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 CO_2 and O_2 measurements at Jungfraujoch were continued. Trends were not updated for the newest data since there is still an issue with the results in 2016 as obvious from Figure 1, in particular for O_2. The trends for the period 2005 to 2015 are 2.17 ± 0.09 ppm y^{-1} for the CO_2 increase rate and -24.3 ± 1.3 per meg y^{-1} for the $\delta O_2/N_2$ decrease rate, respectively (Figure 1).

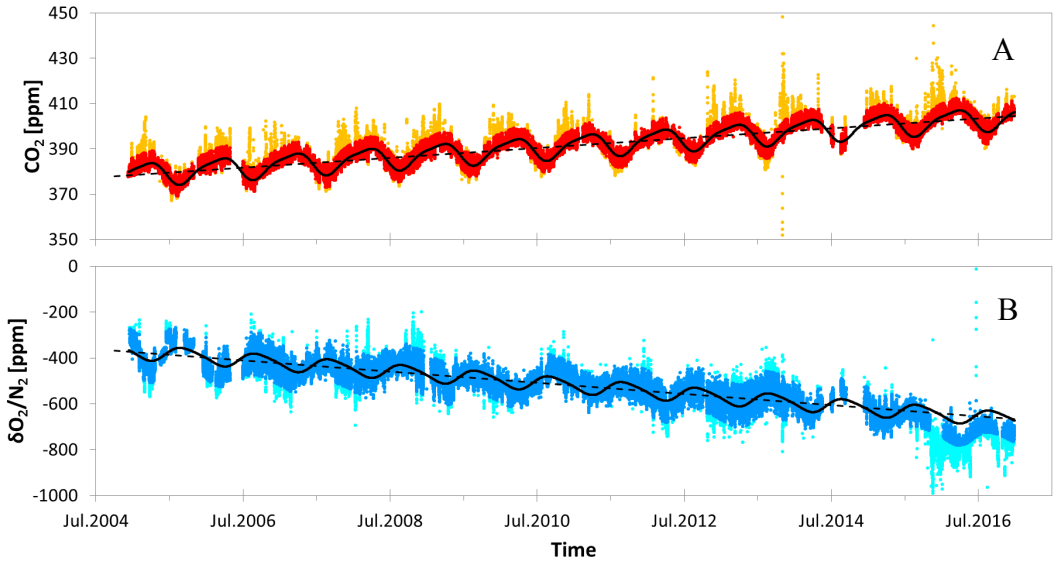

Figure 1. A: Unfiltered CO_2 in-situ measurements (orange), filtered CO_2 in-situ measurements (red), 2-harmonic fit with slope (black) as a function of time, and linear CO_2 increase (black dashed) as a function of time; B: Unfiltered $\delta O_2/N_2$ in-situ measurements (cyan), filtered O_2 in-situ measurements (blue), spline fit (black) as a function of time, and linear $\delta O_2/N_2$ decrease (black dashed) as a function of time.

The strongly deviating O_2 values starting from November 13, 2015 onwards coincide with a change of the pump that moves the outside air. Up to now we cannot rule out that we had a leaky line more or less throughout the year 2016, since most of the values seem to be too low. Yet, there were no correspondingly increased CO_2 values measured as shown in Figure 2. The year 2016 does not exhibit a different CO_2 seasonality compared to the mean of 2005 to 2015. But the O_2 seasonality is obviously biased to more depleted values by about 90 permeg. Hence, it seems that the O_2 values for most of the year 2016 are shifted to more negative values for yet unknown reasons compared to the values for the mean 2005 to 2015.

