

**International Foundation  
High Altitude Research Stations  
Jungfrauoch + Gornergrat HFSJG**

**Activity Report 2012**

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## **Message of the President**

Once again the International Foundation HFSJG can look back on an extraordinary year - a year with excellent scientific activity, a year with stimulating historical reviews of the visions of outstanding pioneers, and a year with a highly optimistic perspective on the future.

At Jungfraujoch an impressive number of scientists from the Foundation's member countries and beyond have been conducting cutting-edge research in a multitude of areas, including e.g. meteorology, environmental sciences, astrophysics, and medicine. It gives me great pleasure to see that a large part of this work is done by students and early-career scientists. I am convinced that they will remember their stays at one of the most unique research sites in the world as being highly profitable and as a once in a lifetime experience, becoming thus effective goodwill ambassadors of Top of Europe. As documented in the present report most of the studies can only be performed at very high altitude and/or in a high alpine environment. Furthermore, many of these studies are linked to measurements at other research sites in Europe and overseas. The research infrastructure at Jungfraujoch operated by our Foundation has therefore continued being of utmost relevance to a globally linked scientific community. I am extremely happy that in our effort to support this international networking we could formally intensify the collaborative contacts between our Foundation and the Umweltforschungsstation Schneefernerhaus at Zugspitze in Bavaria.

At Gornergrat significant progress could be achieved in the realization of the new project "Stellarium Gornergrat", involving the University of Bern, the University of Geneva, the Burgergemeinde Zermatt, and the Foundation HFSJG. The commitment shown in this endeavour by our honorary president, Prof. Hans Balsiger, by Prof. Willy Benz, Director of the Physikalisches Institut of the University of Bern, Prof. Kathrin Altwegg, Executive Director of the Center for Space and Habitability at the University of Bern, Prof. Didier Queloz of the Observatoire de Genève, as well as by the President of the Burgergemeinde Zermatt, Mr. Andreas Biner, and Mr. Fernando Clemenz, Director of the Matterhorn Group, is gratefully acknowledged. We are confident that in 2013 the new observatory will become operational, to the benefit of a broader and especially young public target group.

The inspiring look back in history was dominated by the centenary of the Jungfrau Railways. In a series of events our benevolent partner and supporter from the very beginning of scientific research at Jungfraujoch commemorated the visionary work of Adolf Guyer-Zeller and his team. In parallel the Foundation HFSJG and the Jungfrau Railways celebrated 75 years of research at the Sphinx observatory. What was first a meteorological observatory, has over the years become a distinctive globally known landmark, and is nowadays one of the most important high alpine environmental laboratories worldwide. At Jungfraujoch the jubilee activity included from our side the opening of a new scientific exhibition for the public and the realisation of a significantly improved visibility of our infrastructure. On a national scale the birthday celebration of the Sphinx observatory was integrated in the 192nd Annual Congress of the Swiss Academy of Sciences SCNAT. This congress under the theme "Höher und kälter – Forschung am geographischen Limit" was held in Interlaken and was organized jointly by the Jungfraujoch Commission of the SCNAT and the Swiss Committee on Polar and High Altitude Research. It commemorated the pioneering work of Alfred de Quervain, in particular his exploration of the glaciers in Greenland, and his visionary efforts as initiator of the scientific station at Jungfraujoch. I would like to thank the past and present president of SCNAT, Prof. Denis Monard, and Prof. Thierry Courvoisier, and the chair of the SCNAT platform MAP, Prof. Hans Rudolf Ott, for having offered to us this prestigious outreach chance. I also gratefully acknowledge the devotion, the hard work, and the financial support by all those who contributed to the success of this event.

Operating a research infrastructure in a high alpine environment requires permanent adaptations to the changing needs of scientists, beside continuous maintenance in response to the harsh environment. New long-range international projects, as e.g. the Integrated Carbon Observation System ICOS bring up specific claims. Dynamical strategic planning and

visionary looks into the future are therefore a must also for the Foundation HFSJG. Ongoing discussions in the context of the planned “White Paper” addressing this topic are extremely useful and are expected to help in securing the unique environmental research site in harmonious coexistence with the dynamically expanding touristic destination.

The fact that we can look back again on a successful year has to be ascribed primarily to the outstanding work done by the scientists. My sincere congratulations and thanks, therefore, go to them. Then, credit is due to the broad networking and support of many institutions and individuals. In this regard, we highly appreciate and gratefully acknowledge the long standing loyalty and responsibility demonstrated toward our Foundation by our national as well as our non-Swiss member institutions, including our main funding body, the Swiss National Science Foundation. Among the many individuals I would like to thank in particular Prof. Hans Balsiger, our Honorary President, and Prof. Martin C.E. Huber, the president of the Jungfrauoch Commission SCNAT. But a smooth day to day operation of the research stations would not be possible without the dedicated work of our Director, Prof. Markus Leuenberger, and his highly motivated team. My sincere thanks, therefore, to all of them.

Together with all the members, partners and friends of our Foundation, our devoted management and of course the numerous research teams achieving scientific output with social impact at the European level and beyond, we are incessantly working to ensure that the Foundation HFSJG is able to pursue its challenging goals. Let us continue to work hard to serve a broad international science community, for a better understanding of our environment, and thus for a sustainable benefit of society.



Erwin O. Flückiger

Bern, April 2013

## Report of the Director

75 years of research at the Sphinx observatory! In late 2012, the Sphinx observatory – Jungfrauoch's landmark – celebrated three quarters of a century of scientific service. If the observatory could speak, it would certainly have fascinating tales to tell about scientists, visitors, workers and distinguished guests that were there over the many years.

I am in the very fortunate situation to sum up the activities that were undertaken at the infrastructure of HFJSG at Jungfrauoch and Gornergrat over the course of 2012.

When celebrating the long history of a research institution one generally highlights the achievements in past but often forgets the present-day research. With the new exhibition at Jungfrauoch, we tried to do both by mainly focussing on science being currently conducted at Jungfrauoch, but with a glance back at the past. The exhibition is open to everyone visiting Jungfrauoch, or a part of it can be viewed on our homepage.

New activities are progressing well at the observatory Gornergrat South – after two years of silence – with the installation of telescopes within the framework of the “*Stellarium Gornergrat*” project. The new project focusses on educating young students of secondary and high school level in basic astronomy.

### The Foundation HFSJG

On April 2, 2012 the new science exhibition was opened to the public. It is situated near the Sphinx hall and easily accessible by everyone visiting Jungfrauoch. The favourable location guarantees that a large number of tourists catch at least a glimpse of the many research activities going on at Jungfrauoch.



*Figure 1: Inauguration of the Science Exhibition on April 2, 2012. Delegation of the invitees from SCNAT, Paul Scherrer Institute, Federal Laboratory for Material Science and Technology, Federal Office for the Environment, Federal Office for Meteorology and Climatology, MeteoSwiss, Université de Liège (Belgium), University of Bern (left), snapshot of the exhibition during the inauguration speech of the director (right)*

2012 was an interim year regarding the meeting of the Board of the HFSJG Foundation, which as per its by-laws is held every other year. Therefore the statement of accounts for the year 2011 was approved and the HFSJG administration was given discharge by the Foundation's Board by correspondence ballot voting. The HFSJG bookkeeper, Mr. Christian Gasser has stepped down from his HFSJG mandate after many years of work for our Foundation as auditor and bookkeeper. I express my sincere thanks to Mr. Gasser for his dedicated commitment for the Foundation. Mrs. Theres Trachsel, at trachsel - administration & treuhand, Bern, took office on January 1, 2012.

At the end of May 2012, the HFSJG secretary, Mrs. Louise Wilson, retired. I would like to take this opportunity to thank Louise for her long (more than 15 years) engagement with our Foundation. I feel that I am not overstating by saying that everybody loved her for her friendly and helpful behaviour. I personally appreciated her exact and thorough work and her

spoken and written communication skills as well as her talent to sense what is expected. Thank you, Louise, for all your help.

Our new secretary, Mrs. Claudine Frieden, commenced her employment in spring 2012 in order to guarantee a good transfer of the many tasks within the HFSJG administration.

The Jungfrauoch Commission held its annual meeting on October 25, 2012, at the Hotel Royal - St. Georges, Interlaken. The table of contents of the White Paper, which was initiated at the Jungfrauoch Commission meeting in 2011 and briefly described in the last year's report of the director, was presented by the HFSJG director. The decision was taken to distribute this strategic document in a first step to all members of the Commission for consultation. After modification with the incoming remarks, the White Paper will be the basis for the final document that will be worked out by the working group members "Strategy planning Jungfrauoch" in close collaboration with representatives of the Jungfrau Railway. This final document will be presented for approval to the SCNAT as well as at the meeting of the HFSJG Board to be held on October 25 and 26, 2013, in Interlaken.

The 192<sup>th</sup> SCNAT annual congress was organized jointly by members of the Jungfrauoch Commission and the Swiss Committee on Polar and High Altitude Research. The congress was devoted to the pioneer in polar and high altitude research, Alfred de Quervain, the initiator of the research station at Jungfrauoch.

The Astronomic Commission meeting was held on January 20, 2012, in Bern. The issues of space limitation at the Sphinx observatory as well as the continued emissions from the construction work at Jungfrauoch were lively discussed. Potential solutions like an over-pressurized laboratory to minimize local contaminations, were mentioned but require an in depth consideration. Funding for ICOS was mentioned but at the time of the meeting no further information was available. In the meantime, we have assured secured funding for the period 2013-2016. The final planning and scheduling of the science exhibition was discussed with a presentation of the responsible design company KARGO. Furthermore, the HFSJG president announced that a working group of the Jungfrauoch Commission was built to write a strategic document (White Paper).

The meeting of the Board and the General Assembly of the Sphinx AG took place at Jungfrauoch on June 6, 2012. The HFSJG president as well as the director attended.

The webpage of the Foundation was further developed. Besides easy access to projects by means of diverse searching tools, details about the scientific exhibition including video sequences are also placed on the website.

### **The High Altitude Research Station Jungfrauoch**

As can be seen from the individual reports and the lists and statistics, the High Altitude Research Station Jungfrauoch remains a lively site for high level science. In 2012, 34 (2011: 28) institutions were active at Jungfrauoch. More than half of the total 47 (2011: 40) research projects were primarily based on remote controlled automated monitoring around the clock.

The involvement of the many research groups in international programs such as the Global Atmosphere Watch (GAW) or the Network of Detection of Atmospheric Composition Change (NDACC) is a key prerequisite of the top level research being conducted at Jungfrauoch. The presence and active role in national and international networks is important in order to improve the visibility of a station. In this regard Jungfrauoch plays a major role with the involvement in about 30 programs (Table 1).

The fact that there was no direct involvement from Austria or the United Kingdom in 2012 does not display the overall picture since there have been collaborations of these countries with other European institutions that are active on Jungfrauoch as documented by the collaborations visible in Figure 3 as well as on the HFSJG Webpage (<http://www.hfsjg.ch/jungfrauoch/researchprojects/overview.php>). At the time of writing this report, institutions from the UK are actively participating at Jungfrauoch within the

framework of the current CLACE campaign (Cloud and aerosol characterization experiments).

By number of projects, Germany and Belgium were again the most frequent users after Switzerland (Figure 2). Similarly, the number of working days spent at Jungfraujoch is dominated by Swiss, Belgian and German groups. (Figure 5).

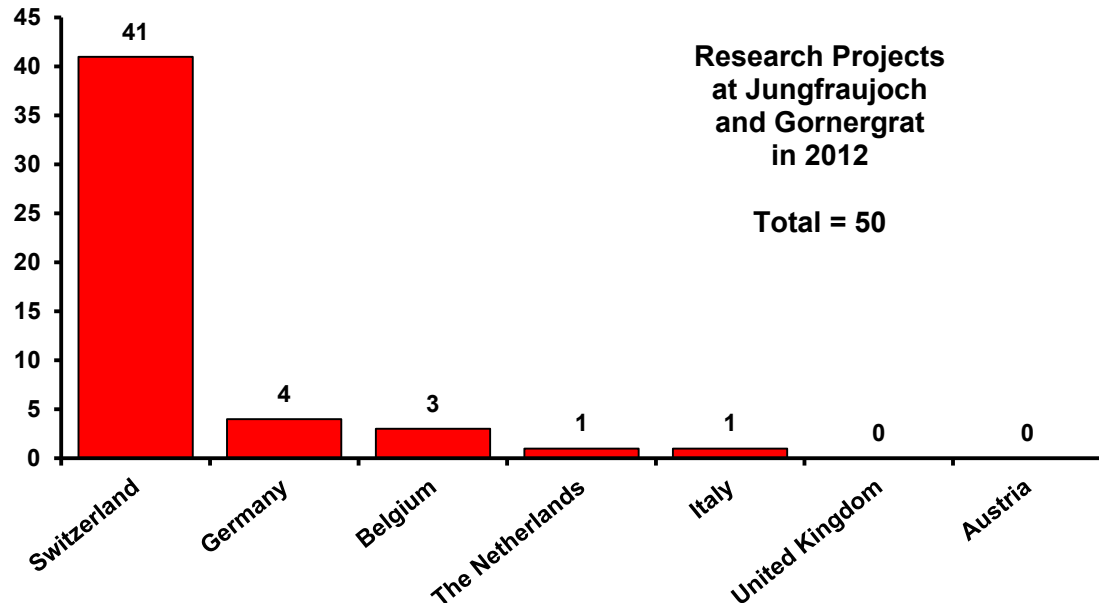


Figure 2: Number of research projects at the High Altitude Research Station Jungfraujoch and Gornergrat in 2012 by country

A significant increase of overnight stays was recorded in 2012 (815 in 2012, 439 in 2011). This is mainly due to two large medical campaigns that were hosted by our custodians at Jungfraujoch. Scientists spent a total of 1004 person-working days at Jungfraujoch. As shown in Figure 5, this is also a major increase over the previous year (2011: 536). However, the trend to remote operation of experiments is progressing further and therefore campaigns are very welcome from any research field.

