Name of research institute or organization:

Climate and Environmental Division, Physics Institute, University of Bern

Title of project:

High precision carbon dioxide and oxygen measurements at Jungfraujoch

Project leader and team:

Prof. Dr. Markus Leuenberger, project leader
Peter Nyfeler, Hanspeter Moret, Ingrid van der Laan-Luijkx, Sander van der Laan, Michael Schibig

Project description:

In 2011, the CO_2 and O_2 measurements at Jungfraujoch were continued. Based on the online measurements, which are performed since late 2004 at Jungfraujoch, we calculated long term changes in the CO_2 and O_2 contents of the atmosphere. Therefore we averaged the high resolution data to one-hourly averages. For long term trend calculations only the background values are of interest. That's why we took only the night time data (2 am to 6 am). Then a two harmonic spline calculation was applied to the data and all values beyond 2.7 σ were excluded. This means, if the data is normally distributed, that 99 % of the data points were kept for further calculation. This procedure was repeated until convergence. With the remaining values the trends and seasonality of the CO_2 and O_2 change were calculated.

CO_2 increases at a rate of 1.9 ± 0.01 ppm / yr, O_2 and APO decreases at a rate of -25 ± 0.15 per meg / and of -15 ± 0.17 per meg / yr respectively, in which the uncertainty is the error of the linear component of the fit. Since we had problems with accuracy and precision of the oxygen measurement system, the oxygen and APO decrease rate are probably not very precise. We hope to improve this situation with the reanalysis of the old calibration cylinders when they are back from Jungfraujoch.

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. CO_2 has its maximum in March. Due to the photosynthesis of plants, the CO_2 value is decreasing until September. Then the respiration becomes stronger than the assimilation and the CO_2 value starts to increase again until March.

The oxygen values should behave more or less inversely to the CO_2 values, with a delay of about one month. The inversion of the O_2 seasonality to the CO_2 seasonality is caused by the fact, that plants release oxygen and assimilate CO_2 during photosynthesis. The reason for the delay is that the ocean has a stronger influence on the O_2 than on the CO_2, because the solubility pump and the biological pump act in the same direction for O_2 but not for CO_2 (Uglietti, 2009, PhD thesis).