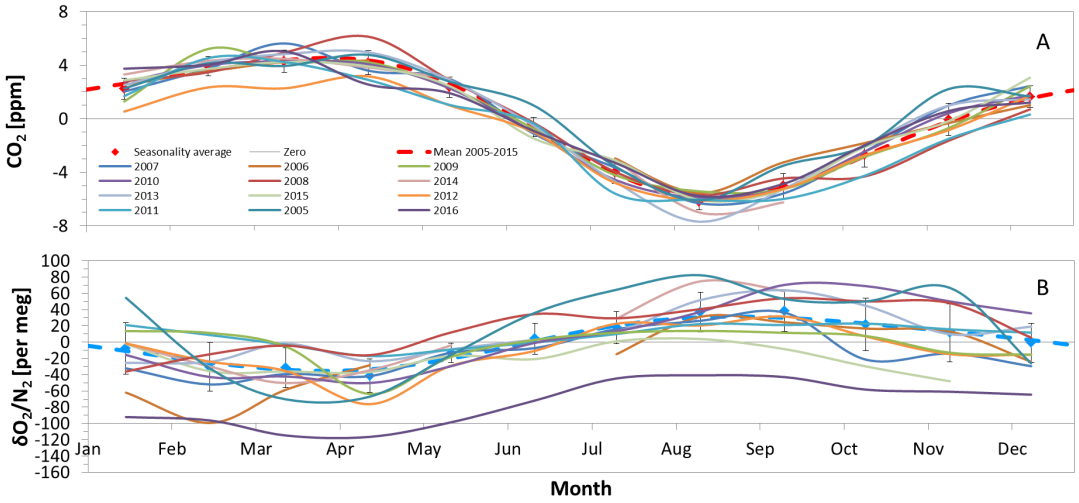

Figure 2. A: Monthly mean CO_2 seasonalities at Jungfraujoch for the period 2005 to 2015 for all samples (red diamonds), nighttime values only (red dashed line); B: Monthly mean $\delta O_2/N_2$ seasonalities at Jungfraujoch for the period 2005 to 2015 for all samples (blue diamonds), nighttime values only (blue dashed line). Seasonalities for all years from 2006 to 2016 are displayed.

