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

Project leader and team:

Prof Dr. Markus Leuenberger, project leader
Ingrid and Sander Van der Laan, Chiara Uglietti, Peter Nyfeler and Hanspeter Moret

Project description:

During 2010 we continued the combined CO_2 and O_2 measurements at Jungfraujoch. 2010 was the warmest year since the instrumental recordings were commenced regarding the global average temperature. From the CO_2 measurements at Jungfraujoch we have indications that the annual growth rate for 2010 was exceptionally high which could be due to an unexpected low seasonality. In paticular the summer CO_2 uptake by the plants was rather low. In addition 2010 has a very low annual NAO index that could point to a lower CO_2 ocean uptake leaving a larger amount of CO_2 in the atmosphere. Since the end of 2004 we determine the CO_2 concentration continuously. In this period the CO_2 concentration increased by about 10 ppm. This corresponds to an mean annual increase of about 1.9 ppm/yr.

The evolution of CO_2, O_2 and APO (Atmospheric Potential Oxygen) is displayed in Figure 1 [*Uglietti et al.*, 2011]. In contrast to the increasing CO_2, O_2 concentrations are decreasing corresponding mainly to the oxygen consumption through fossil fuel oxidation. Similarly APO is decreasing with time. This information can be used to derive an improved quantification of the CO_2 uptake by the ocean.

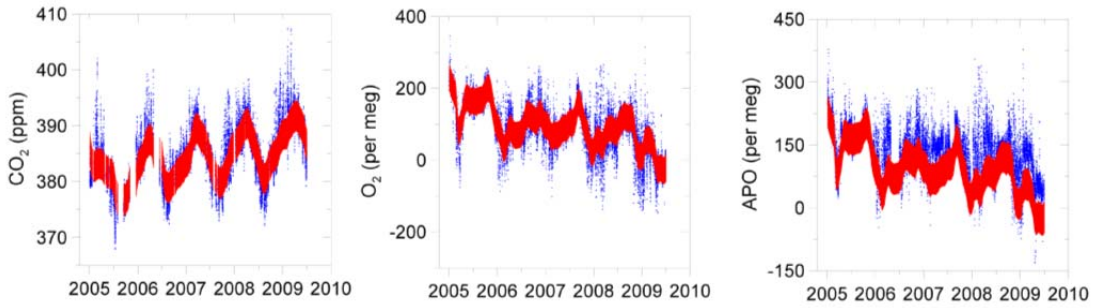

Figure 1: CO_2, O_2 and APO evolution at Jungfraujoch

The seasonal characteristics of these three parameters can be estimated from our continuous records at Jungfraujoch and were quantified to be 8.7±0.2 ppm for CO_2, 80±13 permeg for O_2 and 23±15 permeg for APO as shown in Figure 2 [*Uglietti et al.*, 2011]. This numbers are in good agreement with those derived from our flask measurements [*Sturm et al.*, 2005; *Uglietti et al.*, 2008; *Valentino et al.*, 2008].

