

Name of research institute or organization:

Climate and Environmental Division, Physics Institute, University Bern

Title of project:

High precision carbon dioxide and oxygen measurements at Jungfraujoch

Part of this programme:

ICOS, GAW, Obspack, Globalview

Project leader and team:

Prof. Dr. Markus Leuenberger, project leader
Michael Schibig, Peter Nyfeler, Hanspeter Moret and Tesfaye Berhanu

Project description:

Combined online CO₂ and O₂ measurements at Jungfraujoch were continued and trends were updated for the period 2005 to 2014 which resulted in a CO₂ increase rate of 2.04 ± 0.03 ppm y⁻¹ and a decrease rate of -22.44 ± 0.47 per meg y⁻¹, respectively. Due to the documented deviation in O₂ for spring/summer 2013, we reinvestigated the O₂ correction and calibration procedure again and found (i) shortcomings in the programmed dilution correction that (ii) led to an update of assigned values for the working gas tanks that have been used throughout the complete measurement period. This led to an absolute shift as well as a slight slope change for O₂ compared to previous reports.

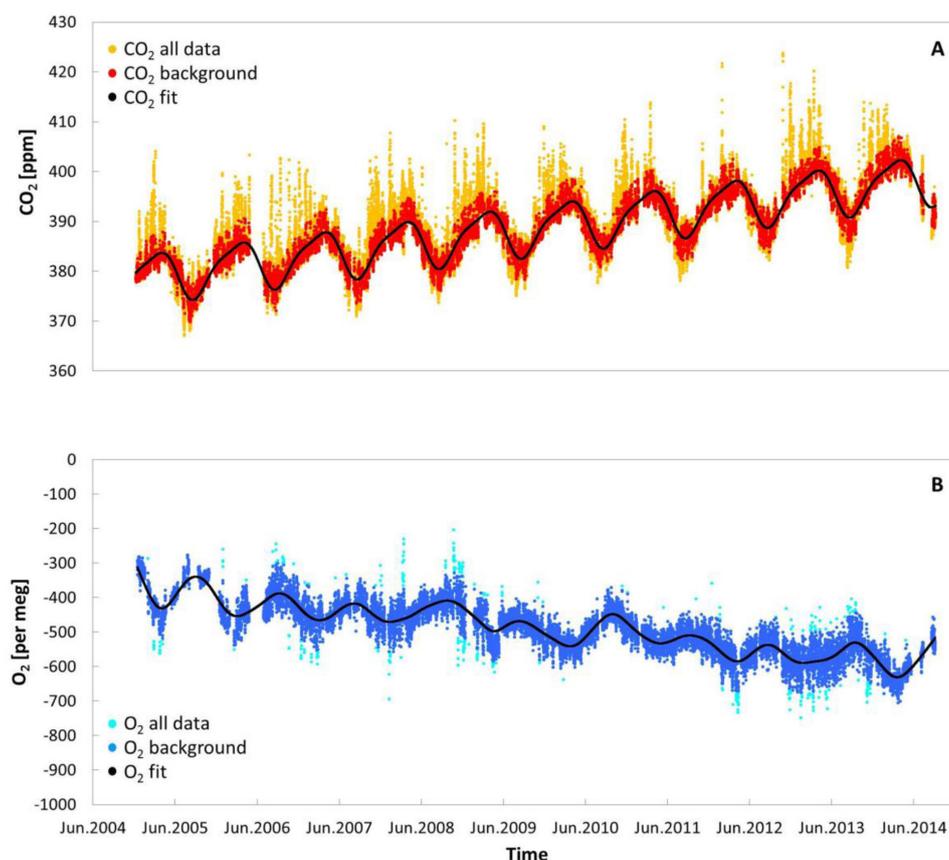


Figure 1. A: Unfiltered CO₂ in-situ measurements (orange), filtered CO₂ in-situ measurements (red) and 2-harmonic fit with slope (black) as a function of time; B: Unfiltered O₂ in-situ measurements (cyan), filtered O₂ in-situ measurements (blue) and spline fit (black) as a function of time.