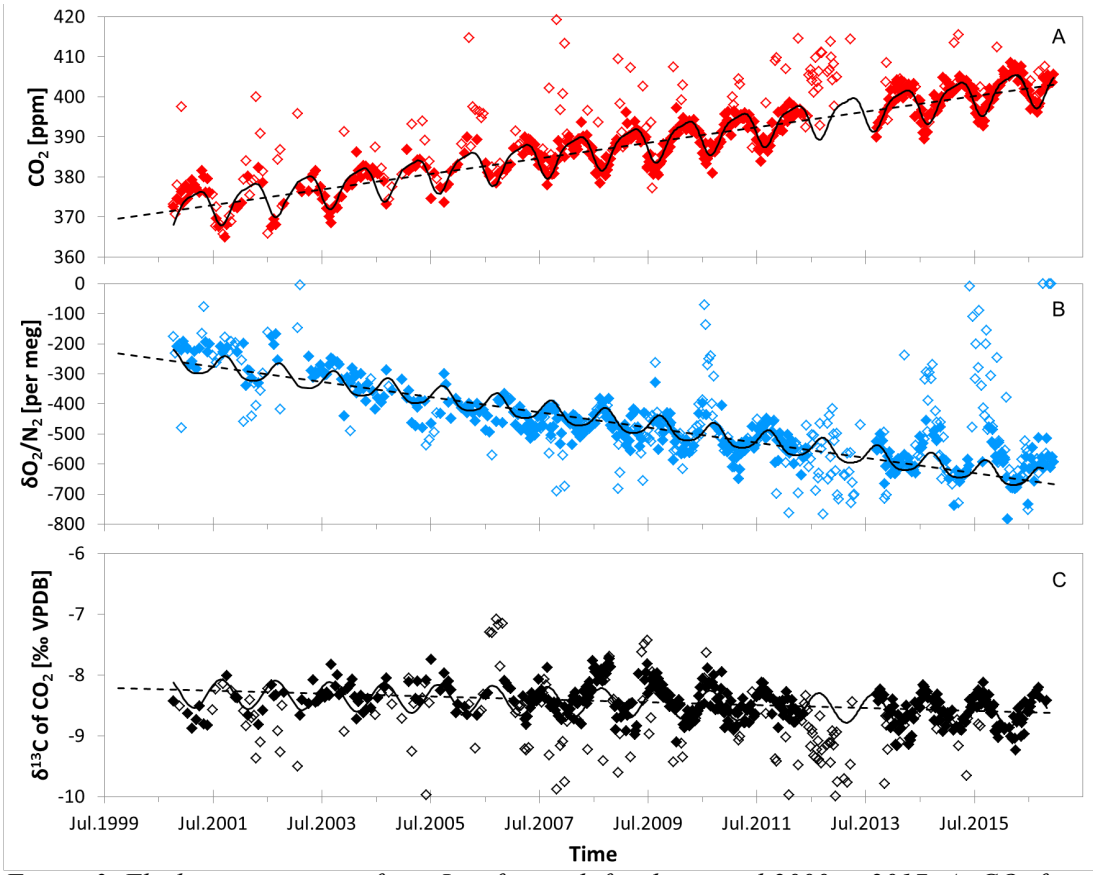

Figure 3. Flask measurements from Jungfraujoch for the period 2000 to 2017. A: CO_2 for all samples (open red diamonds), background values (full red diamonds), 2-harmonic fit (black line) and linear slope (black dashed line); B: $\delta O_2/N_2$ for all samples (open blue diamonds), background values (full blue diamonds), 2-harmonic fit (black line) and linear slope (black dashed line); C: $\delta^{13}C$ of CO_2 for all samples (open black diamonds), background values (full black diamonds), 1-harmonic fit (black line,) and linear slope (black dashed line).