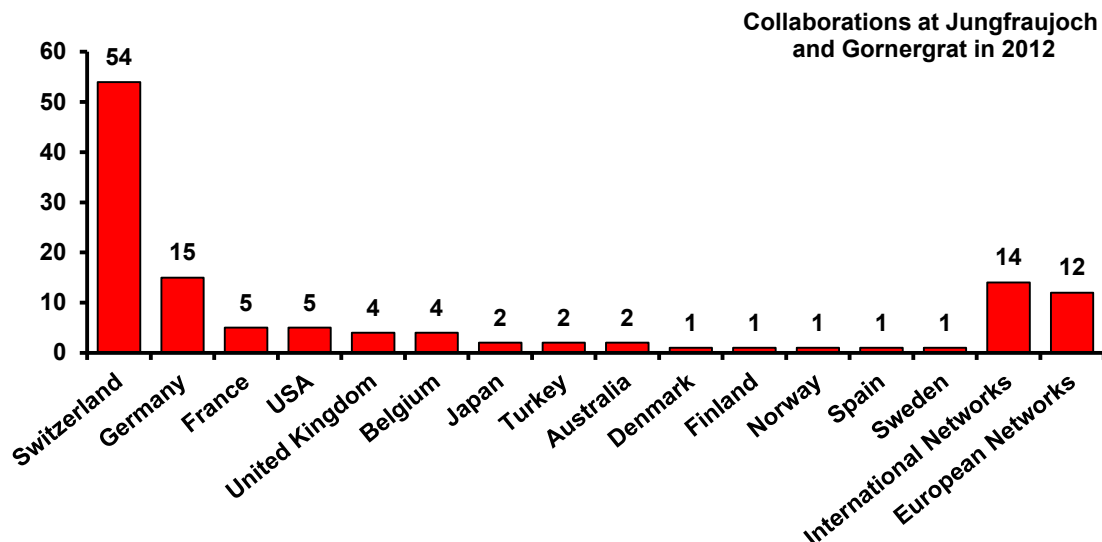


Figure 3: Number of collaborations at the High Altitude Research Station Jungfraujoch and Gornergrat in 2012

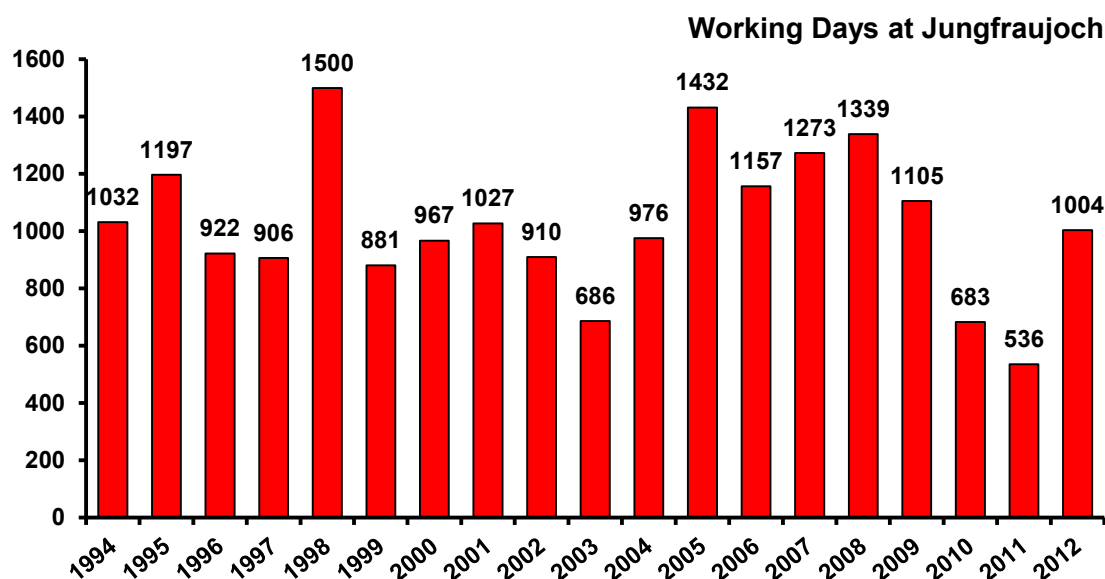


Figure 4: Number of working days spent by scientists at the High Altitude Research Station Jungfrauoch during the past years

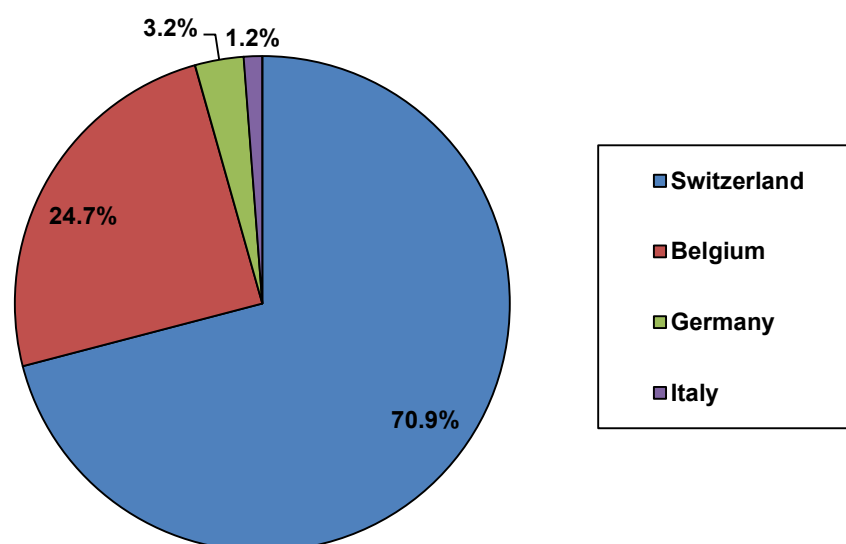


Figure 5: Percentage of person-working days in 2012 at the High Altitude Research Station Jungfrauoch per country

The research conducted at Jungfrauoch resulted in the following output in 2012:

- 32 refereed publications
- 48 conference presentations / posters
- 3 popular publications and presentations
- 8 data publications and reports
- 2 Master (1) and secondary school (1) theses, and
- 5 book / edited books

Scientific results obtained at Jungfrauoch were presented by the various research groups at a number of international conferences in 2012, e.g. at the European Geophysical Union, General Assembly, Vienna, Austria, April 22-27, 2012 (A), at the 8<sup>th</sup> FENS Forum of Neuroscience 2012, Barcelona, July 14-18, 2012 (E), at the 11<sup>th</sup> Atmospheric Spectroscopy



Applications meeting (ASA 2012), united with the “12th HITRAN Conference”, Reims, August 29-31, 2012 (F), at the NDACC-IRWG Annual Meeting, Wengen, Switzerland, June 11-15, 2012 (CH), at the EUREF'12: Paper contributions to the EUREF-Symposium in Paris, June 6-8, 2012 (F), at the ACCENT-IGAC-GEIA Conference, Toulouse, June 11-13, 2012 (F), at the SBSTA Science meeting, Bonn, May 13, 2012 (D), at the 23<sup>rd</sup> European Cosmic Ray Symposium, Moscow, 2012 (RUS), at the AAAR 31<sup>st</sup> Annual Conference, Minneapolis, Minnesota, October 8-12, 2012 (USA), at the 12<sup>th</sup> International Global Atmospheric Chemistry (IGAC) Science Conference, Beijing, September 17-21, 2012 (CHN), at the HALOE and ACE-FTS infrared solar observations, poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, August 27–31, 2012 (CDN), at the 15<sup>th</sup> International Conference on Laser Optics, St. Petersburg, June 25-29, 2012 (RUS), at the European Aerosol Conference (EAC), Granada, September 02-07, 2012 (ES), at the Geological Society of America, Annual meeting, Charlotte, North Carolina, November 4-7, 2012 (USA), at the ICCP-2012, Leipzig, July 30 – August 3, 2012 (D), at the AGU Fall Meeting, San Francisco, December 3-7, 2012 (USA), at the Joint European Stable Isotope Users group Meeting (JESIUM 2012), Leipzig, September 02-07, 2012 (D), at the Quadrennial Ozone Symposium QOS 2012, Toronto, August 27–31, 2012 (CDN), at the 29<sup>th</sup> International Physics Congress, Bodrum, September 5-8, 2012 (TR).

Again, a large number of refereed publications and conference contributions are explicitly linked to our research facility. This convincingly documents the importance of the Jungfraujoch Research Station within the European setting, in particular in the field of environmental science. Jungfraujoch is recognized as a key station within many national and international networks as listed in Table 1.

In the following I would like to highlight the wealth of research by presenting two examples, (i) a new technique for the chemical characterization of aerosols and (ii) the effect of high altitude exposure on patients with mild congenital heart disease.

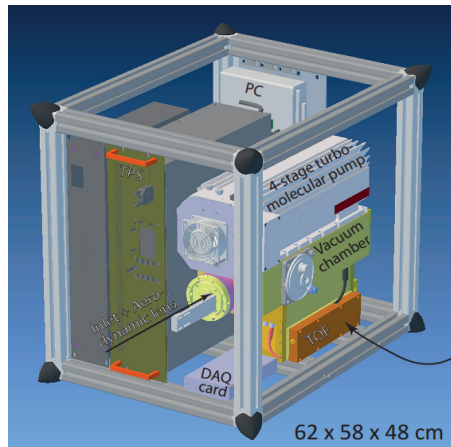


Figure 6: Sketch of ToF-ACSM.

The first project entitled “Aerosol Chemical Speciation Monitor (ACSM) measurements on the Jungfraujoch within the frame of the EU project ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network)” of Dr. André Prévôt and his team from the Laboratory of Atmospheric Chemistry at the Paul Scherrer Institute has two goals: (i) gaining knowledge about the chemical composition at the high altitude site Jungfraujoch over at least a one year period and (ii) testing and validation of the new time of flight mass spectrometer shown in Figure 6.

Work on the project was started in late June 2012.

The second project entitled “Effect of high altitude exposure on hemodynamic response to exercise in patients with mild congenital heart disease” was led by Prof. Dr. Jean-Paul Schmid from the Cardiovascular Prevention & Rehabilitation, Swiss Cardiovascular Centre Bern, University Hospital (Inselspital), Bern.

Orientation about health issues related to the exposure to high altitudes is important for visitors or workers at Jungfraujoch. Therefore, medical investigations of this nature are highly relevant and very welcome. The project conducted by Prof. Schmid dealt with testing the hemodynamic response (cardiac output) of a steady state exercise at high altitude (3454 m) in adolescents with congenital heart disease and with measurements of the influence

of high altitude on single components of cardio-pulmonary response during a maximal exercise stress test. Results are summarized in the activity report to this medical campaign.



*Figure 7: Non-invasive measurement of cardiac output using an inert gas rebreathing method during a constant work load exercise test in an adolescent with minor congenital heart disease (a recent study of Prof. Jean-Paul Schmid from the Swiss Cardiovascular Center Bern at the research station Jungfrauoch)*

Additional scientific highlights were published in several peer-reviewed journals:

- Amitrano et al., Earth and Planetary Science Letters, 2012 presents a method of acoustic emission monitoring used to investigate rock.
- Brunner et al., Atmos. Chem. Phys., 2012 discusses an extended Kalman-filter for regional scale inverse emission estimation.
- Conen et al., Atmos. Meas. Tech., 2012 registers atmospheric ice nucleators active at  $\geq -12$  °C on PM10 filters.
- Deolal et al., Atmos. Chem. Phys., 2012 presents long-term in situ measurements of NO<sub>x</sub> and NO<sub>y</sub> at Jungfrauoch.
- Hendrick et al., Atmospheric Chemistry and Physics, 2012 discusses the analysis of stratospheric NO<sub>2</sub> trends above Jungfrauoch.
- Ruckstuhl et al., Atmospheric Measurement Techniques, 2012 presents a robust extraction of baseline signal of atmospheric trace species using local regression.
- Logan et al., J.A., Journal of Geophysical Research-Atmospheres, 2012 presents changes in ozone over Europe from sondes, regular aircraft (MOZAIC) and alpine surface sites.
- Parrish et al., Atmospheric Chemistry and Physics, 2012 presents long-term changes in lower tropospheric baseline ozone concentrations at northern mid-latitudes.
- Popp et al., Atmos. Meas. Tech., 2012 discusses high resolution NO<sub>2</sub> values obtained from remote sensing from the Airborne Prism EXperiment (APEX) imaging spectrometer.
- Risi et al., J. Geophys. Res., 2012 presents process-evaluation of tropospheric humidity simulated by general circulation models using water vapor isotopologues.
- Saikawa et al., Atmos. Chem. Phys., presents global and regional emissions estimates for HCFC-22.
- Schneider et al., Atmos. Meas. Tech., 2012 discusses ground-based remote sensing of tropospheric water vapor isotopologues within the project MUSICA.
- Spiegel et al., Atmospheric Measurement Techniques, 2012 discusses the evaluation of capabilities and uncertainties of droplet measurements for the fog droplet spectrometer (FM-100).
- van der Laan-Luijkx et al., Atmos. Meas. Tech. Discuss., 2012 presents a detailed multiple year flask sampling intercomparison.
- Wilson et al., Atmospheric Chemistry and Physics, 2012, Have primary emission reduction measures reduced ozone across Europe? An analysis of European rural background ozone trends 1996–2005.