We faced several problems in 2014. The main problems were associated with the cooling and drying device that broke several times and required replacement. We could manage to replace it with a spare instrument, however, this worked only two weeks. Then we had to wait for a replacement shipment from FTS Systems which took more than three months due to a problem of accounting. After arrival we faced again many incidents of mal-functioning. At the end we noticed problems of the power supply. After solving these, everything went back to normal running conditions (Figure 1).



Figure 1. Mean CO₂ seasonalities at Jungfraujoch for the period 2005 to 2014 for all (red), nighttime values only (blue) and the corresponding difference (green) first panel; the same for O₂ second panel and for APO third panel.

The seasonal amplitudes for CO₂, O₂ and APO amount to 10.7 (10.2) ppm, 85 (85) permeg and 37 (36) permeg for all and nighttime only (in paranthesis) in-situ data, respectively. It is interesting to note that the often discussed difference between daytime and nighttime values is not very prominently seen at Jungfraujoch. This further underpins the excellent site conditions at Jungfraujoch for being a close-to-ideal place for a continental background station.

However, it is interesting that the difference of flask and in-situ CO₂ measurements clearly shows a summer bias. This may either indicate that (i) polluted air masses are uplifted earlier in the morning during summer than during winter time since the flask measurements are always taken at the same time (between 7 and 8 am) or (ii) that it corresponds to a bias of inadequate sampling frequency for this type of analysis. The mean seasonality of the flask is 9.3 ppm about 1 ppm less than for the in-situ data with 10.2 ppm for the nighttime and 10.7

ppm for all in-situ data. However, we have to note that the uncertainty of the monthly mean values of the flask data is about twice as large as for the in-situ data.

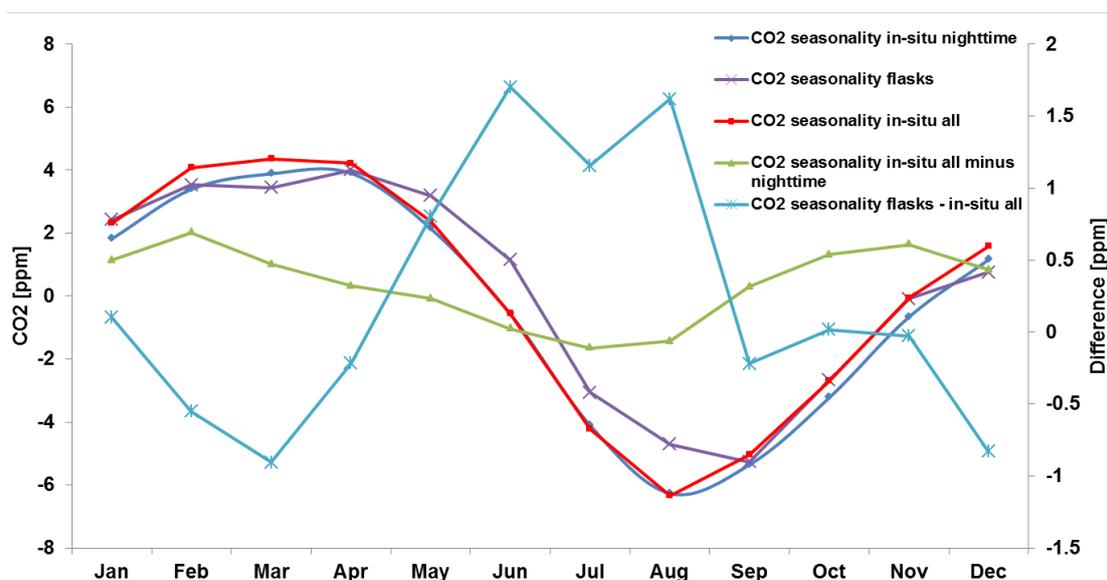


Figure 3. Comparison of the seasonality of in-situ data (red, all values), (blue, nighttime values only) and flask data (violet) and their in-situ differences (green, right axis) and difference between flask and in-situ (light blue).

