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), Bern, Switzerland
[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

Oxidation ratios of different processes like photosynthesis, respiration or fossil fuel combustion are relatively stable over time. Therefore, combined CO_2 and O_2 measurements can be used to determine how much of the emitted CO_2 is taken up by the ocean and the biosphere and how much stays in the atmosphere.

The in-situ CO_2 and O_2 measurements were continued throughout the whole year with mainly minor interruptions due to technical issues. In fall 2019, the target measurements of the CO_2 analyser became noisier and it was finally replaced in December 2019 with a device of the same make and model. Due to the steady increase of atmospheric CO_2, the new analyser has an increased work range (old range: 350 - 450 ppm; new range 380 – 480 ppm). With the replacement of the analyser the noise has vanished (Figure 1).

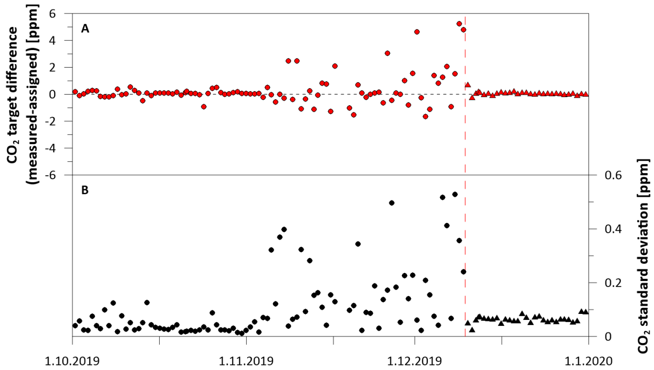

Figure 1. A: Difference of CO_2 target cylinder measurements minus the assigned CO_2 value, red dots represent values before the analyser was replaced (indicated by the red dashed line), red triangles show the same parameter with the new analyser. B: Black dots indicate the standard deviation of the target gas values with the old analyser, black triangles represent the standard deviation of the target gas measurements after the replacement.

To calculate the annual CO_2 increase and the seasonality at Jungfraujoch, only night-time values (0:00-5:59 UTC) were used because they represent mostly background air from the free troposphere. During the day, there is the possibility of some influences of tourists as well as upwelling of air masses from the valley. The CO_2 trend from 2005 to 2019 was calculated to be 2.24 ± 0.03 ppm yr^{-1} (Figure 2). The average seasonal amplitude over this period was 10.78 ± 1.01 ppm with a maximum in March/April and a minimum in August (Figure 3).

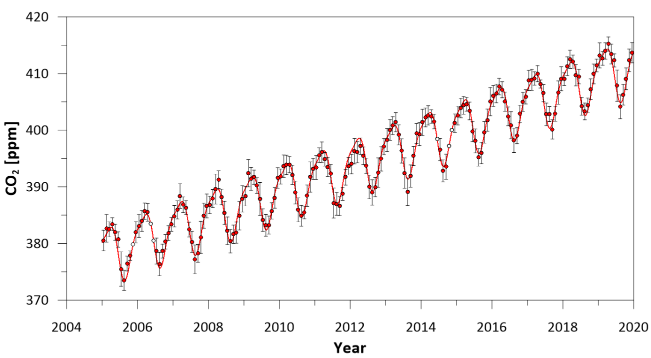

Figure 2. Monthly averages of the CO_2 measurements from Jungfraujoch (Sphinx) calculated from the nightly hourly means (0:00-5:59 UTC) from 2005 to 2019. The empty dots mark months where there are less than 50 data points available, they were calculated using the 2-harmonic fit function, which is represented by the red line.

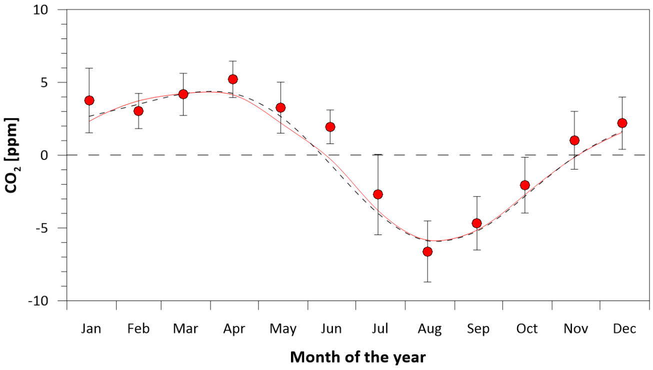

Figure 3. Monthly averages of the detrended 2019 CO_2 measurements are represented by the red dots, the red line shows the average seasonality over the years 2005-2018, which follows very close the 2-harmonic fit function indicated by black dashed line.