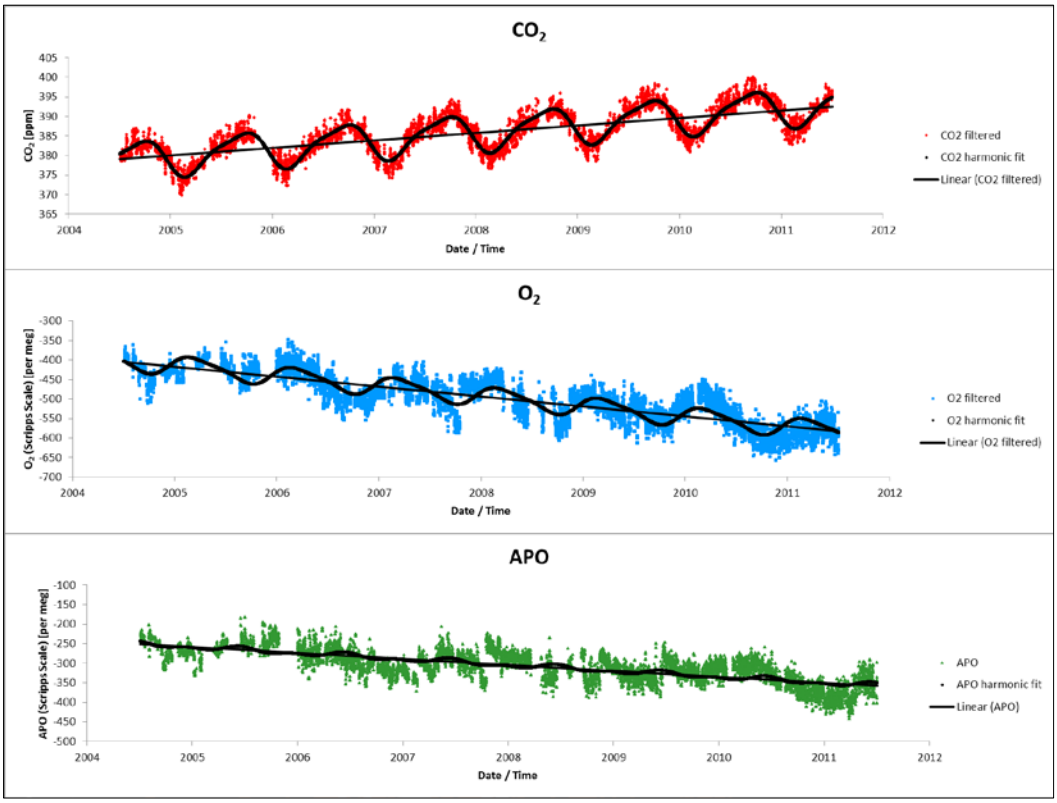

Figure 1. *Filtered CO_2 (red), O_2 (blue) and APO (green) values at Jungfraujoch with linear and harmonic fits.*

This delay is true for the oxygen measurements in spring. In summer the oxygen values don't increase, as we would expected, to roughly 12 per meg like the long-term average. The maximum is not in September but rather in November. A possible reason for that can be our oxygen measurement system that showed accuracy and precision problems in the last few months, which we weren't able to fix yet but, as stated earlier in this report, we hope to increase the accuracy by re-measuring the old calibration cylinders when they come back to Bern.

Until March the APO is in good agreement with the long-term seasonality. The decrease from March to July is stronger and the minimum is a month earlier than in the long-term trend. The APO's maximum is higher than the long-term trend and was measured in November.

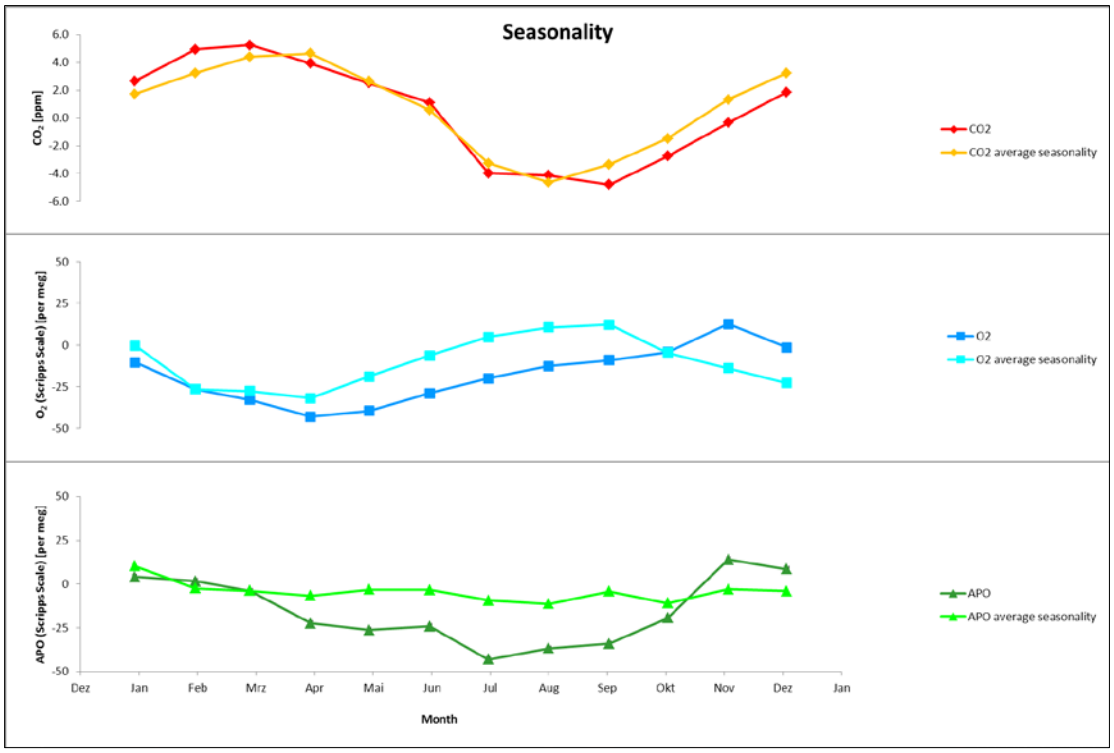

***Figure 2**. Seasonalities at Jungfraujoch for CO_2 in 2011 (red) and averaged since 2005 (orange) first panel; for O_2 in 2011 (blue) and averaged (turquoise) second panel; for APO in 2011 (green) and averaged (lime) third panel.*

Intercomparison with Empa

The continuation of the CO_2 measurements at Jungfraujoch was guaranteed based on a contract between the Swiss GCOS office and the Division of Climate and Environmental Physics since 2010. A long-term monitoring is secured by Empa that will take over the CO_2 measurements on Jungfraujoch after 2012. Therefore an intercomparison was initiated in 2010 to guarantee a smooth transition of measurements. Results were summarized in the GCOS report (Leuenberger et al., 2011) and are partly reproduced here.