These measurements are part of the ICOS-CH project.

Key words:

Greenhouse gas, climate change, CO₂ emissions

Internet data bases:

The Jungfrauoch data can be downloaded from our homepage (http://www.climate.unibe.ch/?L1=research&L2=atm_gases) or from the WMO GAW: World Data Centre for Greenhouse Gases (<http://ds.data.jma.go.jp/gmd/wdcgg/cgi-bin/wdcgg/accessdata.cgi?index=JFJ646N00-KUP&select=inventory>)

Collaborating partners/networks:

ICOS partners, Globalview, Obspack, Swiss GCOS office, EMPA, University of Groningen, the Netherlands, MPI BGC Jena, Germany

Scientific publications and public outreach 2014:

Refereed journal articles and their internet access

Schibig, M. F., M. Steinbacher, B. Buchmann, I.T. van der Laan-Luijkx, S. van der Laan, S. Ranjan, and M.C. Leuenberger, Comparison of continuous in-situ CO₂ observations at Jungfrauoch using two different measurement techniques, *Atmos. Meas. Tech. Discuss.*, **7**, 7053-7084, doi: 10.5194/amtd-7-7053-2014, 2014. <http://www.atmos-meas-tech-discuss.net/7/7053/2014/>

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Leuenberger, M. C., M.F. Schibig, and P. Nyfeler, Gas adsorption and desorption effects on cylinders and their importance for long-term gas records, *Atmos. Chem. Phys. Discuss.*, **14**, 19293-19314, doi: 10.5194/acpd-14-19293-2014, 2014.

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Laan, S., I.T. Laan-Luijkx, L. Zimmermann, F. Conen, and M. Leuenberger, Net CO₂ surface emissions at Bern, Switzerland inferred from ambient observations of CO₂, delta(O₂/N₂), and ²²²Rn using a customized radon tracer inversion, *Journal of Geophysical Research (Atmospheres)*, **119**, 1580-1591, doi:10.1002/2013JD020307, 2014. <http://onlinelibrary.wiley.com/doi/10.1002/2013JD020307/abstract;jsessionid=F6899F92F11FF7A9B4EC1A24B6766EA2.f01t04>

Conference papers

Schibig, M., M. Leuenberger, P. Nyfeler, and E. Mahieu, Comparison of continuous background in-situ and column integrated CO₂ observations at Jungfrauoch with an urban site in the city of Bern, in *EGU General Assembly Conference Abstracts*, pp. 10437, Vienna, Austria, April 27 – May 2, 2014.

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Schibig, M., T. Berhanu, I. van der Laan-Luijkx, S. van der Laan, P. Nyfeler and M. Leuenberger, 10 years of combined CO₂ and O₂ measurements at the Jungfrauoch High Altitude Research Station Jungfrauoch, in *Proceedings of 1st ICOS Science Conference on Greenhouse Gases and Biogeochemical Cycles*, Brussels, Belgium, September 23-25, 2014.

Brunner, D., N. Buchmann, W. Eugster, S. Seneviratne, E. Davin, N. Gruber, M. Leuenberger, I. Bey, I. Bamberger, S. Henne, Y. Liu, S. Mystakidis, B. Oney, and A. Roches, A greenhouse gas monitoring and modelling system for Switzerland: The CarboCount CH project, in *EGU General Assembly Conference Abstracts*, pp. 14851, Vienna, Austria, April 27 – May 2, 2014.

Bamberger, I., W. Eugster, B. Oney, D. Brunner, M. Leuenberger, R. Schanda, S. Henne, and N. Buchmann, Tall tower or mountain top measurements?, in *EGU General Assembly Conference Abstracts*, pp. 7169, Vienna, Austria, April 27 – May 2, 2014.

Data books and reports

Leuenberger, M., WMO World Data Centre for Greenhouse Gases, c/o Japan Meteorological Agency 1-3-4, Otemachi, Chiyoda-kuTokyo 100-8122, Japan, CO₂ Data from Jungfrauoch (2014).

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