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

Project leader and team:

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

Project description:

The continuation of the combined online CO_2 and O_2 measurements at Jungfraujoch documents an unbroken increase in CO_2 (1.98 ± 0.01 ppm / yr) as well as a corresponding O_2 decrease (-23.9 ± 0.2 per meg / yr). However, the O_2 record shows an unexpected deviation towards higher values starting in spring/summer 2013. Whether this deviation from expected values is a real phenomena remains to be proofed by remeasurements of our standards at the Bern laboratory. This effect is even more pronounced in atmospheric potential oxygen (APO, trend -13.0 ± 0.2 per meg / yr) as documented by its deviation from the thick black line. This line represents a two harmonic spline calculation that was applied to the data excluding values beyond 2.7 σ. The unexpected O_2 and APO deviations cannot be due to a change of the paramagnetic cell that took place in September 2013 since a shift has already been observed in June 2013. It is much more plausible that miss-assigned values to our working standards are observed. Therefore, the data requires a reevaluation based on independent calculation from the working standard, i.e. high and low span gases.

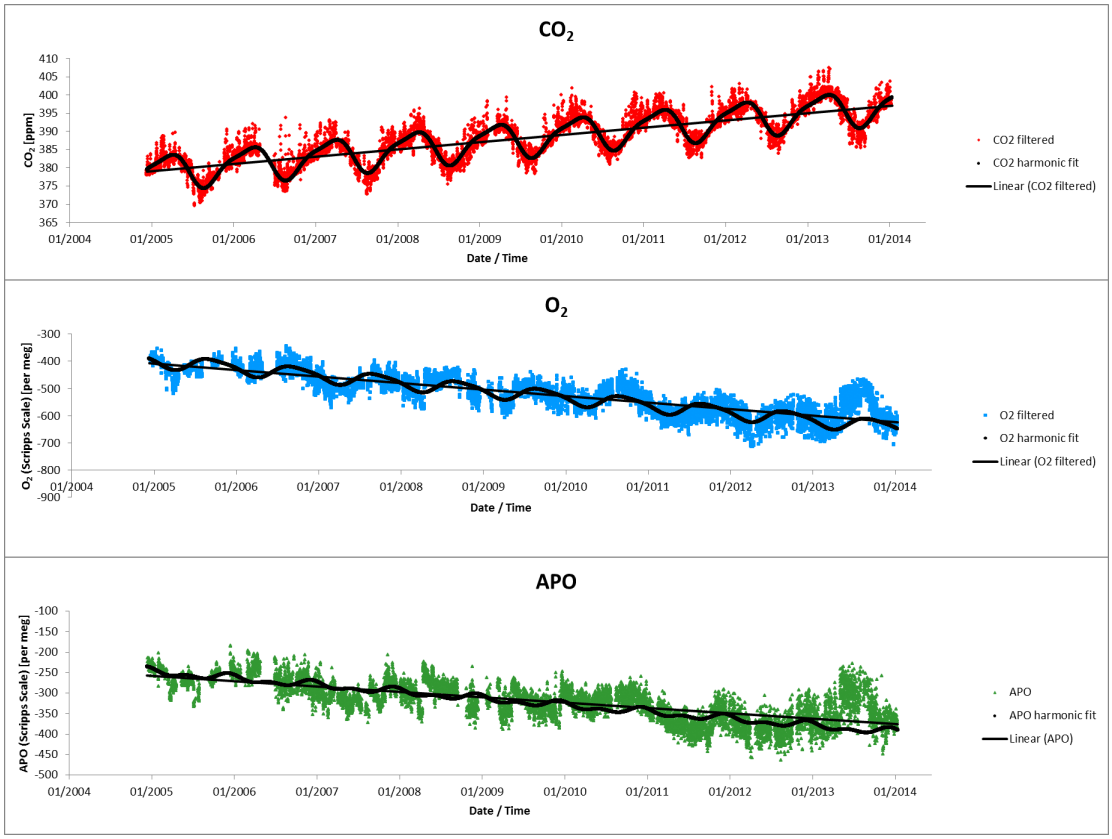

Figure 1. Filtered CO_2 (red), O_2 (blue) and APO (green) values at Jungfraujoch with linear and harmonic fits.

