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

Project leader and team:

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Bela Tuzson
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Project description:

Isotope ratios of CO_2 are highly valuable to investigate CO_2 sources, sinks and fate at local, regional and global scales. This is possible because the physical and biochemical processes that are involved in the carbon cycle lead to characteristic isotopic fractionation. However, such studies often require extensive and long term measurements under field conditions, which are only feasible with a recently developed direct absorption spectrometer employing quantum cascade lasers (QCL). The instrument is designed for continuous and high precision CO_2 isotope ratio measurements at ambient concentration. It is compact and entirely cryogen-free, which greatly facilitates field applications that require long-term, fast and *in situ* monitoring. The concentration of the three main CO_2 stable isotopologues ($^{16}O^{12}C^{16}O$, $^{16}O^{13}C^{16}O$ and $^{18}O^{12}C^{16}O$) is simultaneously measured, and both the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios are obtained with a precision of < 0.05 ‰.

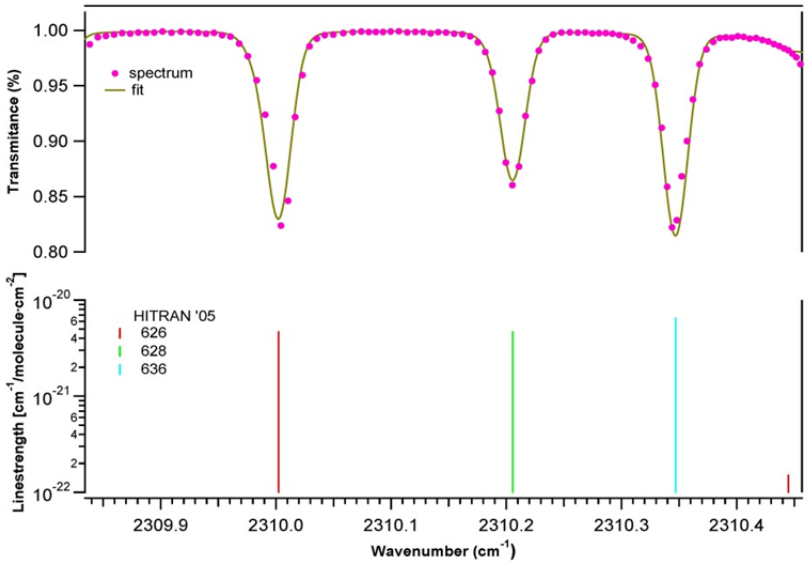

Figure 1: Measured (dots) and fitted spectrum (solid line) of the CO_2 isotopologues (top) and the corresponding line strengths (bottom).

The QCL spectrometer delivers for the first time continuous measurements of CO_2 isotopologues in the free troposphere at Jungfraujoch (3580 m a.s.l.). Detailed data analysis was performed for a three month winter period starting in February 2009. During this period, various pollution events were identified based on changes in the

relation between CO_2 and carbon monoxide (CO) mixing ratios. Each of these events show significant changes in $\delta^{13}C$-CO_2 and $\delta^{18}O$-CO_2 which can be used to determine CO_2 source signatures using the Keeling-plot intercept method. Furthermore, these signatures can also be linked to source regions using Lagrangian backward trajectories.

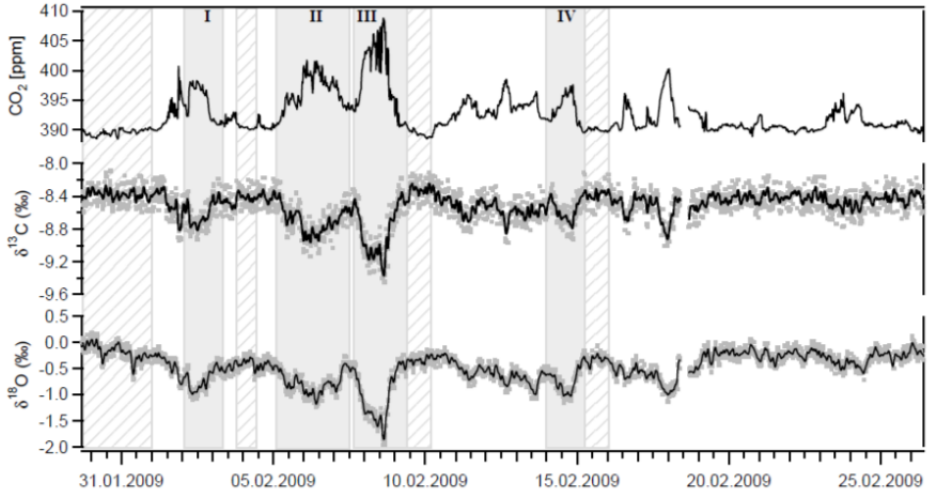

Figure 2: Time series of CO_2 mixing ratio and its isotopic composition. For the delta values, the gray dots represent 10 min averages, while the solid line is an interpolation using a smooth spline. The shaded areas indicate distinct pollution events. Hatched areas are periods with free tropospheric background conditions.