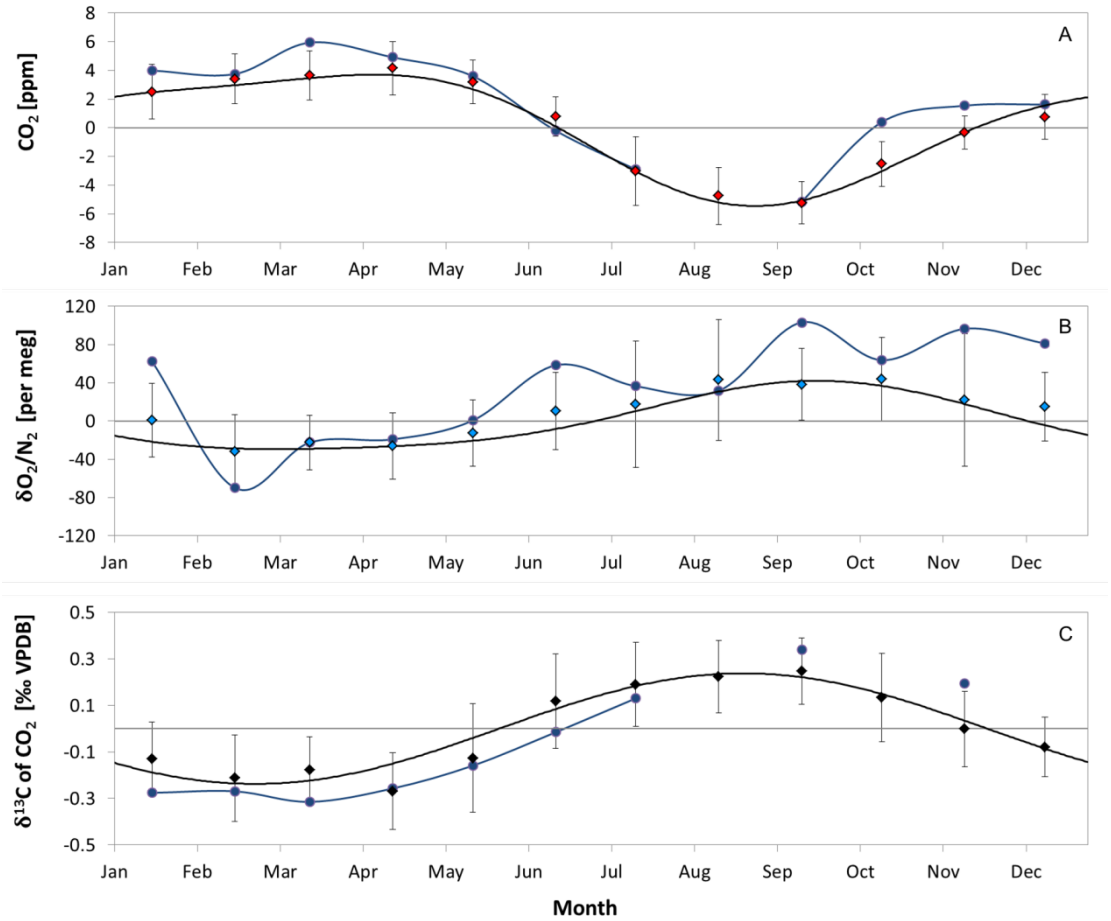

Figure 4. Seasonality based on flask measurements from Jungfraujoch for the period 2000 to 2016. A: Seasonality of CO_2 (red diamonds) and 2-harmonic fit (black line); B: Seasonality of $\delta O_2/N_2$ (blue diamonds) and 2-harmonic fit (black line); C: Seasonality of $\delta^{13}C$ of CO_2 (black diamonds), and 1-harmonic fit (black line). For comparison, the seasonality for all species for the year 2016 (blue dots and line).

The seasonal amplitudes for CO_2 and $\delta O_2/N_2$ are 10.5 ± 1.0 (10.1 ± 1.3) ppm and 80 ± 32 (81 ± 41) per meg for all and nighttime only (in paranthesis) in-situ data, respectively (Figure 2). The values of 2016 were excluded in these calculations.

Also the flask sampling at Jungfraujoch was continued and the measurements of 2016 were compared to the trends for the period 2000 to 2015 which resulted in a CO_2 increase rate of 1.94 ± 0.1 ppm y^{-1}, a $\delta O_2/N_2$ decrease rate of -25.3 ± 1.5 per meg y^{-1}, and a $\delta^{13}C$ of CO_2 decrease rate of -0.023 ± 0.007 ‰ y^{-1}, respectively (Figure 3). The trends of the flask measurements are in good agreement with the online measurements. The seasonalities based on the data of the flask measurements were 9.34 ± 2.4 ppm, 73 ± 75 per meg, and 0.51 ± 0.23 ‰ for CO_2, $\delta O_2/N_2$, and $\delta^{13}C$ of CO_2, respectively (Figure 4). These values are slightly lower than the seasonality calculated, based on the measurements of the online system.

Key words:

Greenhouse gas, climate change, CO_2 emissions

Internet data bases:

The Jungfraujoch 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 2016:

Refereed journal articles and their internet access

Schibig, M.F., E. Mahieu, S. Henne, B. Lejeune, M.C. Leuenberger, Intercomparison of in situ NDIR and column FTIR measurements of CO2 at Jungfraujoch, Atmos. Chem. Phys., **16**, 15, 9935-9949, doi: 10.5194/acp-16-9935-2016, 2016. http://www.atmos-chem-phys.net/16/9935/2016/

Conference papers

Berhanu, T.A., E. Satar, S. Szidat, D. Brunner, M. Steinbacher, R. Schanda, P. Nyfeler, M. Leuenberger, Quantification of fossil fuel associated CO_2 emissions based on radiocarbon measurements at the Beromünster tall tower, Switzerland, 2nd ICOS conference, Helsinki, Finland, September 27-29, 2016.

Berhanu, T.A., M.F. Schibig, C. Uglietti, M. Leuenberger, 10-years of CO_2, O_2 and $\delta^{13}C$ records at two remote sites of Jungfraujoch, Switzerland and Puy de Dome, France, 2nd ICOS conference, Helsinki, Finland, September 27-29, 2016.

Leuenberger, M., M. Schibig, E. Mahieu, S. Henne, B. Lejeune, Intercomparison of in-situ NDIR and column FTIR measurements of CO_2 at Jungfraujoch, 2nd ICOS conference, Helsinki, Finland, September 27-29, 2016.

Schibig, M., E. Mahieu, S. Henne, B. Lejeune, M. Leuenberger, Intercomparison of in-situ NDIR and column FTIR measurements of CO_2 at Jungfraujoch, East Ridge Users Meeting organized by HFSJG, Bern, Switzerland, May 13, 2016.

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, CO_2 Data from Jungfraujoch, 2016.

Address:

Physikalisches Institut
Universität Bern
Sidlerstrasse 5
CH-3012 Bern

Contacts:

Prof. Markus Leuenberger
Tel.: +41 31 631 4470
Fax: +41 31 631 8742
e-mail: leuenberger@climate.unibe.ch
URL: http://www.climate.unibe.ch/?L1=people&L2=personal&L3=leuenberger