**Table 1.** List of major nationally and internationally coordinated networks and/or research programs where Jungfrauoch is a key station

<b>NDACC</b>	Network for the Detection of Atmospheric Composition Change Primary Site ( <a href="http://www.ndacc.org/">http://www.ndacc.org/</a> )
<b>GAW, GAW-CH</b>	Global Atmosphere Watch, Global GAW Station ( <a href="http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html">http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html</a> ), and ( <a href="http://www.meteoschweiz.admin.ch/web/de/meteoschweiz/internationales/GAW.html">http://www.meteoschweiz.admin.ch/web/de/meteoschweiz/internationales/GAW.html</a> )
<b>GAW-PFR</b>	GAW Aerosol Optical Depth (AOD) Network ( <a href="http://www.pmodwrc.ch/worcc/pmod.php?topic=gawpfr_aod_network_menu">http://www.pmodwrc.ch/worcc/pmod.php?topic=gawpfr_aod_network_menu</a> )
<b>GCOS</b>	Global Climate Observing System ( <a href="http://www.wmo.int/pages/prog/gcos/">http://www.wmo.int/pages/prog/gcos/</a> )
<b>GCOS-CH</b>	Swiss GCOS office ( <a href="http://www.meteoschweiz.admin.ch/web/de/meteoschweiz/internationales/gcos/swiss_gcos_office.html">http://www.meteoschweiz.admin.ch/web/de/meteoschweiz/internationales/gcos/swiss_gcos_office.html</a> )
<b>SOGE</b>	System for Observation of Halogenated Greenhouse Gases in Europe ( <a href="http://www.nilu.no/soge/files/network/jungfrauoch.html">http://www.nilu.no/soge/files/network/jungfrauoch.html</a> )
<b>GEOMON</b>	Global Earth Observation and Monitoring of the Atmosphere ( <a href="http://www.geomon.eu/">http://www.geomon.eu/</a> )
<b>AGAGE</b>	Advanced Global Atmospheric Gases Experiment Collaborative Sampling Station ( <a href="http://agage.eas.gatech.edu/">http://agage.eas.gatech.edu/</a> )
<b>NADIR/NILU</b>	NILU's Atmospheric Database for Interactive Retrieval ( <a href="http://www.nilu.no/nadir/">http://www.nilu.no/nadir/</a> )
<b>IMECC</b>	Infrastructure for Measurements of the European Carbon Cycle ( <a href="http://imecc.ipsl.jussieu.fr/index.html">http://imecc.ipsl.jussieu.fr/index.html</a> )
<b>EUMETNET</b>	Network of European Meteorological Services ( <a href="http://www.eumetnet.eu/">http://www.eumetnet.eu/</a> )
<b>SwissMetNet</b>	Automatic Measuring Network of MeteoSwiss ( <a href="http://www.meteoschweiz.admin.ch/web/de/klima/messsysteme/boden/swissmetnet.html">http://www.meteoschweiz.admin.ch/web/de/klima/messsysteme/boden/swissmetnet.html</a> )
<b>RADAIR</b>	Swiss Automatic Network for Air Radioactivity Monitoring ( <a href="http://www.bag.admin.ch/themen/strahlung/00045/02372/02374/index.html?lang=de">http://www.bag.admin.ch/themen/strahlung/00045/02372/02374/index.html?lang=de</a> )
<b>ICOS</b>	Integrated Carbon Observation System ( <a href="http://www.icos-infrastructure.eu/">http://www.icos-infrastructure.eu/</a> )
<b>NADAM</b>	Netz für automatische Dosis-Alarmierung und Meldung ( <a href="http://www.naz.ch/de/aktuell/tagesmittelwerte.shtml">http://www.naz.ch/de/aktuell/tagesmittelwerte.shtml</a> )
<b>NABEL</b>	Nationales Beobachtungsnetz für Luftfremdstoffe - National Air Pollution Monitoring Network ( <a href="http://www.empa.ch/plugin/template/empa/699/*---/l=1">http://www.empa.ch/plugin/template/empa/699/*---/l=1</a> )
<b>AGNES</b>	Automated GPS Network for Switzerland ( <a href="http://www.swisstopo.admin.ch/swisstopo/geodesy/pnac/html/en/statjujo.html">http://www.swisstopo.admin.ch/swisstopo/geodesy/pnac/html/en/statjujo.html</a> )
<b>PERMASENSE</b>	Wireless Sensing in High Alpine Environments ( <a href="http://www.permasense.ch/">http://www.permasense.ch/</a> )
<b>PERMOS</b>	Permafrost Monitoring Switzerland ( <a href="http://www.permos.ch/">http://www.permos.ch/</a> )
<b>NMDB</b>	Real-Time Database for High Resolution Neutron Monitor Measurements ( <a href="http://www.nmdb.eu">http://www.nmdb.eu</a> )
<b>E-GVAP I + II</b>	The EUMETNET GPS Water Vapour Programme ( <a href="http://egvap.dmi.dk/">http://egvap.dmi.dk/</a> )
<b>ACTRIS</b>	Aerosols, Clouds, and Trace gases Research Infrastructure Network ( <a href="http://www.actris.net/Home/tabid/4276/Default.aspx">http://www.actris.net/Home/tabid/4276/Default.aspx</a> )
<b>EUSAAR</b>	European Supersites for Atmospheric Aerosol Research ( <a href="http://www.eusaar.net/files/activities/transnat_act.cfm">http://www.eusaar.net/files/activities/transnat_act.cfm</a> )
<b>EUCAARI</b>	European Integrated project on Aerosol Cloud Climate and Air Quality Interactions ( <a href="http://www.cas.manchester.ac.uk/resprojects/eucaari/">http://www.cas.manchester.ac.uk/resprojects/eucaari/</a> )
<b>COST 726</b>	Long term changes and climatology of UV radiation over Europe ( <a href="http://www.cost726.org/">http://www.cost726.org/</a> )
<b>Swiss Glacier Monitoring Network</b>	Federal Office for the Environment (BAFU) ( <a href="http://glaciology.ethz.ch/messnetz/?locale=en">http://glaciology.ethz.ch/messnetz/?locale=en</a> )
<b>InGOS</b>	Integrated non-CO <sub>2</sub> Greenhouse Gas Observing System ( <a href="http://www.ingos-infrastructure.eu/">http://www.ingos-infrastructure.eu/</a> )

Most of the measurements made at Jungfrauoch are publicly available via the respective databases, many of them in real or near real-time.

The Research Station remained attractive in 2012 as in previous years. Several organizations initiated meetings of national and international scientific committees in the Jungfrau region and often combined these meetings with an excursion to Jungfrauoch. The research station was also visited by a large number of student and teachers groups as part of a lecture or training school. Examples of the 53 individual and group visitors in 2012 are:

- Paul Scherrer Institut, Hr. P. Zieger; 22.01.2012
- Gewinner von Nacht der Forschung Uni Bern, Fr. R. Murati; 30.01.2012
- Ice-co GmbH, Frau Camadini; 19.02.2012
- Delegation aus Korea, Fr. K. Antonietti; 23.02.2012
- ExtremCom12, Hr. J. Beutel, and Dr. F. Legendre; 13.03.2012
- Schindler Aufzüge, Hr. M. Karlen; 15.03.2012
- Onkologie-Zentrum Biel, Hr. D. Vetterli; 16.03.2012
- Chinesische Delegation, Hr. H-R Keusen; 22.03.2012
- Familie von Hr. v.d. Bergh, Hr. v.d. Bergh; 22.03.2012
- Studenten von Uni Frankfurt, Prof. J. Curtius; 27.03.2012
- VPT BLS, Pensionierte, Hr. H. Bärtschi; 12.04.2012
- Uni Basel / PSI, Hr. E. Hammer; 13.04.2012
- Deutsche Wissenschaftler und Journalisten, Prof. Dr. M. Wilhelm; 21.04.2012
- ETHZ LIDAR, Dr. U. Krieger; 30.04.2012
- Prof. S. Pratsinis; 02.04.2012
- ETH Zürich / PSI, Hr. E. Hammer; 10.05.2012
- Paul Scherrer Institut, Hr. P. Zieger; 14.05.2012
- Primarschule Bönigen, Hr. S. Weisskopf; 15.05.2012
- Astronom, Herr G. Bourban; 25.05.2012
- Fr. K. Aplin; 10.06.2012
- Paul Scherrer Institut, Hr. Weingartner, Besuch Prof. Thomas Leisner; 12.06.2012
- Herr S. Geissbühler; 12.06.2012
- Migeotte, IRWG/TCCON Meeting, Hr. Ch. Servais; 15.06.2012
- Herr Brand; 23.06.2012
- WCRP SPARC Workshop, Dr. M. Hegglin; 27.06.2012
- Uni Bern, Prof. Harald Krug; 28.06.2012
- Geographie Uni Bern, Prof. S. Brönimann; 29.06.2012
- GABA International AG, Fr. B. Egger; 07.07.2012
- Wengen Tourismus, Hr. P. Brunner; 10.07.2012
- UCLA, Prof. L. Estrada; 14.07.2012
- Fr. I. Zbinden, Bundespersonal; 19.07.2012
- Uni Basel, Zahnmedizin, Fr. S. Kaiser, JB; 17.08.2012
- Deutscher Wetterdienst, Hr. Fröhlich; 18.08.2012
- Familie von Hr. v.d. Bergh, Hr. H. van den Bergh; 20.08.2012
- Ehepaar P. und A. Naef, MeteoSwiss, Hr. P. Naef; 23.08.2012
- EMPA, Fr. B. Buchmann; 25.08.2012
- Meteo Schweiz, Hr. Chr. Félix; 04.09.2012
- Hokkaido University, Hr. Shin Sugiyama; 05.09.2012
- Swisscom Station, Hr. Goldie; 08.09.2012
- Wengen Tourismus; 28.09.2012
- Uni Stuttgart, Hr. Prof. G. Baumbach; 03.10.2012
- Das FIRST Lab, Hr. B. Tuzson (EMPA); 04.10.2012
- Siemens, Hr. E. Würzler; 13.10.2012
- CEDB, Club der ehemaligen Dozierenden Burgdorf, Prof. H. Häberlin; 30.10.2012
- Glaziologie Studenten, ETHZ Prof. M. Funk; 07.11.2012
- Delegation von Hr. v. d. Bergh; 08.11.2012
- Naturforschende Gesellschaft in Bern, Prof. E. Flückiger; 10.11.2012
- Gewinner Wettbewerb des Eidg. Finanzdepartementes, Hr. S. Rüfenacht; 09.12.2012



The management HFSJG was particularly honoured to welcome the following official delegations:

- Media event, «Top Science at the Top of Europe», Scientific exhibition at Jungfrauoch; May 3, 2012
- Reception and tour with experts from Roshydromet (Moskau and St. Petersburg); May 2-3, 2012
- Reception and tour with the board of directors of the University of Bern; June 2, 2012
- Reception and tour with NASA STS-134 astronauts and accompanying persons CERN/AMS at Jungfrauoch; July 26, 2012
- Reception and tour with guests of the 192<sup>th</sup> Jahreskongresses 2012 der Akademie der Naturwissenschaften Schweiz SCNAT, „Höher und kälter – Forschung am geographischen Limit“; October 27, 2012



*Figure 8: Delegation of the directorate of the University of Bern at Jungfrauoch on June 2, 2012 (on the left); NASA and ESA astronauts of the STS-134 mission at the research station Jungfrauoch, July 26, 2012 (on the right). This was the penultimate mission of NASA's Space Shuttle program and marked the final flight of Space Shuttle Endeavour.*

The large number of requests for visits of the research station at Jungfrauoch was paralleled by an unbroken intense interest by print media and TV, with more than 49 contributions in 2012. The winner of the “Nacht der Forschung” of the University of Bern, Mrs. Remina Murati from Bern was invited for a Jungfrauoch excursion with a guided tour of the Research Station.

In order to provide the researchers good working conditions, continuous efforts are made to update the infrastructure. In 2012 several infrastructural changes were made at the Jungfrauoch Research Station: (i) a protective door was built in at Sphinx laboratory level 2 to minimize instrument noise and contamination exposure; (ii) the HFJSG entrances were refurbished for better visibility and corporate identity; (iii) preparations were made for the protection roof renovation coming up in 2013 and 2014.

(i) Noise emission at the Sphinx laboratory on level 2 was unacceptable for research work or during tours with visitors. Therefore, a protective door was installed for noise reduction as well as contamination minimization from contaminated air masses uplifted through the elevator channel. After installation a significant improvement was noticed.

(ii) In addition to the science exhibition, the refurbishing of the HFSJG infrastructure entrances to a modern appearance has led to improved visibility and recognition of the research facilities at Jungfrauoch.



*Figure 9: Installation of the protective door (left) and additional access points for outside air measurements at the Sphinx cupola (right).*

(iii) As already announced in the last activity report, there is an urgent need to renew the protection roof of the research station. Preparations by our architect have been done and quotes are available. The renovation is planned for the summer/autumn months of 2013 and 2014.

Due to the tremendous demand of research groups to participate in the 2013 CLACE campaign that commenced in January and will last until mid-March 2013, additional access points requested for outdoor sampling were installed. The only available space for such access points without significant interference to on-going research projects was the Sphinx cupola.

A significant reduction of emissions at Jungfraujoch was observed after the construction work and completion of the new tunnel system for tourists ended in mid-March 2012. This has been documented by  $\text{NO}_x$  values, for instance. Yet, there is a growing demand to carefully document and investigate the grade of contamination in order to maintain the highest quality of the measurements. A continued open discussion about challenging issues at Jungfraujoch between the Jungfrau Railways and our Foundation is important.