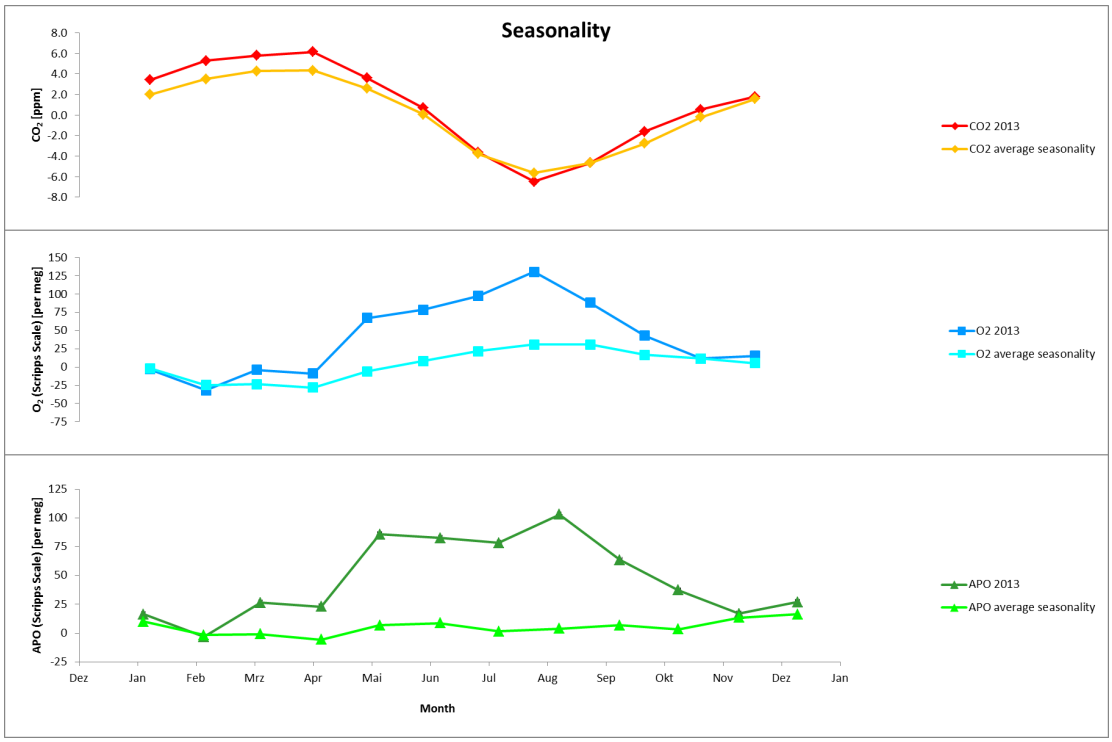

Figure 1. Seasonalities at Jungfraujoch for CO_2 in 2013 (red) and averaged since 2005 (orange) first panel; for O_2 in 2013 (blue) and averaged (turquoise) second panel; for APO in 2013 (green) and averaged (lime) third panel.

The seasonal changes of CO_2 and O_2 are shown in Figure 2. These were calculated by subtracting the long-term mean as well as the linear trends from the original data. There is generally a good agreement from year to year for the CO_2 seasonality as documented by the upper panel. The situation is different for O_2 and APO as obvious from the middle and lower panels. The variability of seasonal amplitudes are large for our O_2 measurements. Part of which has to do with the larger uncertainty of O_2 measurements and the assignments of working standards. As obvious from Figure 2, the seasonality in 2013 is significantly higher than on average which further points to miss-assigned working standard values. The working standards have been changed on 23.1.2013, 3.5.2013, 25.7.2013 and 10.9.2013. The exceptional high values for O_2 and APO from May to September support our suspect of miss-assigned working gas values by about 70 per meg for the period 3.5.2013 to 25.7.2013 and by 100 per meg for 25.7.2013 to 10.9.2013. No effect can be seen for CO_2 indicating that the CO_2 assigned value is correct.

Correct calculations of trends and seasonal amplitudes can be quite tricky since they inter-depend on each other. Most statistical tools, nowadays, allow disentangling trend and seasonality, however most of them do it incorrectly. This can be tested by a pseudo data set with a given trend and seasonality. A retrieval generally leads to an increasing under- or overestimation of the trend or offset with increasing seasonal amplitudes. Also the phase lag of the seasonality is critical in those retrievals. Additionally, trend and its uncertainty depend strongly on the time interval used for its calculation as shown in the graphs of Figure 3.