Figure 3 looks closer into the difference between both systems. The figure shows the Picarro data minus the Maihak data for the hourly averages. Also indicated are switches of the working gas cylinders as well as the low span cylinder for the Maihak system (Leuenberger et al., 2011).

The agreement between the two systems is quite good, especially in the first part of the comparison. The absolute difference between to two systems varies between 0.1 and 0.3 ppm. For this comparison, it should be kept in mind that the assigned values of the standards of the Maihak system are not better than 0.2 ppm (Leuenberger et al., 2011).

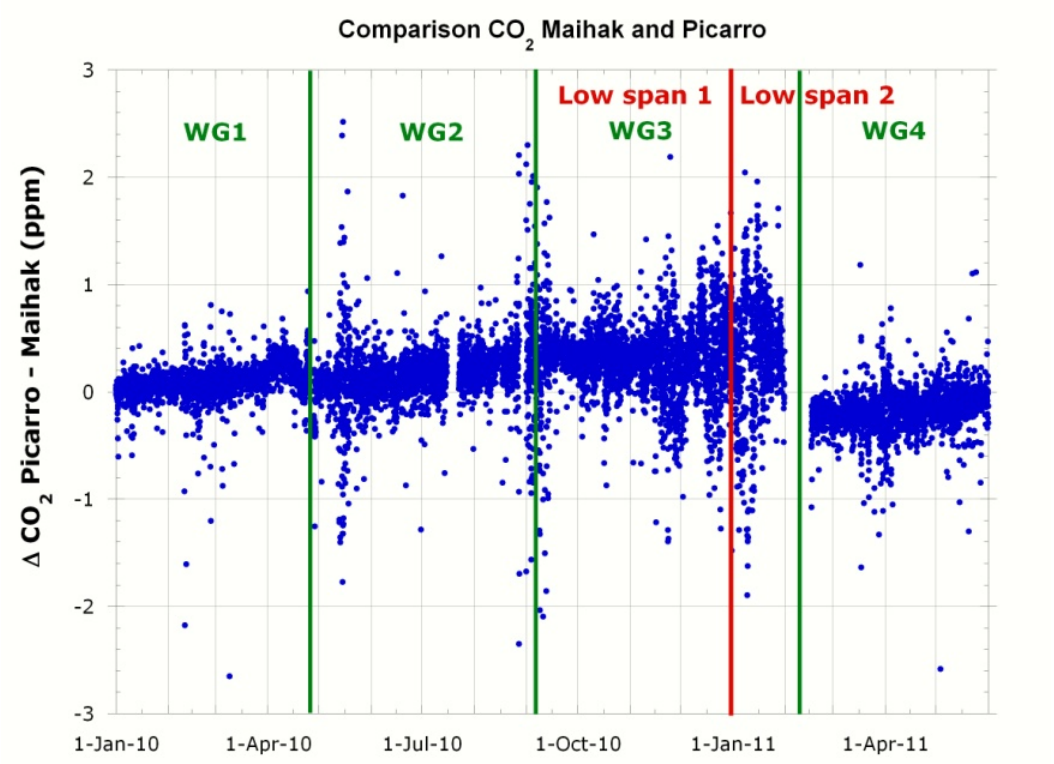

***Figure 3**. Differences between the hourly averaged CO_2 measurements using the Maihak and the Picarro system*

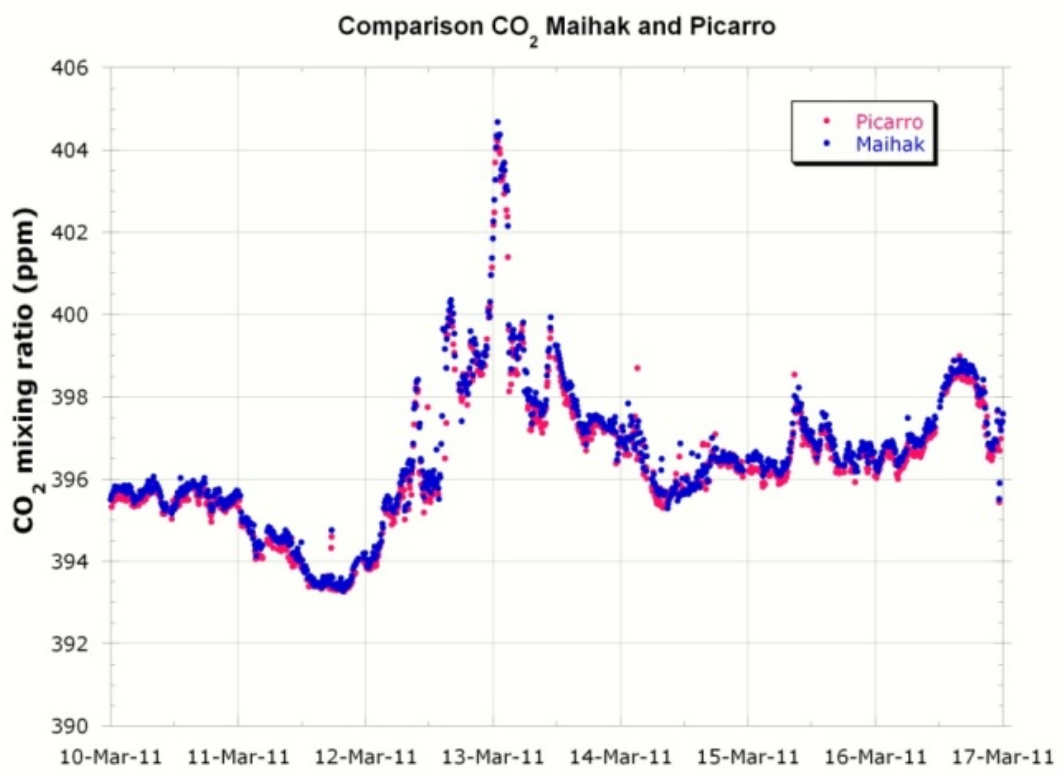

***Figure 4**. Comparison of the high resolution CO_2 observations between the Maihak (University Bern) and the Picarro (EMPA) system based on the averages of the last 115 seconds of the Maihak 6 minute periods in the second week of March 2011. The Picarro data was matched to the same time stamp.*

Figure 4 displays the comparability of the high resolution data (6 min values) of both systems. The two systems follow each other very well on smaller timescales too.

Additionally, we measured each other's calibration gases to gain more information about the two systems and to observe jumps in the dataset (Leuenberger et al., 2011). The evaluation of this data is in progress.