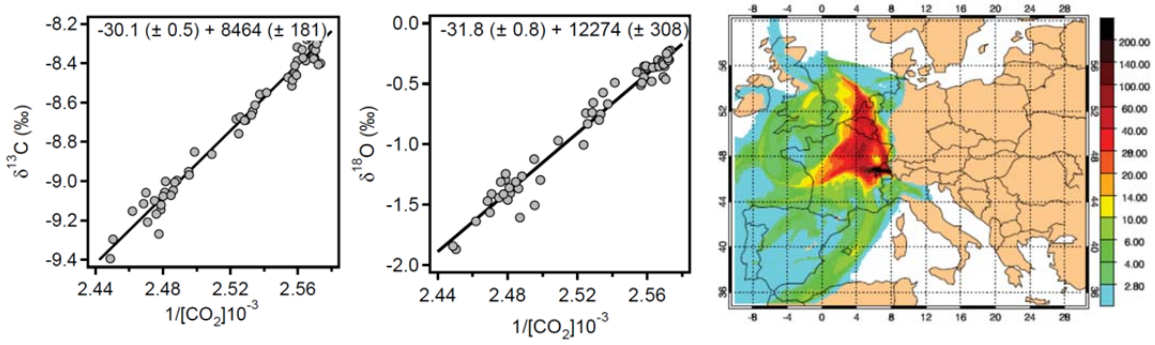

Figure 3: Details for pollution event III. For Keeling plots, one hour means of isotope ratio values are plotted against the inverse of the CO_2 mixing ratio. LPDM calculations, show the potential source regions (surface footprints) of air-masses reaching JFJ. Yellow to red colors (s kg^{-1} m^3) identify regions from which elevated CO_2 potentially originated. Left: Keeling plot for $\delta^{13}C$-CO_2; middle: Keeling plot for $\delta^{18}O$-CO_2; right: LPDM.

Key words:

Isotope ratio measurements, laser spectrometry, quantum cascade laser

Collaborating partners/networks:

Bundesamt für Umwelt (BAFU)/ Federal Office for the Environment (FOEN)
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 2010:

Refereed journal articles and their internet access

Tuzson, B., Henne, S., Brunner, D., Steinbacher, M., Mohn, J., Buchmann, B. and Emmenegger, L. (2010). Continuous isotopic composition measurements of tropospheric CO2 at Jungfraujoch (3580ma.s.l.), Switzerland: real-time observation of regional pollution events. Atmos. Chem. Phys. Discuss. **10**: 24563–24593, doi:10.5194/acpd-10-24563-2010.
http://www.atmos-chem-phys-discuss.net/10/24563/2010/acpd-10-24563-2010.pdf

Conference papers

Emmenegger, L., Tuzson, B., Mohn, J., Heeb, N., Brunner, D., Steinbacher, M. and Buchmann, B. (2010). Regional pollution events observed by continuous measurements of δ^{13}C-CO_2 and δ^{18}O-CO_2 at Jungfraujoch using quantum cascade laser spectroscopy. ACP Symposium. Interlaken, Switzerland.

Emmenegger, L., Tuzson, B., Mohn, J., Zahniser, M., Kammer, A. and Zeeman, M. J. (2010). Real-time measurement of δ13C and δ18O in CO2 by QCLAS - from the soil to the free troposphere. EGU 2010, European Geosciences Union, Vienna, Germany.

Tuzson, B., Kammer, A., Zeeman, M. J., Mohn, J., Zahniser, M. and Emmenegger, L. (2010). In situ investigation of CO_2 dynamics of biosphere-atmosphere carbon exchange based on real-time measurement of δ^{13}C and δ^{18}O by QCLAS. COST-SIBAE WG3 Laser Workshop. Zürich, Switzerland.

Tuzson, B., Mohn, J., Steinbacher, M., Henne, S., Brunner, D. and Emmenegger, L. (2010). Long-term and in situ spectroscopic measurements of δ^{13}C and δ^{18}O of CO_2 at Jungfraujoch (3580 masl) reveal regional pollution events. ISI 2010, The Fifth International Symposium on Isotopomers. Amsterdam, Netherlands.

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