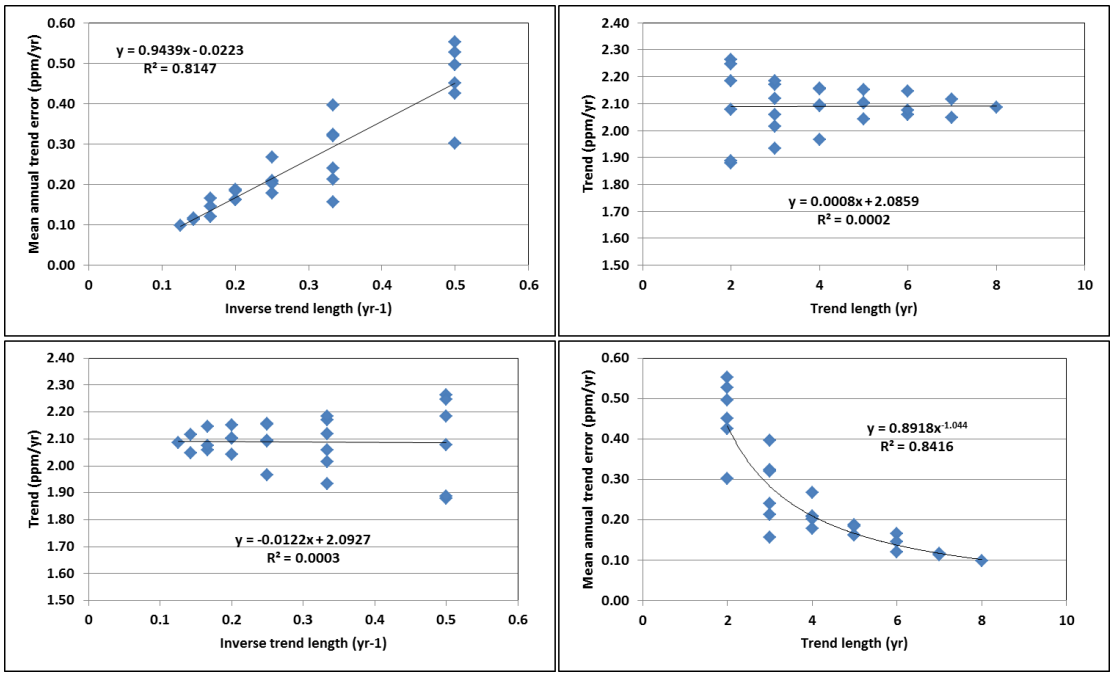

Figure 3. Dependencies of trend estimation and its uncertainty on trend length based on measured Jungfraujoch CO_2 values with a seasonality of roughly 10 ppm and a trend of 2 ppm/yr. Not shown are dependencies on seasonal amplitude strength and its phase lag (see details in text).

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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; 182 times from 1.3.2011 to 29.2.2012)

Collaborating partners/networks:

IMECC partners, Swiss GCOS office, EMPA

Scientific publications and public outreach 2013:

Refereed journal articles and their internet access

van der Laan-Luijkx, I.T., S. van der Laan, C. Uglietti, M.F. Schibig, R.E.M. Neubert, H.A.J. Meijer, W.A. Brand, A. Jordan, J.M. Richter, M. Rothe, and M.C. Leuenberger, Atmospheric CO2, delta(O-2/N-2) and delta(CO2)-C-13 measurements at Jungfraujoch, Switzerland: results from a flask sampling intercomparison program, Atmospheric Measurement Techniques, **6**, 7, 1805-1815, doi: 10.5194/amt-6-1805-2013, 2013. http://dx.doi.org/10.5194/amt-6-1805-2013.

Conference papers

Leuenberger M., van der Laan-Luijx I., van der Laan S.,' Schibig M, and Nyfeler P., Combined CO_2 and O_2 measurements at the High Altitude Research Station Jungfraujoch, Switzerland, 9th CO_2 conference, Bejing, China, 2013.

Leuenberger M., Steinbacher M., Buchmann B.; van der Laan-Luijx I. , van der Laan S., Schibig M., and Nyfeler P., Comparison of continuous in-situ CO_2 observations at Jungfraujoch, Switzerland using two different measurement techniques, 9th CO_2 conference, Bejing, China, 2013.

Leuenberger M., Steinbacher M., Buchmann B.; van der Laan-Luijx I., van der Laan S., Schibig M., and Nyfeler P., Comparison of continuous in-situ CO_2 observations at Jungfraujoch, Switzerland using two different measurement techniques, 17th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases, and Related Tracer Measurement Techniques, Bejing, China, 2013.

Leuenberger M., van der Laan-Luijx I., van der Laan S., Schibig M, and Nyfeler P., Combined CO_2 and O_2 measurements at the High Altitude Research Station Jungfraujoch, Switzerland, 17th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases, and Related Tracer Measurement Techniques, Bejing, China, 2013.

Data books and reports

Leuenberger M., van der Laan S., van der Laan-Luijkx I.T., Schibig M.F., (2013): Comparison of continuous in-situ CO_2 observations at Jungfraujoch using two different measurement techniques. Fourth GCOS interim report.

Leuenberger M., (2013), Jahresbericht 2013 für kombinierte CO_2- O_2 Messungen auf dem Jungfraujoch zuhanden Swiss GCOS office.

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 (2013) (downloaded 182 times from 1.3.2011 to 29.2.2012).

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