High precision carbon dioxide and oxygen measurements at Jungfraujoch

Markus C. Leuenberger[1], Michael F. Schibig[2], Peter Nyfeler[2], Hanspeter Moret[2]

[1] Climate and Environmental Physics, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland
and
Director of the International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat (HFSJG), 3012 Bern
[2] Climate and Environmental Physics, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland

leuenberger@climate.unibe.ch

Part of this programme: ICOS

Keywords: CO_2 measurements; O_2 measurements

1. Project description

Atmospheric CO_2 is increasing because of human activities such as fossil fuel combustion or land use change. However, the observed CO_2 increase in the atmosphere corresponds only to about half of the carbon emitted. The other half is taken up partly by the ocean and partly by the biosphere. It is crucial to know the partitioning between the two reservoirs because of their different nature. With combined CO_2 and O_2 measurements, it is possible to determine the partitioning of emitted fossil fuel carbon into the oceanic and biospheric sink.

The in-situ CO_2 and O_2 measurements were continued throughout the whole year with minor interruptions due to technical issues. To calculate the annual CO_2 increase and the seasonality at Jungfraujoch, only night-time values (0:00-5:59 UTC) were considered, because they represent mostly background air from the free troposphere. The CO_2 trend from 2005 to 2018 was calculated to be 2.22 ± 0.04 ppm yr^{-1} (Figure 1). The average seasonal amplitude over this period was 10.72 ± 1.00 ppm with a maximum in March/April and a minimum in August (Figure 2).

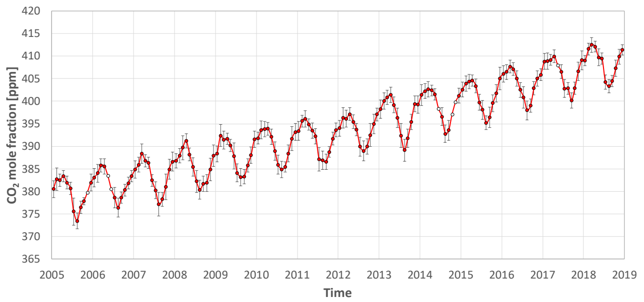

Figure 1. Monthly averages of the CO_2 mole fraction measurements from Jungfraujoch (Sphinx) calculated from the nightly hourly means from 2005 to 2018. The empty dots mark months were there are less than 50 data points available.

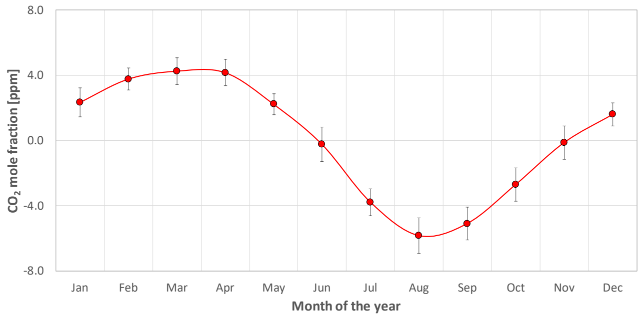

Figure 2. Average CO_2 seasonality over the period 2005 to 2018 calculated from detrended monthly averages.

As mentioned in earlier reports, since 2015 there are some issues with the $\delta O_2/N_2$ values, which we were not able to explain completely. It was brought to our attention that since 2015 the temperature control of the common gas inlet at the Sphinx observatory deteriorated and huge temperature changes occur. Interestingly, this seems to affect the $\delta O_2/N_2$-ratio of the sample air and adds some additional temperature signal to the measurements.

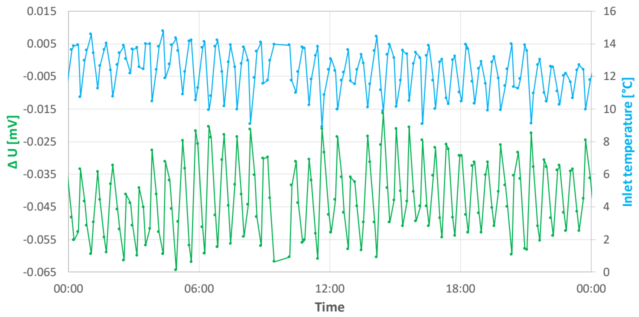

Figure 3. The raw signal of the paramagnetic cell used to measure O_2 (in green, primary y-axis) mirrors the temperature signal (in blue, secondary y-axis, pers. Comm. Simon Wyss, Empa) of the common inlet of the Sphinx laboratory, shown here for the 11th of December, 2018).

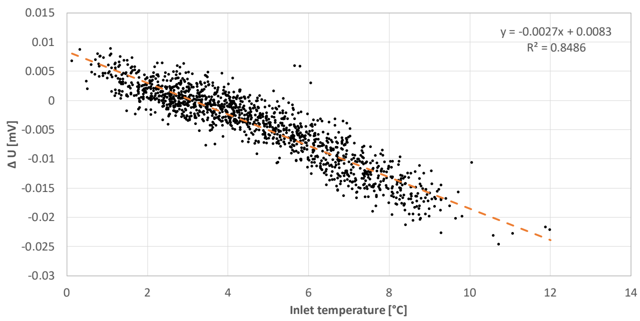

Figure 4. The O_2 raw signal of the paramagnetic cell against the inlet temperature (shown here for the period 10th-19th December 2018) shows a nice correlation. Unfortunately, this correlation is not always well pronounced, making it difficult to find a good correction.

