Continuous measurement of stable CO_2 isotopes at Jungfraujoch, Switzerland

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1. Project description

Long-term observations of carbon dioxide (CO_2) provide direct information about their variability and rate of change in the atmosphere. Co-located observations of stable CO_2 isotope ratios add unique information on the CO_2 fluxes between the different pools involved in the carbon cycle owing to isotopic fractionation during environmental processes. Atmospheric CO_2 concentration and its stable isotope ratios ($\delta^{13}C$ and $\delta^{18}O$) are measured continuously and simultaneously by in-situ quantum cascade laser absorption spectroscopy (QCLAS) since December 2008 at the Jungfraujoch research station as previously described (Tuzson et al., 2008 and 2011; Sturm et al. 2013). These unique data, available as 10 min averages, enable the analysis of variations at hourly time-scales, and allow for an evaluation of atmospheric transport model simulations of CO_2 and $\delta^{13}C$. A pre-requisite for these activities are the long-term high data quality.

Therefore, we conducted an inter-comparison of the continuous in-situ QCLAS measurements with data from off-line analysis of discrete air samples. The discrete air samples were collected in triplicates on a bi-weekly basis and analysed at MPI-BGC Jena. Data are kindly provided by A. Jordan, H. Moossen and M. Rothe. The CO_2 concentration is determined by gas-chromatography with flame ionization detection (GC-FID) following the reduction of CO_2 with hydrogen. The stable CO_2-isotope ratios are determined by standard isotope ratio mass spectrometry (IRMS, Werner et al., 2001).

2. Results

Figure 1 and Table 1 summarize the inter-comparison results for the period 2009-2017 and highlight the high data quality.

Table 1. Average difference between "in-situ" and "off-line" measurements compared to WMO goals.

Parameter	"in-situ" minus "off-line" (AVG ± 1 SD)	WMO "Extended Compatibility"
CO_2	-0.1 (± 0.6) ppm	0.2 ppm
$\delta^{13}C$-CO_2	-0.06 (± 0.10) ‰	0.1 ‰
$\delta^{18}O$-CO_2	-0.03 (± 0.22) ‰	0.1 ‰

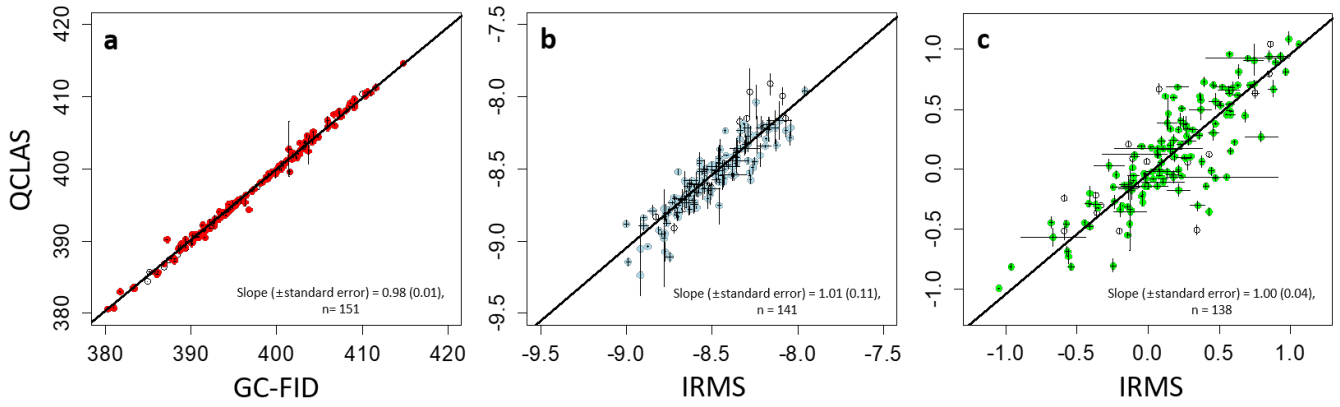

Figure 1. Inter-comparison of continuous in-situ measurements by QCLAS with off-line analysis of discrete air samples by GC-FID and IRMS. a) CO_2, in ppm, b) $\delta^{13}C$-CO_2, in ‰, and c) $\delta^{18}O$-CO_2, in ‰. Coloured circles represent in-situ data as 30-min averages (±1SD) and corresponding off-line data represent the average (±1 SD) of three identical samples from one sampling activity. Open circle data points are from incomplete data pairs (e.g., when less than three parallel off-line air samples are available) and have been excluded from the fit and inter-comparison.

3. Conclusions and Outlook

Real-time observations capture hourly variations and thereby provide insights into the dynamics of atmospheric CO_2. The high quality of the continuous $\delta^{13}C$-CO_2 data was confirmed by comparison with reference IRMS results obtained from bi-weekly sampled air samples. The accuracy and the quality of the QCLAS data allows for their use in evaluating atmospheric transport model simulations of CO_2, which are ongoing. The interpretation of these simulation data aims at source apportionment of CO_2 from anthropogenic emission and biosphere respiration.

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Internet data bases

http://www.empa.ch
http://empa.ch/web/s503/laser
https://www.icos-ri.eu/

Collaborating partners / networks

Institut für Umweltgeowissenschaften, University of Basel
Climate and Environmental Physics, University of Bern
Max Planck Institute for Biogeochemistry, Jena, Germany

GAW – Global Atmosphere Watch
ICOS – Integrated Carbon Observation System
RINGO – Readiness of ICOS for Necessities of integrated Global Observations

Scientific publications and public outreach 2019

Conference Papers

Pieber, S.M., B. Tuzson, D. Brunner, S. Henne, A. Jordan, H. Moossen, M. Rothe, M. Steinbacher, L. Emmenegger, A decade of continuous high altitude atmospheric CO_2 isotope ratio ($\delta^{13}C$, $\delta^{18}O$) measurements at Jungfraujoch, CH, European Geoscience Union General Assembly, Vienna, Austria, April 7-12, 2019.

Pieber, S.M., D. Brunner, S. Henne, A. Jordan, H. Moossen, M. Rothe, M. Steinbacher, B. Tuzson, L. Emmenegger, A decade of continuous and discrete trace gas and stable isotope ratio measurements at Jungfraujoch: method comparison, RINGO Annual Scientific Meeting, Southampton, UK, March 20-22, 2019.

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