The temperature control of the common inlet system at the sphinx observatory is still having some issues and shows strong temperature peaks, which directly influence our paramagnetic O_2 measurements. Up to now, no correction function that works to our full satisfaction was found.

A test with a newly developed cavity ring-down spectroscopy (CRDS) O_2 analyser shows the same O_2 values as measured by the paramagnetic cell with the differences between the CRDS and the paramagnetic cell being around zero (Figure 4) (Berhanu et al., 2019). This is a further indication that the O_2 variations are coming from the gas measured by the system and are not caused by problems with the paramagnetic cell.

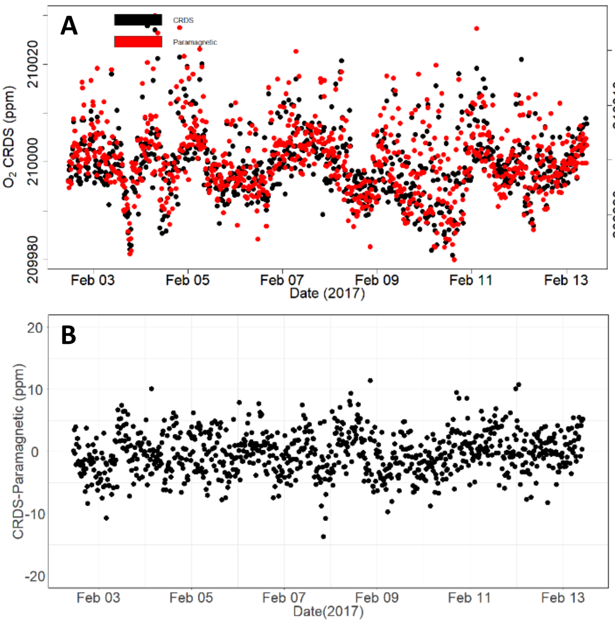

Figure 4. A: O_2 values measured during a 12-day test interval by a newly developed O_2 CRDS from Picarro Inc. and the paramagnetic cell in black and red, respectively, against time. B: Difference (CRDS – paramagnetic) against time. (Berhanu et al., 2019)

Since it is unclear when the temperature control will be working properly again, it was decided to test a dip tube with a 90° bend at the end that samples air from the centre of the common inlet system. There the influence of the temperature surge caused by the heating should be minimal. A short test done in December with different orientations looked promising. The temperature signal vanished from $\delta O_2/N_2$ values while the orientation of the dip had no influence (Figure 5) on the measured O_2 values. The dip tube was installed for additional testing on 13th of January 2020.

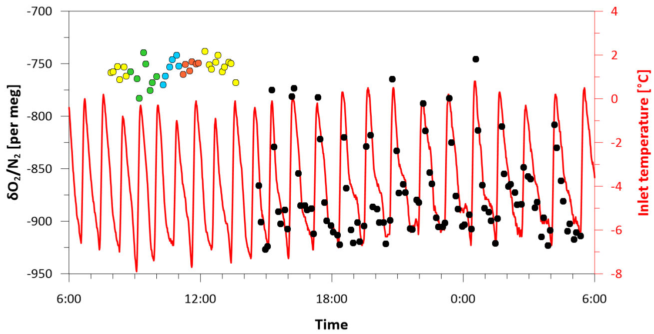

Figure 5. $\delta O_2/N_2$ values from the first test using a dip tube in the common inlet in different orientations (yellow: opening upwards; green: opening horizontal eastwards; blue: opening downwards; orange: opening horizontal westwards) and without dip tube (black dots), the scale is given on the primary y-axis. The red curve corresponds to the inlet temperature as measured by EMPA with the scale given on the secondary y-axis.

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 2019

Refereed journal articles and their internet access

Berhanu, T.A., J. Hoffnagle, C. Rella, D. Kimhak, P. Nyfeler, M. Leuenberger, High-precision atmospheric oxygen measurement comparisons between a newly built CRDS analyser and existing measurement techniques, Atmos. Meas. Tech., **12**, 12, 6803-6826, doi: 10.5194/amt-12-6803-2019, 2019. https://www.atmos-meas-tech.net/12/6803/2019/

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