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=NRT) or from the homepage of World data Centre of Greenhouse Gases (http://gaw.kishou.go.jp/cgi-bin/wdcgg/accessdata.cgi?index=JFJ646N00-KUP&select=inventory; 154 times since 1.1.2011)

Collaborating partners/networks:

IMECC partners, Swiss GCOS office, EMPA

Scientific publications and public outreach 2011:

Refereed journal articles and their internet access

Uglietti, C., M. Leuenberger, and D. Brunner,(2011): Large-scale European source and flow patterns retrieved from back-trajectory interpretations of CO_2 at the high alpine research station Jungfraujoch. Atmos. Chem. Phys. Discuss., 11, 1–45. http://www.atmos-chem-phys-discuss.net/11/813/2011/acpd-11-813-2011-discussion.html

Conference presentations

van der Laan-Luijkx, Ingrid, presentation about the Jungfraujoch measurements of the Climate and Environmental Physics Division, University Bern, GGMT meeting, 25.-28. October 2011, New Zeeland.

Schibig, Michael, poster presentation (based on Uglietti, 2011) about the Jungfraujoch measurements of the Climate and Environmental Physics Division, University of Bern, 12th Swiss Global Change Day organised by ProClim, 19. April 2011, Bern.

Data books and reports

Leuenberger M., van der Laan S., van der Laan-Luijkx I.T., Buchmann B., Steinbacher M., Schibig M.F., (2011): Comparison of continuous in-situ CO_2 observations at Jungfraujoch using two different measurement techniques. Second GCOS interim report.

Address:

Physikalisches Institut
Universität Bern
Sidlerstrasse 5
CH-3012 Bern

Contacts:

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