Currently, we try to find a viable way to eliminate the temperature signal from our $\delta O_2/N_2$ data. Moreover, discussions are under way how to improve the temperature control of the common inlet and reach thermal stability similar or even better than before 2015.

Also the flask sampling continued in 2018. The 20-year-old custom-built inlet system of the mass spectrometer used to determine the air composition of the flask samples was worn out and had a lot of downtime for readjustment and fixing. This caused a huge backlog of unmeasured flask samples. In late fall a new custom-built inlet system was installed and validated and since then the number of pendent flask samples was reduced considerably. However, since there is still a big gap in the 2018 data, an updated time series of the flask samples will be presented in the next report.

Internet data bases

https://gaw.kishou.go.jp/
https://www.esrl.noaa.gov/gmd/ccgg/obspack

Collaborating partners / networks

ICOS partners, GAW, GLOBALVIEW, ObsPack, Swiss GCOS office, EMPA, MPI BGC Jena, Germany

Scientific publications and public outreach 2018

Refereed journal articles and their internet access

Yuan, Y., L. Ries, H. Petermeier, M. Steinbacher, A.J. Gómez-Peláez, M.C. Leuenberger, M. Schumacher, T. Trickl, C. Couret, and F. Meinhardt, Adaptive selection of diurnal minimum variation: a statistical strategy to obtain representative atmospheric CO_2 data and its application to European elevated mountain stations, Atmospheric Measurement Techniques, 11, **3,** 1501-1514, doi: 10.5194/amt-11-1501-2018, 2018. https://www.atmos-meas-tech.net/11/1501/2018/

Lin, X., P. Ciais, P. Bousquet, M. Ramonet, Y. Yin, Y. Balkanski, A. Cozic, M. Delmotte, N. Evangeliou, and N.K. Indira, Simulating CH4 and CO2 over South and East Asia using the zoomed chemistry transport model LMDz-INCA, Atmos. Chem. Phys., **18**, 9475-9497, 2018. https://doi.org/10.5194/acp-18-9475-2018

Major, I., L. Haszpra, L. Rinyu, I. Futó, Á. Bihari, S. Hammer, A.T. Jull, and M. Molnár, Temporal Variation of Atmospheric Fossil and Modern CO 2 Excess at a Central European Rural Tower Station between 2008 and 2014, Radiocarbon, **60**, 5, 1285-1299, doi: 10.1017/RDC.2018.79, 2018. https://doi.org/10.1017/RDC.2018.79

Kountouris, P., C. Gerbig, C. Rödenbeck, U. Karstens, T.F. Koch, and M. Heimann, Atmospheric CO 2 inversions on the mesoscale using data-driven prior uncertainties: quantification of the European terrestrial CO_2 fluxes, Atmospheric Chemistry and Physics, **18**, 4, 3047-3064, 2018. https://doi.org/10.5194/acp-18-3047-2018

Conference Papers

Schibig, M.F., P. Nyfeler, M.C. Leuenberger, High precision CO_2 and O_2 measurements at the High Altitude Research Station Jungfraujoch, Switzerland, 16th Swiss Geoscience Meeting, Bern, Switzerland, November 30 – December 1, 2018.

Affolter, S., M.F. Schibig, T. Berhanu and M.C. Leuenberger, Comparison of two high alpine CO_2 records from the Jungfraujoch area, 16th Swiss Geoscience Meeting, Bern, Switzerland, November 30 – December 1, 2018.

Schibig, M.F., P. Nyfeler, M.C. Leuenberger, Measuring atmospheric argon at Jungfrau East Ridge to estimate the oceanic influence on atmospheric oxygen using a mass spectrometer, 3rd ICOS Science Conference, Prague, Czech Republic, September 11-13, 2018.

Burri, S., N. Buchmann, L. Emmenegger, L. Hörtnagl, M.C. Leuenberger, M. Steinbacher, R. Zweifel & the ICOS-CH consortium, ICOS Switzerland – Greenhouse gas stories from high altitudes, 3rd ICOS Science conference, Prague, Czech Republic, September 11-13, 2018.

Affolter, S., M.F. Schibig, T. Berhanu, V. Mandrakis and M.C. Leuenberger, The comparison of two high altitude carbon dioxide records from the Jungfraujoch area (Switzerland) reveals diurnal differences, EGU, Vienna, Austria, April 8-13, 2018.

Address

University of Bern
Physics Institute
Climate and Environmental Physics
Sidlerstrasse 5
CH-3012 Bern
Switzerland

Contacts

Prof. Dr. Markus Leuenberger
Tel.: +41 31 631 4470
e-mail: leuenberger@climate.unibe.ch