As in previous years, several coordination discussions took place with the management of the Jungfrau Railways. The main annual coordination meeting at Jungfraujoch, a platform for the discussion of items of common concern, took place on October 23, 2012, and was attended by the director of the research stations and Mr. Urs Otz. Prime topics related to the HFSJG were (i) the emissions related to the construction of the new passageway; (ii) the announcement of the director that the protection roof of the research station is going to be renewed in 2013/2014 (iii) the exchange of rooms between HFSJG and Jungfrau Railways (JB) has been formalized (the workshop of JB is moving into the old exhibition hall of HFSJG infrastructures with corresponding space available for HFSJG in the new JB cavern for storage).

### **The High Altitude Research Station Gornergrat**

After two years of silence at the observatory Gornergrat South, a moderate renovation of the infrastructure is one of the precursors for the new equipment being installed in the coming months within the framework of the “*Stellarium Gornergrat*” project. The financial funding comes from the two host universities, i.e. University of Bern (Physics Institute) and the Université de Genève (Observatoire de Genève), from the Burgergemeinde Zermatt, and from an SNF grant under the SNF program AGORA.

“*Stellarium Gornergrat*” is an astronomical facility to be installed at Gornergrat for educational purposes with the goal to provide access to astronomical observation to the public in general and to young people. The clean and dry air at this site as well as its location on the southern side of the Alps maintains, on the average, favourable meteorological conditions. It has been recognized by professional astronomers as one of the best sites in Switzerland for astronomical observations. This astronomical facility is designed to deliver professional performance and to be remotely controlled from any location with the help of an easy-to-use web-interface. It is conceived to become an ideal platform for the education of students, for visitors at the Gornergrat as well as for the general public, and thus to evolve into a prime site in Switzerland for astronomy and science education.

*Stellarium Gornergrat* is organized around three different elements: (1) The observation infrastructure at Gornergrat, namely a large telescope and other specialized observing tools. (2) A web portal to control the facility and provide access to the observations and educational tools and packages. (3) Educational materials and programs.

The educational programs are targeted to make this facility a major tool for education. They will be planned and organized in close collaboration with teachers and with existing Swiss infrastructure for science outreach and communication at UniGe and UniBe.

The first minor step of the hardware installation was achieved in 2011 with the mounting of the all-sky camera that delivers pictures from Gornergrat to track the movement of the moon and sun. The telescopes and their mount were ordered during the reporting period and will undergo an in-depth testing procedure prior to the definitive installation at Gornergrat in spring 2013.

Teams and projects at the High Altitude Research Station Gornergrat are less numerous than at Jungfrauoch as documented by its statistics. In 2012, 3 (2011: 3) teams were active at Gornergrat. Among a total of 3 (2011: 3) research projects, 2 (2011: 2) were primarily based on automatic measurements around the clock.

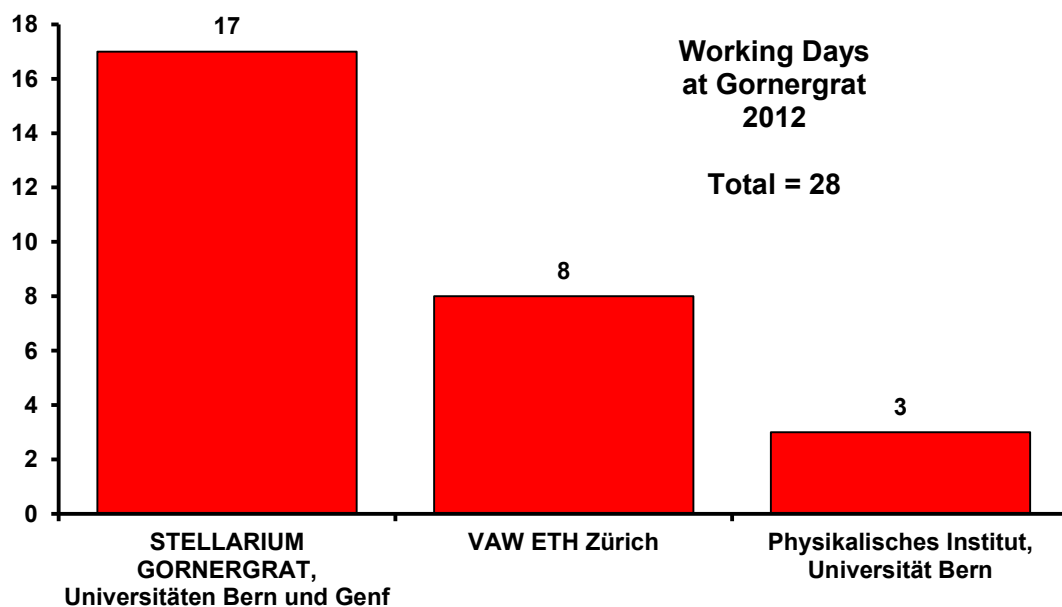


Figure 10: Number of working days at the High Altitude Research Station Gornergrat in 2012 by research groups



*Figure 11: Telescopes and mount for Gornergrat for testing at the University of Bern (left), Matterhorn during sunset (right)*

### **Summary and Acknowledgements**

The year 2012 – the 75<sup>th</sup> anniversary of the Sphinx observatory, Jungfrauoch's landmark – has brought many memorable times. The new science exhibition will serve as an interface between the research community and tourists. We hope that many of the large number of tourists will be attracted by the science displays and will interact with our community and the Foundation. So far, we have had many positive responses.

At Gornergrat the project “Stellarium Gornergrat” is well on track. The first educational training at Gornergrat is planned soon.

Again, I am deeply impressed with the research output from the many projects being conducted in either peer-reviewed publications, conference presentations or in the individual activity reports. It is exactly the principle aim of the HFSJG to promote science, and it is an excellent testimony for our continued support regarding infrastructure, maintenance and administration.

HFSJG is well aware that the success of our Research Stations is based on the support of multiple partners. The international structure of our foundation with its members, their annual contributions and their representatives are as central as the Swiss National Science Foundation for the most significant funding. The research organizations using the HFSJG infrastructure, the scientists devoted to research, and the administrative personnel of HFSJG are crucial for our success. Particularly, I would like to thank the two custodian couples who were in charge at Jungfrauoch over the course of 2012, Mrs. and Mr. Fischer as well as Mrs. and Mr. Otz for their continuously excellent and competent work and for providing researchers with a friendly and motivating atmosphere.

The year 2012 must have been an incredible year for the Jungfrau Railways with its centennial celebration. I certainly can say that the HFSJG is lucky to have such a competent and cooperative partner and is proud to share a significant portion of the time frame of these 100 years of success. Similarly, with the Gornergrat Bahn we have an excellent partner for our observatory on Gornergrat. Therefore, I would like to thank the Jungfrau Railway Holding AG (Prof. Thomas Bieger, president of the Board and Mr. Urs Kessler, Chief Executive Officer), the Matterhorn Gotthard Railway (Jean-Pierre Schmid, president and Fernando Lehner, Chief Executive Officer and its representative in the HFSJG Board, Mr. René Bayard) and the Gornergrat Railway for the good collaboration. With their goodwill and their substantial support both research stations have benefited year by year. Thank you.



A sincere thank you goes to staff members of the Jungfrau Railways who experienced busy times during the preparation phases of the centennial as well as beyond. These times required continuous exchange of information in order for us to benefit from each other. In this respect we express our special thanks to Mr. Jürg Lauper, head of infrastructure and his deputy, Mr. Heinz Schindler, to Mr. Gabriel Roth, head of Zugförderung und Werkstätte (ZfW/JB) und Leiter Jungfraubahnen AG, to Mr. Andreas Wyss, chief of technical services and maintenance division, and his team. HFSJG is very grateful to Mrs. Brigitte Soche and Mr. Martin Soche and the personnel of the restaurants at the Top of Europe for the excellent hosting of our staff, scientists, and visitors.

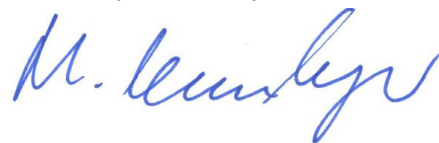
For Gornergrat our thanks go to Burgergemeinde Zermatt (Mr. Andreas Biner, president and Mr. Fernando Clemenz) for the continuous support of the scientific projects at Gornergrat particularly for their involvement in the new Stellarium Gornergrat project. The financial contribution was important to make this project fly. A big thank you goes to Mrs. Nicole Marbach and Mr. Thomas Marbach, the directors of the Kulmhotel Gornergrat and their team, for their warm hosting of HFSJG staff and researchers. Without their goodwill and support it would not be possible to operate an astrophysical observatory at such a magnificent site.

I do not only act as director, but I am also an active researcher at Jungfraujoch, and therefore I know what it means for somebody coming from far away to have an excellently working observatory. Only the active use of the HFSJG infrastructures by many research partnerships, organizations and institutions will lead to higher visibility and recognition. In other words, we are on a give and take basis, preferentially in a win-win situation. Having this in mind, I sincerely thank all scientists for their interest and innovative power in suggesting and conducting research at both stations with greatest care and dedication and with a high degree of esprit de corps. Campaigns or long-term experiments allow extending and strengthening this cooperation and collaboration further.

As already mentioned above, a good and well maintained infrastructure is mandatory to hold our standards. This requires excellent expert knowledge, time and financial investments. In this respect I would like to thank SWITCH for maintaining the fast internet connection with hardly any interruption, as well as Christian Heim and Fritz Bütikofer with his team from the “Informatikdienste der Universität Bern” for their excellent support regarding all kinds of requests in IT matters. Their help is especially valuable during rather hectic times of large campaigns.

The administrative staff at Bern has again done a good job. In particular the work by Claudine Frieden, our new secretary, is very much appreciated. She adapted very efficiently to the new setting within a short time. Many thanks to Dr. Rolf Bütikofer for carefully supervising and extending the IT processes for and within the HFSJG. Thanks go to Mr. Karl Martin Wyss for his competent services as our treasurer, and Mrs. Theres Trachsel for the bookkeeping, and the professional auditing by Treuhand Cotting AG, Bern (Mr. Harro Lüdi). I am particularly grateful to the University of Bern, its Rector Prof. Dr. Martin Täuber and the Administrative Director, Dr. Daniel Odermatt, and the director of the Physikalisches Institut, Prof. Willy Benz, for the hospitality and support of our administration. Finally, I would like to thank Prof. Erwin Flückiger and Prof. Hans Balsiger for their enthusiastic involvement in the “Stellarium Gornergrat” project.

I conclude by reminding all our readers not to miss the opportunity to visit either Gornergrat or Jungfraujoch or even both and to enjoy the exceptional surroundings in the splendid locations in the Swiss Alps. On behalf of the HFSJG, I warmly welcome you.



Bern, February 8, 2013

Markus Leuenberger



## Research statistics for 2012

### High Altitude Research Station Jungfrauojoch

Institute	Country	Research with overnight stay	Research during the day only
Zurich Center for Integrative Human Physiology, University of Zurich	Switzerland	287	11
Institut d'Astrophysique et Géophysique, Université de Liège	Belgium	245	
Institute for Atmospheric and Climate Science, ETH Zurich	Switzerland	63	24
Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Villigen	Switzerland	39	16
Institut für Umweltgeowissenschaften, Universität Basel	Switzerland	33	
Bergische Universität Wuppertal, Physikalische Chemie / FBC	Germany	22	
Empa, Swiss Federal Laboratories for Materials Testing and Research, Dübendorf	Switzerland	20	43
Institut für Angewandte Physik, Universität Bern	Switzerland	17	
Cardiovascular Center, Inselspital Bern	Switzerland	15	22
Department of Geography, University of Zürich	Switzerland	12	7
Uni Fribourg, Department of Medicine	Switzerland	10	
Medizinische Klinik, Pneumologie, München	Germany	10	
Tofwerk AG, Thun	Switzerland	9	5
University of Geneva, Institute for Environmental Sciences	Switzerland	7	
École Polytechnique Fédérale de Lausanne, Lausanne	Switzerland	5	
Bundesamt für Gesundheit, Bern	Switzerland	4	1
Walter Bersinger	Switzerland	4	
WSL, Institute for Snow and Avalanche Research SLF, Davos	Switzerland	4	
Société Astronomique de Liège	Belgium	3	
Physikalisch-Meteorologisches Observatorium PMOD, World Radiation Center WCR, Davos	Switzerland	3	
Department of Physics, University of Rome "La Sapienza"	Italy	2	10
Klima- und Umweltp Physik, Physikalisches Institut, Universität Bern	Switzerland	1	4
MeteoSwiss, Payerne	Switzerland		21

Institute	Country	Research with overnight stay	Research during the day only
VAW-Glaziologie, ETH Zürich	Switzerland		9
Berner Fachhochschule, Technik und Information, Photovoltaiklabor, Burgdorf	Switzerland		7
Labor für Umwelt- und Radiochemie, Paul Scherrer Institut, Villigen	Switzerland		5
Armasuisse, Thun	Switzerland		2
Physics Institute, University of Zurich	Switzerland		2
<b>TOTAL</b>		<b>815</b>	<b>189</b>

	Overnight stays	Visits with no overnight stay
Visitors, workers	289	827
Media / film / TV and radio	13	54
HFSJG administration		32
<b>Total including researchers</b>	<b>1117</b>	<b>1102</b>