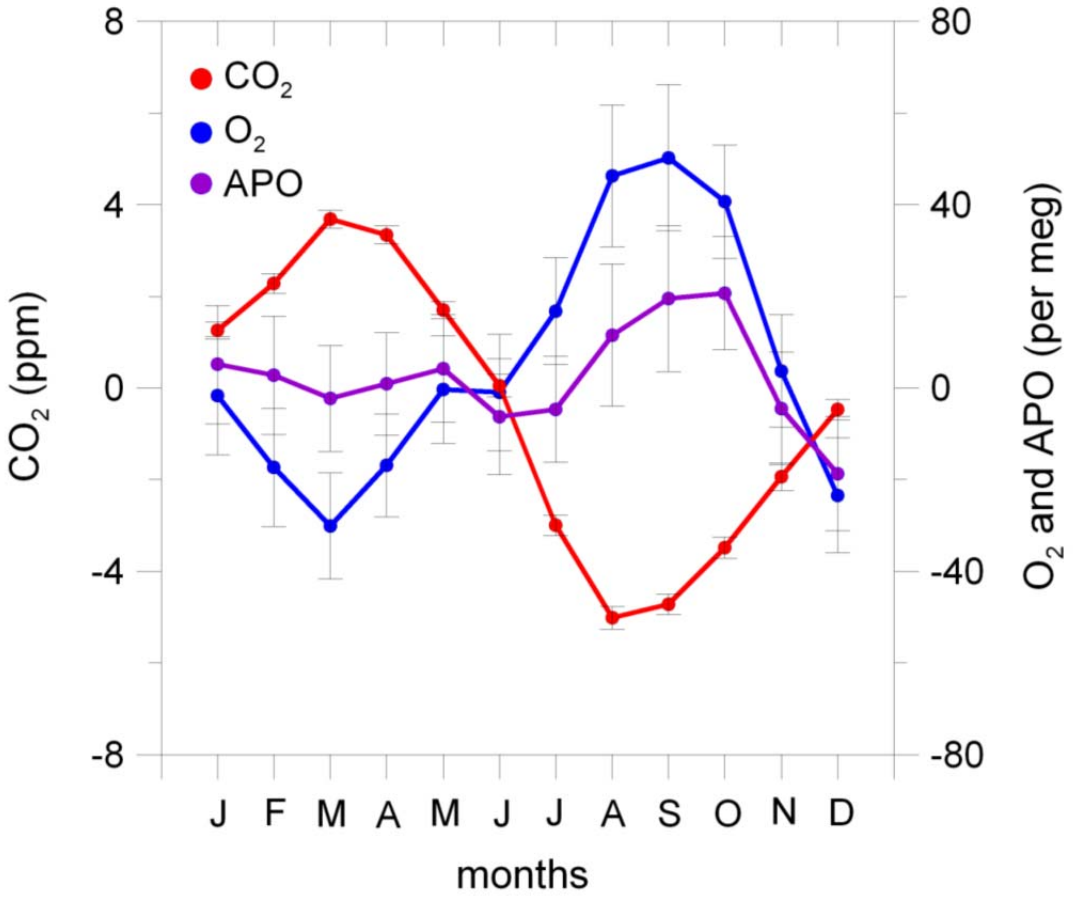

Figure 2: Seaonalities of CO_2, O_2 and APO at Jungfraujoch

The residuals from the background – that is calculated in an iterative approach of 30 days running means exluding all values outside a 2σ range until convergence – were calculated for CO_2 and APO and displayed in Figure 3 [*Uglietti et al.*, 2011]. The measurements are located in a rhombus whose corners mark the different seasons. The sensitivities of APO versus CO_2 corresponds to 120 permeg / 8 ppm which is equivalent to 3 ppm APO / 1 ppm CO_2. This is significantly above the carbon oxidation ratio of fossil fuels whose mean is around 1.4 ppm O_2 / ppm CO_2. Therefore, the ocean exchange with the atmosphere is mainly responible for the variations seen in Figure 3, however part of the variations may also be due to (i) deviations of the 1.1 ppm O_2 /ppm CO_2 relationship of the biosphere – atmosphere exchange used in the definition of APO and (ii) to fossil fuel contributions.

