

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 Jungfrauoch, Switzerland

Project leader and team:

Lukas Emmenegger (project leader), Bela Tuzson, Kerstin Zeyer, Brigitte Buchmann

Project description:

A recently developed instrument employing direct absorption spectroscopy was installed on the high altitude research station Jungfrauoch (Switzerland) for *in situ* and continuous measurements of $\delta^{13}\text{C}\text{-CO}_2$ and $\delta^{18}\text{O}\text{-CO}_2$ isotope ratios (Fig. 1). 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.

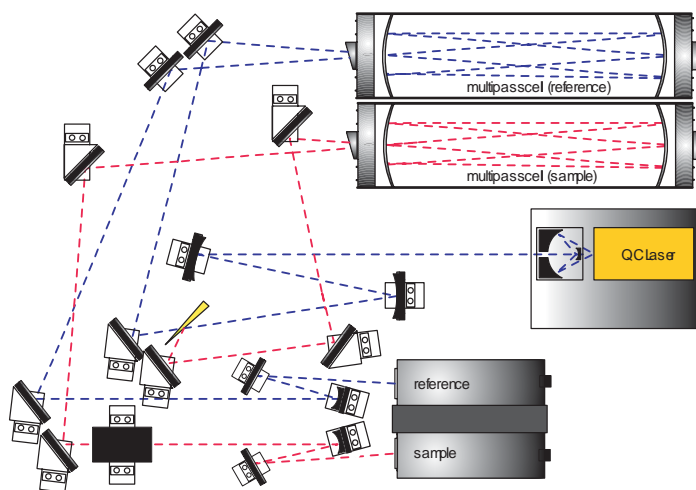


Fig. 2: Optical layout of the QCL spectrometer for stable CO₂ isotope ratio measurements.

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 (Fig 2). Before being deployed at this high altitude station, the instrument's performance was demonstrated in various laboratory and field studies (1,2), achieving a precision better than 0.1‰.

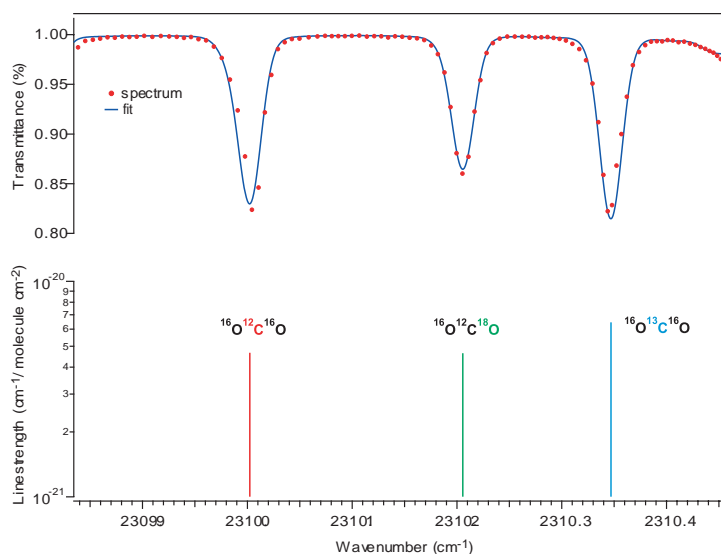


Fig. 2: measured (dots) and simulated (line) spectra and corresponding strength of absorption lines.

The spectrometer has run continuously since September 2008, providing for the first time continuous isotope ratio data of both $\delta^{13}\text{C}\text{-CO}_2$ and $\delta^{18}\text{O}\text{-CO}_2$, which will be further validated based on IRMS for isotope ratios and NDIR for CO_2 mixing ratios.

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

Scientific publications and public outreach 2008:

Refereed journal articles

Tuzson, B., Mohn, J., Zeeman, M. J., Werner, R. A., Eugster, W., Zahniser, M. S., Nelson, D. D., McManus, J. B. and Emmenegger, L. (2008). High precision and continuous field measurements of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in carbon dioxide with a cryogen-free QCLAS. *Applied Physics B: Lasers and Optics*: **92**(3), doi:10.1007/s00340-008-3085-4

Tuzson, B., Zeeman, M. J., Zahniser, M. S. and Emmenegger, L. (2008). Quantum cascade laser based spectrometer for in situ stable carbon dioxide isotope measurements. *Infrared Physics and Technology* **51**(3): 198-206, doi:10.1016/j.infrared.2007.05.006

Conference papers

Emmenegger L., B. Tuzson, J. Mohn, J. M. Zahniser, M. Waechter, M. Sigrist M, high precision isotope ratio analysis of CO_2 and N_2O using quantum cascade laser absorption spectroscopy, International Quantum Cascade Lasers Workshop, Monte Verita, Switzerland.

Emmenegger, L., B. Tuzson, J. Mohn B, M. Zeeman, A. Kammer, applications of laser spectroscopy for CO_2 isotopologues: from the soil to the free troposphere, Swiss Chemical Society Fall Meeting, Zürich, Switzerland.

Tuzson, B., J. Mohn, H. Waechter, M. Zahniser, L. Emmenegger, continuous and high-precision measurements of N₂O and CO₂ isotopes with a cryogenic free QClaser based spectrometer, International Symposium on Isotopomers, Tokyo, Japan, 2008.

Magazine and Newspapers articles

"Neues CO₂-Messgerät auf dem Jungfrauoch", NZZ Online, November 19, 2008.

"Le Jungfrauoch accueille un appareil analysant le CO₂", Le Quotidien Jurassien, November 20, 2008.

"Brèves planète: CO₂", Le Temps, November 20, 2008.

"CO₂-Quellen auf der Spur", Tagesanzeiger, November 20, 2008.

"Empa-Gerät auf Jungfrauoch", Zürcher Oberländer, November 20, 2008.

"Le CO₂ humain traqué au sommet de la Jungfrau", 24 heures, November 21, 2008.

"Schweizer Wissenschaftler erforschen natürliche CO₂-Quellen", Ad Hoc News, November 21, 2008.

"Woher kommt das Kohlendioxid?", Basler Zeitung, November 21, 2008.

"Le CO₂ humain traqué au sommet de la Jungfrau", Tribune de Genève, November 21, 2008.

"Kohlendioxid-Quellen auf der Spur", Jungfrau Zeitung, November 21, 2008.

"Jungfrauoch, der Luft auf der Spur", Berner Zeitung, November 22, 2008.

"Impact des activités humaines sur le CO₂", Le Journal du Jura, November 25, 2008.

"Kontinuierliche CO₂-Daten vom Jungfrauoch", Neue Zürcher Zeitung, November 26, 2008.

"Dem CO₂ auf der Spur", Der Garten Bau, November 27, 2008.

"Klimaforschung in grosser Höhe", Der Bund, November 28, 2008.

Radio and television

"Neues CO₂-Messgerät auf dem Jungfrauoch", Nachrichten DRS, November 20, 2008.

"New CO₂ tracker on Jungfrauoch", interview with L. Emmenegger, World Radio Switzerland, November 21, 2008.

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>