## Long-term experiments and automatic measurements at the High Altitude Research Station Jungfraujoch

Institute	Experiment / Measurements
Institut d'Astrophysique et de Géophysique de l'Université de Liège B-4000 Liège	Atmospheric physics and solar physics
Belgian Institute for Space Aeronomy B-1180 Brussels	Atmospheric physics and atmospheric chemistry
Federal Office of Meteorology and Climatology MeteoSwiss CH-1530 Payerne	Atmospheric physics and atmospheric chemistry (radiation measurements) Global Atmosphere Watch Radiation Measurements
Federal Office of Meteorology and Climatology MeteoSwiss CH-8044 Zürich	Weather observations
Bundesamt für Landestopographie swisstopo CH-3084 Wabern-Bern	Automated Global Positioning System Network AGNES
Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen PSI	Atmospheric physics and atmospheric chemistry Global Atmosphere Watch Aerosol Program
Physikalisch-Meteorologisches Observatorium Davos World Radiation Center CH-7260 Davos Dorf	Solar and terrestrial radiation measurements and Aerosol depth monitoring
Empa - Swiss Federal Laboratories for Materials Testing and Research, CH-8600 Dübendorf	Atmospheric chemistry (O <sub>3</sub> - and NO <sub>x</sub> measurements) NABEL National Air Pollution Monitoring Network, halogenated greenhouse gases and continuous measurements of stable CO <sub>2</sub> isotopes
Abteilung für Weltraumforschung und Planetologie Physikalisches Institut Universität Bern CH-3012 Bern	Astrophysics (cosmic ray measurements)

Institute	Experiment / Measurements
Department of Physics University of Rome „La Sapienza“ I-00185 Rome	Measurement of large zenith angle cosmic rays
Berner Fachhochschule, Technik und Informatik Photovoltaik-Labor CH-3400 Burgdorf	Photovoltaic power plant
Universität Heidelberg Institut für Umweltphysik D-69120 Heidelberg	Long term observations of $^{14}\text{CO}_2$
Climate and Environmental Physics, Universität Bern CH-3012 Bern Bundesamt für Strahlenschutz D-78098 Freiburg i.B.	$^{85}\text{Krypton}$ measurements
Abteilung für Klima- und Umweltphysik, Physikalisches Institut Universität Bern CH-3012 Bern	High precision carbon dioxide and oxygen measurements
Isotope Research - Energy and Sustainability Research Institute Groningen Nijenborgh 4 9747 AG Groningen The Netherlands	Flask comparison of $\text{CO}_2$ and $\text{O}_2/\text{N}_2$ on Jungfrauoch
Max Planck Institut für Biogeochemie Hans Knöll Str. 10 07745 Jena Germany	Flask comparison of $\text{CO}_2$ and $\text{O}_2/\text{N}_2$ on Jungfrauoch
Eawag Überlandstrasse 133 CH-8600 Dübendorf	$^7\text{Be}$ and $^{10}\text{Be}$ in monthly precipitation
Nationale Alarmzentrale Bundesamt für Bevölkerungsschutz CH-8044 Zürich	NADAM Automatic Dose Alarm and Monitoring Network (ambient dose rate)
Bundesamt für Gesundheit CH-1700 Freiburg	RADAIR Measurements of radioactivity in the air and DIGITEL aerosol sampler

<b>Institute</b>	<b>Experiment / Measurements</b>
VAW Laboratory of Hydraulics, Hydrology and Glaciology ETH Zürich CH-8092 Zürich	Glacier measurements
Swiss Federal Institute for Snow and Avalanche Research SLF CH-7260 Davos Dorf	Permafrost monitoring in the Jungfrau east ridge
Department of Geography University of Zürich CH-8057 Zürich	Permasense: Permafrost monitoring in alpine rock walls
Institut für Umweltgeowissenschaften Universität Basel CH-4056 Basel	Measurement of $^{222}\text{Rn}$ for atmospheric tracer applications

Name of research institute or organization:

**Institut d'Astrophysique et de Géophysique, Université de Liège**

Title of project:

High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere.

Project leader and team:

Whitney Bader, Benoît Bovy, Philippe Demoulin, Bernard Lejeune, Emmanuel Mahieu, Ginette Roland (em.), Christian Servais (project leader), Rodolphe Zander (em.), Olivier Flock, Vincent Van De Weerd, Diane Zander.

Project description:

Contribution to the long-term monitoring of the Earth's atmosphere has remained the central activity of the Liège group. Regular observations carried out at the Jungfraujoch with high-performance Fourier-transform infrared (FTIR) spectrometers allow to derive abundances of more than 25 constituents affecting our climate and monitored in the frame of the Kyoto protocol ( $\text{N}_2\text{O}$ ,  $\text{CH}_4$ ,  $\text{CO}_2$ ,  $\text{SF}_6$ ,  $\text{CF}_4$ ...); related to the erosion of the ozone layer in the stratosphere and therefore linked to the Montreal Protocol ( $\text{HCl}$ ,  $\text{ClONO}_2$ ,  $\text{HNO}_3$ ,  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{HF}$ ,  $\text{COF}_2$ ,  $\text{O}_3$ ,  $\text{CCl}_2\text{F}_2$ ,  $\text{CHClF}_2$ ,  $\text{CCl}_3\text{F}$ ,  $\text{CCl}_4$ ...); or altering the oxidation processes in the troposphere ( $\text{CO}$ ,  $\text{C}_2\text{H}_2$ ,  $\text{C}_2\text{H}_6$ ,  $\text{OCS}$ ,  $\text{HCN}$ ,  $\text{H}_2\text{CO}$ ,  $\text{H}_2\text{CO}_2$ ...). The resulting databases allow the precise determination of the short-term variability, seasonal modulations, inter-annual as well as long-term changes affecting most of these species.

During 2012, Liège observers were present during 245 days at the Jungfraujoch and recorded 2115 high-resolution FTIR solar spectra on 116 different days, including 20 days with remote operation from Liège. Here is a selection of key 2012 results derived by our team from Jungfraujoch infrared spectra:

### **Ethane ( $\text{C}_2\text{H}_6$ )**

Ethane is the most abundant non-methane hydrocarbon of the Earth's atmosphere, with a lifetime of approximately 2 months.  $\text{C}_2\text{H}_6$  has both anthropogenic and natural emission sources such as biomass burning, natural gas loss and bio-fuel consumption.

Thanks to new spectroscopic parameters (Harrison *et al.*, 2010), ethane retrievals have been significantly improved and two partial columns (lower troposphere and upper-troposphere/lower-stratosphere UTLS) can now be derived from Jungfraujoch FTIR spectra. Figure 1 displays the retrieved  $\text{C}_2\text{H}_6$  total and partial columns above the Jungfraujoch from September 1994 onwards. Overall decrease of ethane since 1994 amounts to -14 %, -9 % and -39 %, respectively for total, lower troposphere and UTLS columns. A strong seasonal variation is observed, with a maximum in February and peak-to-peak amplitude of 50 % for the total columns. See Bader *et al.* [1] for more details.

### **Carbonyl sulfide (OCS)**

Carbonyl sulfide is the most abundant sulfur-containing trace gas in the atmosphere and is believed to account for a substantial portion of the sulfur in the stratospheric aerosol layer which influences the Earth's radiation budget and stratospheric ozone chemistry. The major identified OCS sources are oceans and anthropogenic emissions, while atmospheric loss and uptake by vegetation and soils constitute the main OCS sinks. The uptake by vegetation strongly influences the distribution and seasonality of OCS throughout most of the Northern Hemisphere.



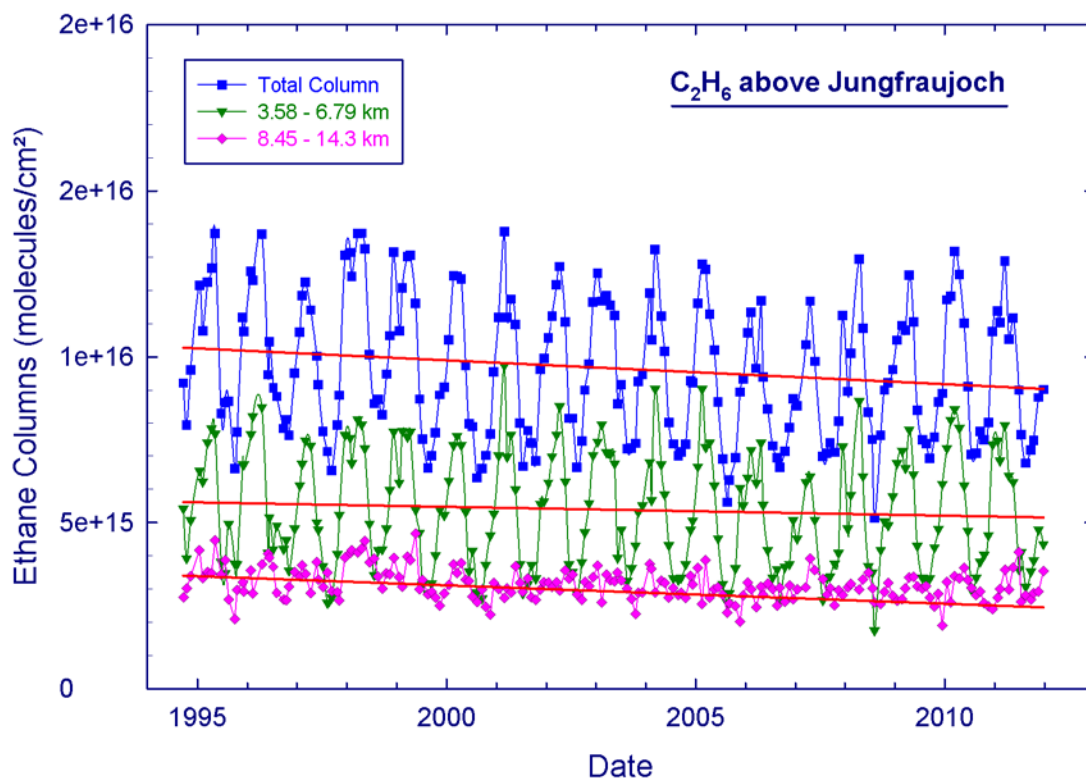


Figure 1: Time series of C<sub>2</sub>H<sub>6</sub> monthly mean total (in blue), low-tropospheric (3.58-6.79 km, in green) and UTLS (8.45-14.3 km, in pink) columns above the Jungfraujoch. Red lines are linear trends.

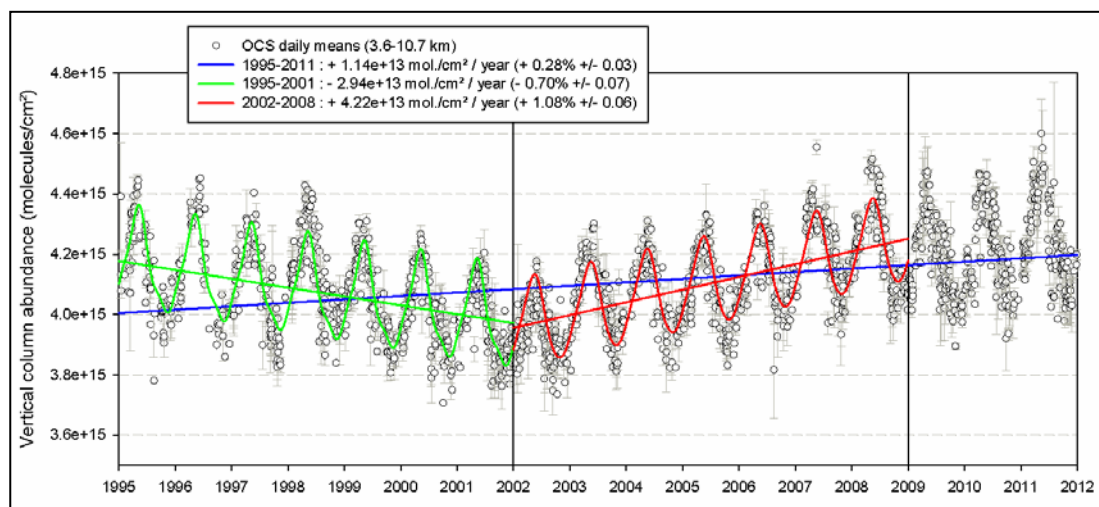


Figure 2: Time series of OCS tropospheric columns above the Jungfraujoch (daily means values). From 1995 to 2001, carbonyl sulfide decreased at a rate of  $0.70 \pm 0.07$  % per year; from 2002 to 2009, it increased at  $1.08 \pm 0.06$  %/year.

There is still a lack of understanding of the strength of some components in the atmospheric OCS budget. It seems that uptake by plants has been strongly underestimated, suggesting that additional significant OCS sources still have to be identified. The study of this gas is thus important and it will help improving our current estimates of OCS budget. Furthermore, recent works suggest that OCS could provide a valuable constraint on photosynthesis and so improve studies of carbon cycle processes.

A new retrieval strategy has been developed to retrieve OCS from Jungfraujoch FTIR spectra: it uses 4 micro-windows in the 2047-2055 cm<sup>-1</sup> spectral domain ( $\nu_3$  band), and the

information analysis for this retrieval indicates a degree of freedom of about 2.6, meaning that we can derive at least 2 significant partial columns from the spectra.

Figure 2 shows the tropospheric OCS columns above the Jungfraujoch: after a few years of decrease, these columns have been increasing since 2002. Reasons of this increase have been investigated, with possible sources being the intensification of emissions from coal combustion and from aluminium production (respectively 30 % and 65 % of the estimated anthropogenic direct OCS emissions). See Lejeune *et al.* [4] for more information.

### Carbon tetrachloride CCl<sub>4</sub>

The carbon tetrachloride gas, emitted at the ground, has been and remains a key component of the stratospheric chlorine budget, still contributing over 10% to the total chlorine loading, and to the stratospheric ozone depletion by a similar percentage. It is also a potent greenhouse gas with a global warming potential relative to CO<sub>2</sub> of 1400, on a 100-year horizon. Monitoring its atmospheric evolution remains, therefore, of relevance to both the Kyoto and the Montreal Protocol.