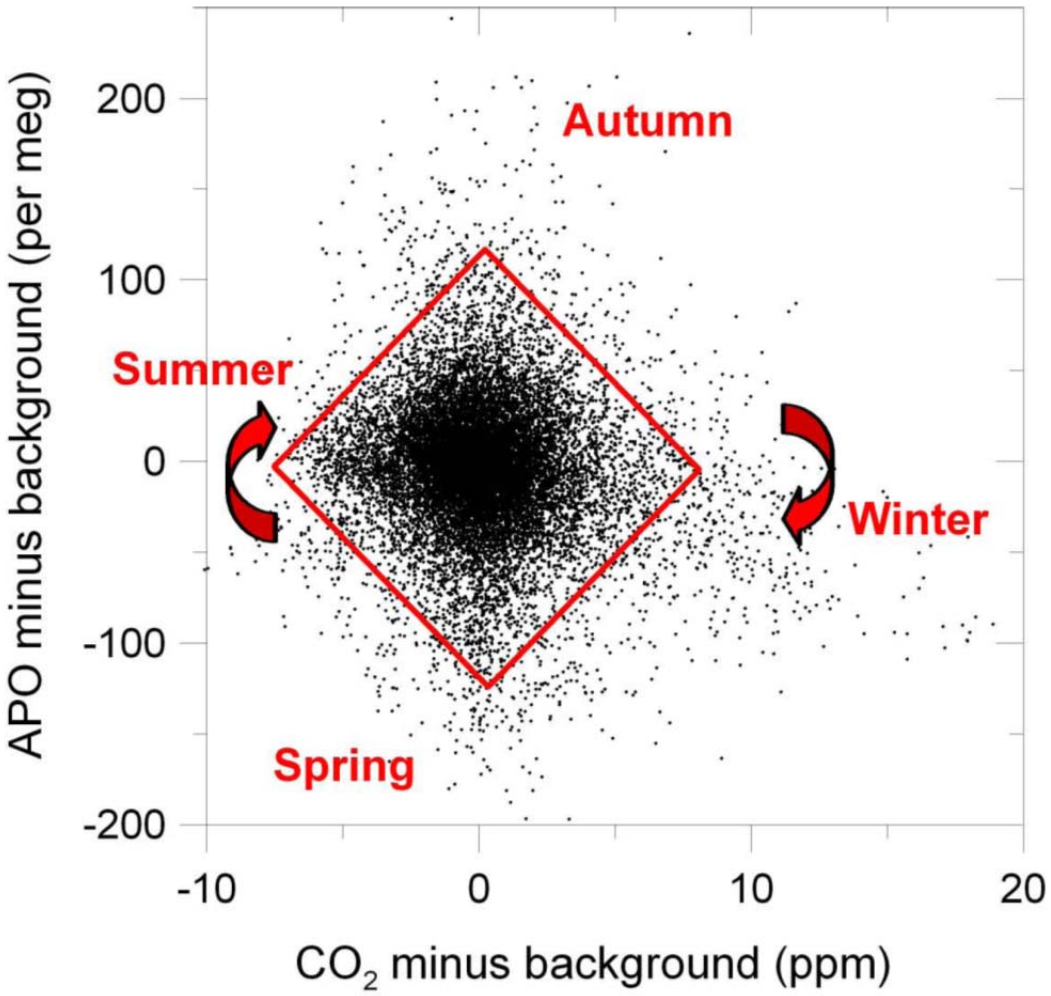

Figure 3: APO versus CO_2 background corrected data from Jungfraujoch displaying the different seasons. Most of the values are located within a rhobus whose corner represent the seasons.

Key words:

Greenhouse gas, climate change, oxidation ratio, CO_2 emissions

Internet data bases:

http://ce-atmosphere.lsce.ipsl.fr/database/index_database.html
http://www.climate.unibe.ch/?L1=research&L2=atm_gases

Collaborating partners/networks:

CarbonEurope IP partners, IMECC partners

Scientific publications and public outreach 2010:

Refereed journal articles and their internet access

Chevallier, F., P. Ciais, T.J. Conway, T. Aalto, B.E. Anderson, P. Bousquet, E.G. Brunke, L. Ciattaglia, Y. Esaki, M. Frohlich, A. Gomez, A.J. Gomez-Pelaez, L. Haszpra, P.B. Krummel, R.L. Langenfelds, M. Leuenberger, T. Machida, F. Maignan, H. Matsueda, J.A. Morgui, H. Mukai, T. Nakazawa, P. Peylin, M. Ramonet, L. Rivier, Y. Sawa, M. Schmidt, L.P. Steele, S.A. Vay, A.T. Vermeulen, S. Wofsy, and D. Worthy, CO_2 surface fluxes at grid point scale estimated from a global 21 year

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Conference papers

Leuenberger, M., and C. Uglietti, Atmospheric O_2 and CO_2 at the High Alpine Station Jungfraujoch, Switzerland - a comparison between online and flask measurements, in *Symposium on Atmospheric Chemistry and Physics at Mountain Sites*, edited by ACP commission of scnat, pp. 41-42, Paul Scherrer Institut, Interlaken, Switzerland, June 8-10, 2010.
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Sturm, P., M. Leuenberger, and M. Schmidt (2005), Atmospheric O_2, CO_2 and $\delta^{13}C$ observations from the remote sites Jungfraujoch, Switzerland, and Puy de Dome, France, *Geophysical Research Letters*, *32*(17).

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Valentino, F. L., M. Leuenberger, C. Uglietti, and P. Sturm (2008), Measurements and trend analysis of O_2, CO_2 and delta C-13 of CO_2 from the high altitude research station Junfgraujoch, Switzerland - A comparison with the observations from the remote site Puy de Dome, France, *Science of the Total Environment*, *391*(2-3), 203-210.