy. Zermatt, Switzerland.

Magazine and Newspapers articles

"Empa-Analysengerät für Kohlendioxid-Isotopen auf dem Jungfraujoeh", Messtechni/Sensorik, Februar, 2009.

"Continuous CO₂ emissions tester uses QC laser", Laser Focus World, March 1, 2009.

"La signature isotopique du CO₂", Green News Technologies, February 2009.

Address:

Empa
Laboratory for Air Pollution/Environmental Technology
Überlandstrasse 129
CH-8600 Dübendorf

Contacts:

Lukas Emmenegger
Tel.: +41 44 823 4699
Fax: +41 44 821 6244
e-mail: lukas.emmenegger@empa.ch
URL: <http://empa.ch/abt134>