The long-term trend of the atmospheric CCl<sub>4</sub> burden has been retrieved from FTIR spectra recorded at the Jungfraujoch between January 1999 and June 2011 (Figure 3). Total columns were derived from spectrometric analysis of the strong CCl<sub>4</sub>  $\nu_3$  band at 794 cm<sup>-1</sup>. A significant improvement in the fitting residuals and in the retrieved CCl<sub>4</sub> columns was obtained by taking into account line-mixing in a strong interfering CO<sub>2</sub> Q-branch. A fit to the CCl<sub>4</sub> daily mean total column time series returns a statistically-significant (2 $\sigma$ ) long-term trend of  $-1.49 \pm 0.08 \times 10^{13}$  mol/cm<sup>2</sup> per year. This corresponds to an annual decrease of  $-1.31 \pm 0.07$  pptv for the mean free tropospheric volume mixing ratio. Furthermore, the total column data set reveals a weak seasonal cycle with a peak-to-peak amplitude of 4.5 %, with minimum and maximum values occurring in mid-February and mid-September, respectively. This small seasonal modulation is attributed primarily to the residual influence of tropopause height changes throughout the year. The negative trend of the CCl<sub>4</sub> loading reflects the continued impact of the regulations implemented by the Montreal Protocol and its strengthening amendments and adjustments. See Rinsland *et al.* [2] for details.

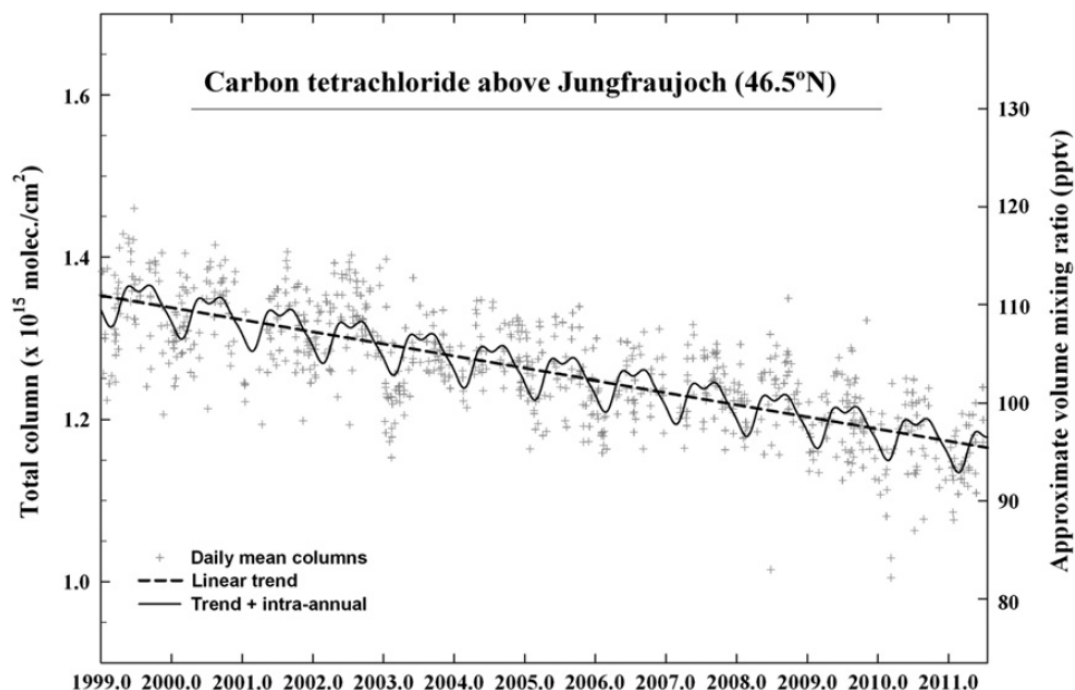


Figure 3: Daily mean CCl<sub>4</sub> total columns above the Jungfraujoch station are shown as plus symbols. The dashed line shows the linear component of the function fitted to all available daily means. The solid curve reproduces the derived seasonal modulation.

### Total reactive nitrogen $\text{NO}_y$

The  $\text{NO}_y$  family of gases, defined as  $\text{NO} + \text{NO}_2 + \text{NO}_3 + 2 \times \text{N}_2\text{O}_5 + \text{HNO}_3 + \text{HNO}_4 + \text{ClONO}_2 + \text{BrONO}_2$ , plays an important role in the ozone depletion ( $\text{NO}$  catalytic cycle, Crutzen 1970). At the Jungfraujoch observatory, FTIR spectrometers measure since 1984 the four most abundant members of  $\text{NO}_y$  i.e.  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{HNO}_3$  and  $\text{ClONO}_2$ . Their sum is a good proxy for  $\text{NO}_y$  (the most important missing gas being  $\text{N}_2\text{O}_5$ ). The trends of these four gases have been derived with a multiple regression model that includes linear trend, seasonal variation, stratospheric aerosol optical depth, solar flux... The apparent discrepancy between the  $\text{NO}_y$  trend and the trend of its source gas  $\text{N}_2\text{O}$  probably arises, according to the models, from the strengthening of the Brewer-Dobson circulation, the stratospheric cooling and the changes in stratospheric chlorine loading. Figures 4 to 7 show some results derived from this study. See Demoulin *et al.* [3] and Hendrick *et al.* [5] for more details.

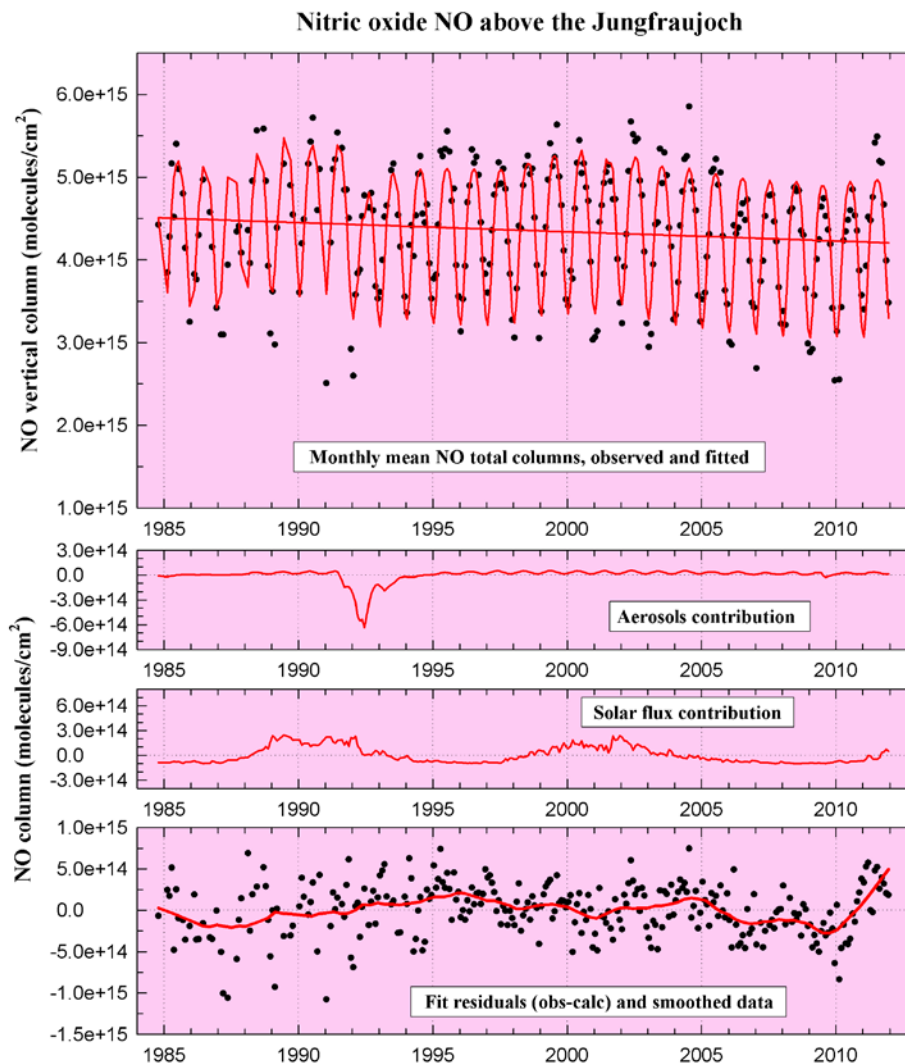


Figure 4: Upper frame: monthly mean NO total columns derived from Jungfraujoch FTIR spectra (black dots), together with best fit of the regression model and linear trend (red lines). A mean NO decrease of  $-0.25 \pm 0.12$  %/yr has been derived for the 1985-2012 time period. Middle frames give the contribution of the aerosol optical depth and of the solar flux to the NO total columns. The large aerosol perturbation from the Mt. Pinatubo eruption on June 15, 1991, is clearly visible. The eleven-year solar cycle influences NO total columns by a few percents. Lower frames show the residuals of the fit (measured - model) (black dots) together with a smoothed curve (red lines) of these residuals.

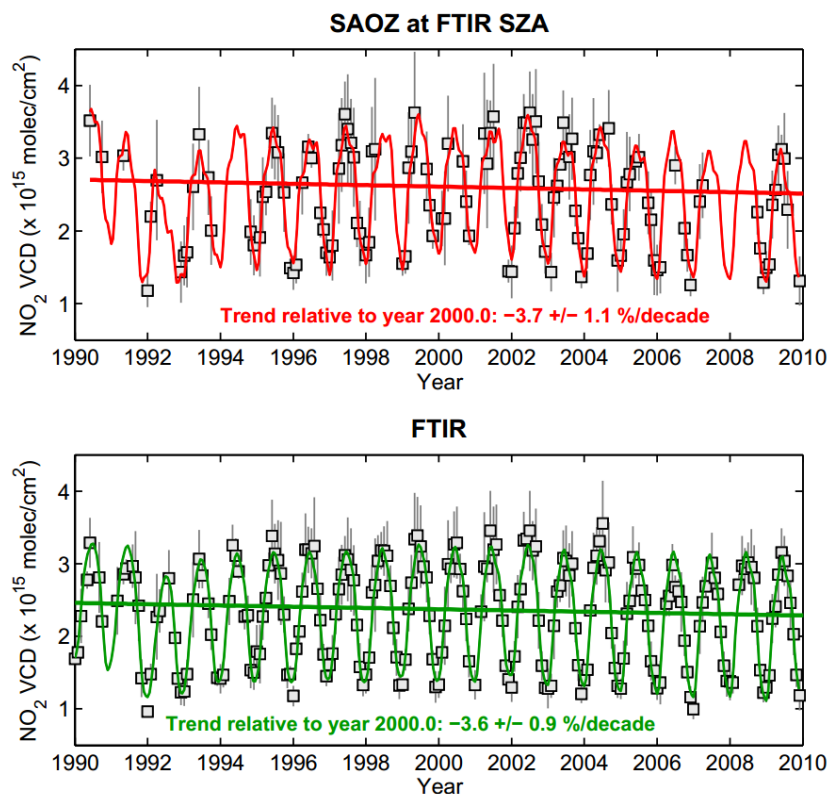


Figure 5: This figure shows the  $\text{NO}_2$  vertical column time series of 2 co-located NDACC instruments: the ULg FTIR solar spectrometer and the BIRA-IASB SAOZ UV-vis instrument, both operating at the Jungfraujoch observatory. As  $\text{NO}_2$  is varying during the day, twilight SAOZ measurements have been reported, for this comparison exercise, to the solar zenith angles of FTIR observations. Colored lines correspond to the linear trend (thick line) and to the  $\text{NO}_2$  columns recalculated using the multiple linear regression model (thin line). Trends derived from both datasets,  $-3.7 \pm 1.1$  and  $-3.6 \pm 0.9$  %/decade, respectively for FTIR and SAOZ instruments, are in very good agreement.

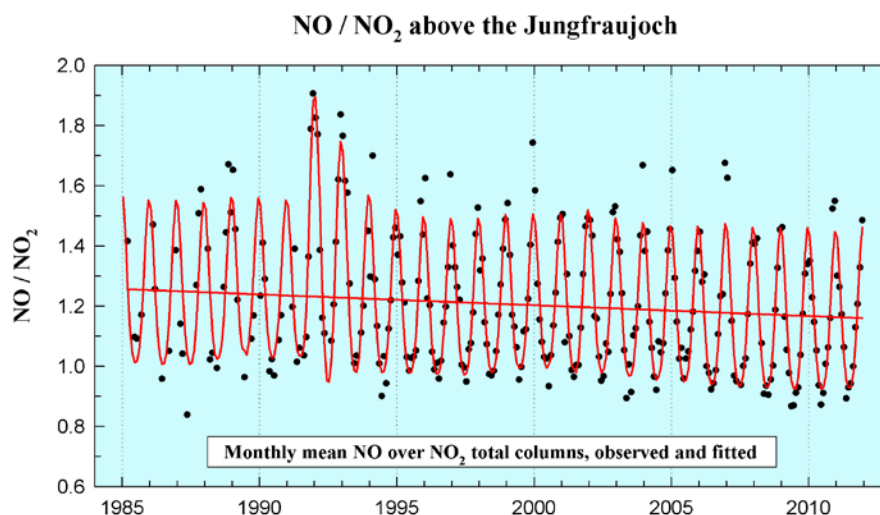


Figure 6: The  $\text{NO}/\text{NO}_2$  ratio is slowly decreasing above the Jungfraujoch, at a rate of  $-0.29 \pm 0.12$  %/year. This decrease is due to increased chlorine loading in the atmosphere, which increases the rate of the reaction  $[\text{NO} + \text{ClO} \rightarrow \text{NO}_2 + \text{Cl}]$ . The  $\text{NO}/\text{NO}_2$  ratio is expected to increase in the 21<sup>st</sup> century, as a result of the decreasing chlorine loading and of  $\text{CO}_2$ -induced stratospheric cooling, which slows the temperature-dependent reaction  $[\text{NO} + \text{O}_3 \rightarrow \text{NO}_2 + \text{O}_2]$  (Revell 2012).

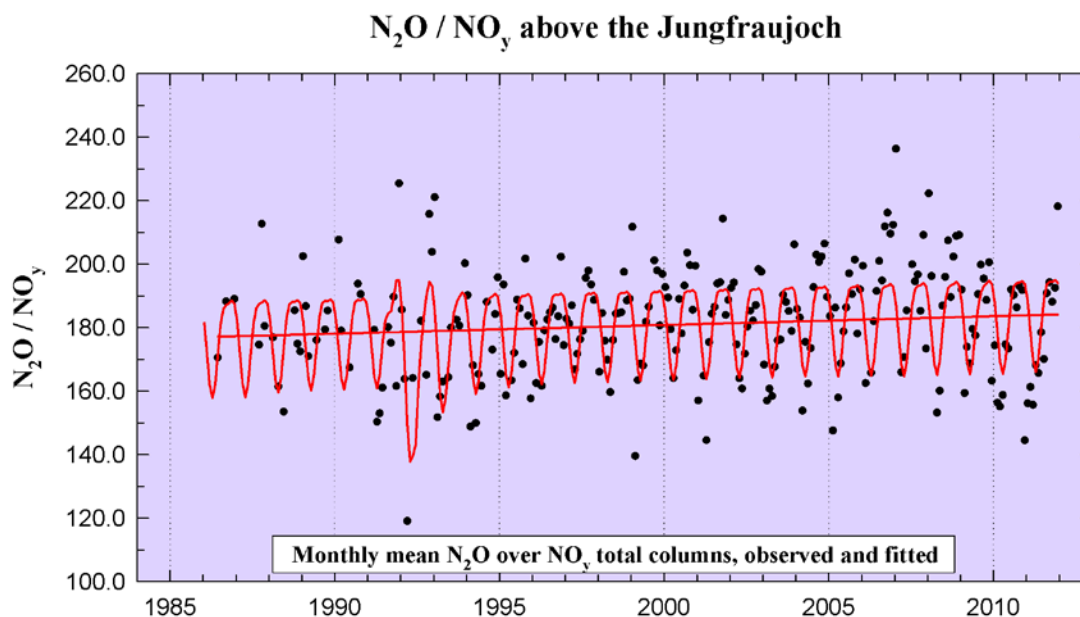


Figure 7: Although N<sub>2</sub>O is the source of NO<sub>y</sub>, NO<sub>y</sub> is not increasing at the same rate ( $0.31 \pm 0.02$  %/year for N<sub>2</sub>O,  $0.11 \pm 0.13$  %/year for NO<sub>y</sub>). This difference is probably due to increasing CO<sub>2</sub> concentrations cooling the stratosphere (Rosenfield and Douglass 1998) and to ozone and halogens changes in the stratosphere (McLinden 2001).

### Varia

Results derived from the Jungfraujoch FTIR spectra are regularly archived at the NDACC data center (<ftp://ftp.cpc.ncep.noaa.gov/ndacc/station/jungfrau/>), usually within less than one year. However, our group is now involved in the NORS project, where we will store a first evaluation of our data at <ftp://ftp.cpc.ncep.noaa.gov/ndacc/RD/jungfrau/> (« Rapid Data Delivery », i.e. typically within less than 1 month).

In June 2012, our group organized at Wengen the annual infrared working group of the NDACC network. This meeting was attended by about 50 scientists from around the world, specialists in Fourier transform infrared spectroscopy applied to the long term study of the Earth atmosphere. It was followed by a visit to the Jungfraujoch laboratories.

### References

- Crutzen P.J., The influence of nitrogen oxides on the atmospheric ozone content, Q.J.R. Meteorol. Soc., **96**, 320-325, 1970.
- Harrison, J.J., N.D.C. Allen, and P.F. Bernath, Infrared absorption cross sections for ethane (C<sub>2</sub>H<sub>6</sub>) in the 3 μm region, J. Quant. Spectrosc. Radiat. Transfer, **111**, 357-363, 2010.
- McLinden C. A. Understanding trends in stratospheric NO<sub>y</sub> and NO<sub>2</sub>, J. Geophys. Res., 106(D21), **27**, 787–27 793, 2001.
- Revell, L., Bodeker, G., Smale, D., Lehmann, R. , Huck, P., Williamson, B., Rozanov, E. and Struthers, H., The effectiveness of N<sub>2</sub>O in depleting stratospheric ozone. Geophys. Res. Lett., **39**, L15806-L15806, 2012.
- Rosenfield J.E. and Douglass, Doubled CO<sub>2</sub> effects on NO<sub>y</sub> in a coupled 2D model, Geophys. Res. Lett., **25**, 4381-4384, 1998.

### Key words:

Earth atmosphere, climate change, greenhouse gases, ozone layer, long-term monitoring, infrared spectroscopy

Internet data bases:

<ftp://ftp.cpc.ncep.noaa.gov/ndacc/station/jungfrau/>, <http://www.nilu.no/nadir/>  
<ftp://ftp.cpc.ncep.noaa.gov/ndacc/RD/jungfrau/>

Collaborating partners/networks:

Main collaborations: IASB (Institut d'Aéronomie Spatiale de Belgique) / NDACC (Network for the Detection of Atmospheric Composition Change, previously NDSC; <http://www.ndacc.org/>) / GAW-CH / partners of the EC-project NORS (<http://nors.aeronomie.be>) / NASA Langley Research Center / ACE-FTS science team / NASA JPL / University of Oslo / EMPA / University of Leeds / IMK (Forschungszentrum Karlsruhe) / satellite experiments: IASI, AURA, OMI, ACE-FTS, ENVISAT / ...

Scientific publications and public outreach 2012:

The complete list of GIRPAS publications can be found at  
<http://girpas.astro.ulg.ac.be/girpas/publi03e.htm> and  
<http://girpas.astro.ulg.ac.be/girpas/Communic.htm>

**Refereed journal articles and their internet access**

Duflot, V., D. Hurtmans, L. Clarisse, Y. R'honi, C. Vigouroux, M. De Mazière, E. Mahieu, C. Servais, C. Clerbaux, and P.-F. Coheur, Measurements of hydrogen cyanide (HCN) and acetylene (C<sub>2</sub>H<sub>2</sub>) from the Infrared Atmospheric Sounding Interferometer (IASI), *Atmos. Meas. Tech. Discuss.*, **5**, 7567-7586, 2012.

<http://www.atmos-meas-tech-discuss.net/5/7567/2012/amtd-5-7567-2012.html>

[5] Hendrick, F., E. Mahieu, G. Bodeker, K.F. Boersma, M.P. Chipperfield, M. De Mazière, I. De Smedt, P. Demoulin, C. Fayt, C. Hermans, K. Kreher, B. Lejeune, G. Pinardi, C. Servais, R. van der A, J.-P. Vernier, and M. Van Roozendaal, Analysis of stratospheric NO<sub>2</sub> trends above Jungfraujoch using ground-based UV-visible, FTIR, and satellite nadir observations, *Atmos. Chem. Phys.*, **12**, 8851-8864, 2012.

<http://hdl.handle.net/2268/121603>

Kerzenmacher, T., B. Dils, N. Kumps, T. Blumenstock, C. Clerbaux, P.-F. Coheur, P. Demoulin, O. García, M. George, D.W.T. Griffith, F. Hase, J. Hadji-Lazaro, D. Hurtmans, N. Jones, E. Mahieu, J. Notholt, C. Paton-Walsh, U. Raffalski, T. Ridder, M. Schneider, C. Servais, and M. De Mazière, Validation of IASI FORLI carbon monoxide retrievals using FTIR data from NDACC, *Atmos. Meas. Tech.*, **5**, 2751-2761, 2012.

<http://orbi.ulg.ac.be/handle/2268/124179>

Kohlhepp, R., R. Ruhnke, M.P. Chipperfield, M. De Mazière, J. Notholt, S. Barthlott, R.L. Batchelor, R.D. Blatherwick, Th. Blumenstock, M.T. Coffey, P. Demoulin, H. Fast, W. Feng, A. Goldman, D.W.T. Griffith, K. Hamann, J.W. Hannigan, F. Hase, N.B. Jones, A. Kagawa, I. Kaiser, Y. Kasai, O. Kirner, W. Kouker, R. Lindenmaier, E. Mahieu, R.L. Mittermeier, B. Monge-Sanz, I. Morino, I. Murata, H. Nakajima, M. Palm, C. Paton-Walsh, U. Raffalski, Th. Reddmann, M. Rettinger, C.P. Rinsland, E. Rozanov, M. Schneider, C. Senten, C. Servais, B.-M. Sinnhuber, D. Smale, K. Strong, R. Sussmann, J.R. Taylor, G. Vanhaelewyn, T. Warneke, C. Whaley, M. Wiehle, and S.W. Wood, Observed and simulated time evolution of HCl, ClONO<sub>2</sub>, and HF total column abundances, *Atmos. Chem. Phys.*, **12**, 3527-3556, 2012.

<http://hdl.handle.net/2268/117940>

[2] Rinsland, C.P., E. Mahieu, P. Demoulin, R. Zander, C. Servais, and J.-M. Hartmann, Decrease of the Carbon Tetrachloride (CCl<sub>4</sub>) Loading above Jungfraujoch, based on High Resolution Infrared Solar Spectra recorded between 1999 and 2011, *J. Quant. Spectrosc. Radiat. Transfer*, **113**, 1322-1329, doi: 10.1016/j.jqsrt.2012.02.016, 2012.

<http://hdl.handle.net/2268/121150>

Risi, C., D. Noone, J. Worden, C. Frankenberg, G. Stiller, M. Kiefer, B. Funke, K. Walker, P. Bernath, M. Schneider, D. Wunch, V. Sherlock, N. Deutscher, D. Griffith, P.O. Wennberg, K. Strong, D. Smale, E. Mahieu, S. Barthlott, F. Hase, O. García, J. Notholt, T. Warneke, G.C. Toon, D. Sayres, S. Bony, J. Lee, D. Brown, R. Uemura, and C. Sturm, Process-evaluation of tropospheric humidity simulated by general circulation models using water vapor isotopologues: 1. Comparison between models and observations, *J. Geophys. Res.*, **117**, D05303, doi: 10.1029/2011JD016621, 2012.

<http://hdl.handle.net/2268/123815>

Schneider, M., S. Barthlott, F. Hase, Y. González, K. Yoshimura, O.E. García, E. Sepúlveda, A. Gomez-Pelaez, M. Gisi, R. Kohlepp, S. Dohe, T. Blumenstock, K. Strong, D. Weaver, M. Palm, N.M. Deutscher, T. Warneke, J. Notholt, B. Lejeune, P. Demoulin, N. Jones, D.W.T. Griffith, D. Smale, and J. Robinson, Ground-based remote sensing of tropospheric water vapor isotopologues within the project MUSICA, *Atmos. Meas. Tech.*, **5**, 3007-3027, doi:10.5194/amt-5-3007-2012, 2012.

<http://hdl.handle.net/2268/135828>



## Conference papers

Bader, W., E. Mahieu, B. Bovy, B. Lejeune, P. Demoulin, and C. Servais, First retrievals of methanol ( $\text{CH}_3\text{OH}$ ) above Jungfraujoch (46.5°N): Optimization of the retrieval strategy and information content, poster presentation at the “Journée des doctorants UNITER”, Université Libre de Bruxelles, Belgique, December 10, 2012.  
<http://hdl.handle.net/2268/135878>

[1] Bader, W., A. Perrin, D. Jacquemart, J.J. Harrison, G.C. Toon, K. Sudo, O.A. Søvde, P. Demoulin, C. Servais, and E. Mahieu, Retrievals of ethane from ground-based high-resolution FTIR solar observations with updated line parameters: determination of the optimum strategy for the Jungfraujoch station, poster presentation at the “11th Atmospheric Spectroscopy Applications” meeting (ASA 2012), united with the “12th HITRAN Conference”, Reims, France, August 29-31, 2012.  
<http://hdl.handle.net/2268/129289>

Bader, W., A. Perrin, D. Jacquemart, K. Sudo, H. Yashiro, M. Gauss, P. Demoulin, C. Servais, and E. Mahieu, Retrievals of ethane from ground-based high-resolution FTIR solar observations with updated line parameters: determination of the optimum strategy for the Jungfraujoch station, poster presentation at the “EGU 2012 General Assembly”, Vienna, Austria, April 22-27, 2012 and at the 4th Symposium on METEOrology and CLIMatology for PhD students - MeteoClim2012, 2012.  
<http://hdl.handle.net/2268/117067>

Bader, W., A. Perrin, D. Jacquemart, K. Sudo, H. Yashiro, O.E. Søvde, P. Demoulin, C. Servais, and E. Mahieu, Retrievals of ethane from ground-based high-resolution FTIR solar observations with updated line parameters: determination of the optimum strategy for the Jungfraujoch station, poster presentation at the “NDACC-IRWG Annual Meeting”, Wengen, Switzerland, June 11-15, 2012.  
<http://hdl.handle.net/2268/124230>

De Mazière, M, K. Hocke, A. Richter, S. Godin-Beekmann, S. Henne, T. Blumenstock, S. Niemeijer, and E. Mahieu, NORS: Demonstration Network Of ground-based Remote Sensing Observations in support of the GMES Atmospheric Service, poster presentation at the 12th International Global Atmospheric Chemistry (IGAC) Science Conference, Beijing, China, September 17-21 2012.  
<http://hdl.handle.net/2268/131119>

[3] Demoulin, P., E. Mahieu, C. Servais, B. Lejeune, W. Bader, G. Roland, R. Zander, K.A. Walker, P.F. Bernath, M. Van Roozendael, and F. Hendrick, Long-term trends of  $\text{NO}_y$  above northern mid-latitudes as inferred from Jungfraujoch, HALOE and ACE-FTS infrared solar observations, poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, Canada, August 27-31, 2012.  
<http://larss.science.yorku.ca/QOS2012pdf/5997.pdf>

Kolonjari, F., E. Mahieu, K.A. Walker, Y. Kasai, A. Kagawa, R. Lindenmaier, R.L. Batchelor, K. Strong, C.D. Boone, and P.F. Bernath, Validation of ACE-FTS using ground-based FTIR measurements of CFC-11, CFC-12 and HCFC-22, poster presentation at the 2012 Summer School in Arctic Atmospheric Science, Alliston, Canada, July 23-27, 2012.  
<http://hdl.handle.net/2268/130119>

[4] Lejeune, B., E. Mahieu, P. Demoulin, C. Servais, W. Bader, B. Bovy, O. Flock, R. Zander, and G. Roland, Trend evolution of carbonyl sulfide above Jungfraujoch deduced from ground-based FTIR and ACE-FTS satellite observations, oral presentation at the “ACE Science Team Meeting”, University of Waterloo, Waterloo, ON, Canada, May 23-24, 2012.  
<http://hdl.handle.net/2268/123804>

Lejeune, B., E. Mahieu, M. Schneider, F. Hase, C. Servais, and P. Demoulin, Long-term series of tropospheric water vapour amounts and  $\text{HDO}/\text{H}_2\text{O}$  ratio profiles above Jungfraujoch, poster presentation at the “EGU 2012 General Assembly”, Vienna, Austria, April 22-27, 2012.  
<http://hdl.handle.net/2268/117439>

Mahieu, E., the GIRPAS- and the ACE-teams, Post-peak trend in inorganic chlorine ( $\text{Cl}_y$ ) from Jungfraujoch, ACE-FTS and HALOE infrared solar observations, oral presentation at the “ACE / SAGE III-ISS International Workshop”, Old Dominion University, Norfolk, VA, USA, October 15-17, 2012.  
<http://hdl.handle.net/2268/132600>

Mahieu, E., W. Bader, B. Bovy, B. Lejeune, C. Vigouroux, P. Demoulin, C. Servais, G. Roland, and R. Zander, Retrieval of methanol ( $\text{CH}_3\text{OH}$ ) from the high-altitude Jungfraujoch station (46.5°N): preliminary total column time series, long-term trend and seasonal modulation, poster presentation at the “NDACC-IRWG Annual Meeting”, Wengen, Switzerland, June 11-15, 2012.  
<http://hdl.handle.net/2268/124069>

Mahieu, E., W. Bader, B. Lejeune, C. Vigouroux, P. Demoulin, C. Servais, G. Roland, and R. Zander, Seeking for the optimum retrieval strategy of methanol ( $\text{CH}_3\text{OH}$ ) using ground-based high-resolution FTIR solar observations recorded at the high-altitude Jungfraujoch station (46.5°N), poster presentation at the “EGU 2012 General Assembly”, 22-27 April 2012, Vienna, Austria, April 22-27, 2012.  
<http://hdl.handle.net/2268/116957>

Pastel, M., S. Godin-Beekmann, E. Mahieu, P. Demoulin, and K. Hocke, A new methodology for integrating ground-based ozone profile data, poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, Canada, August 27–31, 2012.

<http://larss.science.yorku.ca/QOS2012pdf/6009.pdf>

Servais C. and Roland G., Soixante ans de spectroscopie solaire et atmosphérique depuis le Jungfraujoch, Swiss Academy of Sciences, Les chercheurs de l'extrême, Interlaken, October 25-26, 2012.

<http://kongress12.scnat.ch/f/jahreskongress/presentationen/>

Vigouroux, C., M. De Mazière, P. Demoulin, C. Servais, F. Hase, T. Blumenstock, R. Kohlhepp, S. Barthlott, O. García, M. Schneider, J. Mellqvist, G. Personnn, M. Palm, J. Notholt, J. Hannigan, and M. Coffey, Ozone tropospheric and stratospheric trends (1995-2011) at six ground-based FTIR stations (28°N to 79°N), poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, Canada, August 27–31, 2012.

<http://larss.science.yorku.ca/QOS2012pdf/6018.pdf>

### Edited books

Schneider, M., P. Demoulin, R. Sussmann, and J. Notholt, Fourier Transform Infrared Spectrometry, Chapter 6 in Monitoring Atmospheric Water Vapor: Ground-Based Remote Sensing and In-Situ Methods, ISSI Scientific Report Series, **vol. 10**, ISBN 978-1-4614-3908-0, Springer New York, 2012.

<http://link.springer.com/book/10.1007/978-1-4614-3909-7/page/1>

### Theses

Palumbo Adrien, Étude de faisabilité d'une caméra IP destinée au contrôle d'expérience en haute altitude et basée sur un système embarqué dans un FGPA, Travail de fin d'étude présenté en vue de l'obtention du grade de bachelier en informatique et systèmes finalité réseaux et télécommunications, Haute Ecole de la Province de Liège, Seraing, Année académique 2011-2012.

Van Laeken Lionel and Boileau Quentin, La station de recherche du Jungfraujoch. Étude de la composition chimique de l'atmosphère terrestre par la spectroscopie infrarouge à transformée de Fourier, Mémoire de fin d'études secondaires, Ecole Sainte-Marie, Huy, January 2012.

### Magazine and Newspapers articles

Atmosphère ? Atmosphère ! Interview of E. Mahieu in Athena, **277**, 38-41, January, 2012.

<http://recherche-technologie.wallonie.be/servlet/Repository/athena-277.pdf?IDR=11102&EXT=PDF>

### Radio and television

Solar and atmospheric spectroscopy research conducted since 1950 at the Jungfraujoch by the researchers of the University of Liège, permanent video showing to the Jungfraujoch visitors the principle and purpose of work done by Liège researchers, Jungfraujoch 2012.

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Name of research institute or organization:

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**Belgian Institute for Space Aeronomy (BIRA-IASB)**

Title of project:

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Atmospheric physics and chemistry

Project leader and team:

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Dr. M. Van Roozendaal: project leader UV-Vis

Dr. Martine De Mazière: project leader FTIR

Corinne Vigouroux, Bavo Langerock, Bart Dils, Caroline Fayt, Clio Gielen, François Hendrick, Christian Hermans, Alexis Merlaud, Gaia Pinardi, Frederik Tack: team scientists

Project description:

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UV-Vis (main results, significance of results, progress in 2012)

The long-term monitoring of ozone and nitrogen dioxide stratospheric columns initiated in 1990 as part of the BIRA-IASB contribution to the Network for the Detection of Atmospheric Composition Change (NDACC) has been continued in 2012 using the SAOZ instrument. Quality checked data have been regularly submitted to the NDACC data base hosted at NOAA. In addition to the SAOZ stratospheric monitoring, BIRA-IASB has been operating a new MAXDOAS instrument since June 2010. This instrument provides complementary measurements of total contents and tropospheric vertical distributions of a number of trace gases, incl. NO<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>CO, BrO, H<sub>2</sub>O and aerosols. The data analysis is currently ongoing as part of the BIRA-IASB contribution to the EU FP7 NORS (Demonstration Network Of ground-based Remote Sensing Observations in support of the GMES Atmospheric Service) project as well as within the EU FP7 ACTRIS project. In these projects, the primary focus is on tropospheric NO<sub>2</sub> retrieval and their link to in-situ measurements performed by EMPA at the Jungfraujoch station. A second important objective of the NORS project is to set up an operational processing chain for near-real-time delivery of key data sets in support of the GMES Atmospheric Service, currently developed within the EU FP7 MACC-2 project.

Another ongoing activity as part of the national project AGACC-II concerns the study of the possible synergistic use of MAXDOAS and FTIR measurements for formaldehyde (H<sub>2</sub>CO) measurements at the Jungfraujoch. In this context, an intercomparison exercise of H<sub>2</sub>CO slant columns measurements has been conducted by BIRA using MAX-DOAS data from the international CINDI (Cabouw Intercomparison of Nitrogen Dioxide measuring Instruments) campaign that took place in Cabouw, The Netherlands, in June-July 2009. Nine atmospheric research groups simultaneously operating MAX-DOAS instruments of various designs were involved in this exercise. This study has led to a major consolidation of the H<sub>2</sub>CO DOAS analysis methodology (Pinardi et al., 2012) which now forms the basis for more challenging measurements at the high altitude Jungfraujoch station. Preliminary comparisons with FTIR measurements have been conducted highlighting the need to better investigate the impact of the large difference in the height-dependent sensitivity of both techniques.

FTIR solar absorption spectrometry (main results, significance of results, progress in 2012)

BIRA-IASB collaborates with the University of Liège (ULg) for the exploitation of the Fourier transform infrared measurements at the Jungfraujoch and it coordinates a number of national (Belgian) and European projects in which the Jungfraujoch measurements play an important role.

We are working on a more advanced analysis of the O<sub>3</sub> trends (total column trends and partial column trends in 4 atmospheric layers based on FTIR data) for the period 1995-2012. In addition to a statistical analysis of the trends with the bootstrap resampling method, we are now also investigating a regression analysis, highlighting the various processes that impact the observed O<sub>3</sub> variability and trends. Also non-European stations are included in the study.

The study is part of the SI<sup>2</sup>N initiative<sup>1</sup> and will be published in a special issue dedicated to SI<sup>2</sup>N. The Jungfraujoch data represent the northern mid-latitude situation in this study.

The work on the coordinated validation of the IASI FORLI CO and HNO<sub>3</sub> data, using NDACC FTIR data, has been published in 2012 for CO (Kerzenmacher et al., 2012) and will be published in 2013 for HNO<sub>3</sub>.

BIRA-IASB is partner in the EU FP7 ACTRIS Research Infrastructure project. It is responsible for investigating how VOC remote sensing measurements can be linked to in-situ measurements. To this end, it uses the FTIR data at the Jungfraujoch, for CO and C<sub>2</sub>H<sub>6</sub>. Preliminary results have been reported but the study is still ongoing.

The Jungfraujoch is one of the 4 demonstration stations in the EU FP7 project NORS that is coordinated by BIRA-IASB and started in November 2011 (<http://nors.aeronomie.be>). Concerning the FTIR measurements, we will work on CO, CH<sub>4</sub>, NO<sub>2</sub> and H<sub>2</sub>CO. The objective is to make a more rapid data analysis and submission to the NDACC database, for use in the validation of the GMES Atmospheric Service products. Research will be undertaken as to common retrieval strategies for NO<sub>2</sub> and H<sub>2</sub>CO, and regarding a better characterisation of the FTIR data products (error budgets, representativeness...).

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Key words:

Atmospheric composition, long-term monitoring, optical remote sensing, vertical inversion methods, satellite and model validation

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Internet data bases:

- The data are archived in the NDACC database (<http://www.ndacc.org/>), in the NADIR/NILU database (<http://www.nilu.no/projects/nadir>).
- Data processed for ENVISAT validation purposes are also submitted to the ENVISAT CAL/VAL database (<http://nadir.nilu.no/calval>).
- A revised HDF GEOMS format for UV-Vis DOAS data products has been implemented at the NDACC data base, as a contribution to the NORS project
- The GEOMS HDF format for FTIR vertical profile data has been implemented at the NDACC database.
- In the frame of NORS, the data submission will be done in the GEOMS HDF format to the NDACC database, within 1 month after data acquisition.

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Collaborating partners/networks:

- Collaborations with University of Liège and NDACC partners
- Collaboration with European FTIR and UV-Vis teams and modelling teams in the frame of the EU project NORS;
- Collaboration with M. Chipperfield of Univ. Leeds.
- Both the UV-Vis and FTIR observations contribute to the international Network for the Detection of Atmospheric Composition Changes (NDACC).
- Collaboration with B. Buchmann, D. Brunner, S. Henne, S. Reimann and M. Steinbacher of EMPA (NORS and ACTRIS projects)
- Collaboration with F. Goutail and A. Pazmino of LATMOS, France (SAOZ)
- Collaboration with the GOME, ENVISAT, OMI, ACE and MetOp GOME-2 and IASI satellite communities.
- Collaboration with Université Libre de Bruxelles for IASI FORLI data validation.

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<sup>1</sup> SPARC/IO<sub>3</sub>C/IGACO-O3/NDACC Activity on Past changes in the Vertical Distribution of Ozone

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Pinardi, G., M. Van Roozendaal, N. Abuhassan, C. Adams, A. Cede, K. Clémer, C. Fayt, U. Frieß, M. Gil, J. Herman, C. Hermans, F. Hendrick, H. Irie, A. Merlaud, M. Navarro Comas, E. Peters, A. J. M. Piter, O. Puentedura, A. Richter, A. Schönhardt, R. Shaiganfar, E. Spinei, K. Strong, H. Takashima, M. Vrekoussis, T. Wagner, F. Wittrock, and S. Yilmaz, MAXDOAS formaldehyde slant column measurements during CINDI: intercomparison and analysis improvement, *Atmos. Meas. Tech. Discuss.*, **5**, 6679-6732, 2012.  
<http://www.atmos-meas-tech-discuss.net/5/6679/2012/amtd-5-6679-2012.html>

Piter, A.J.M., K. F. Boersma, M. Kroon, J. C. Hains, M. Van Roozendaal, F. Wittrock, N. Abuhassan, C. Adams, M. Akrami, M. Allaart, I. Alonso Calvo, A. Apituley, H.B. Bergwerff, A.J.C. Berkhout, D. Brunner, A. Cede, J. Chong, K. Clémer, C. Fayt, U. Frieß, L.F.L. Gast, M. Gil Ojeda, F. Goutail, R. Graves, A. Griesfeller, K. Großmann, G. Hemerijckx, F. Hendrick, B. Henzing, J. Herman, C. Hermans, M. Hoexum, G.H. van der Hoff, H. Irie, P.V. Johnston, Y. Kanaya, M.P. Keuken, Y.J. Kim, H. Klein-Baltink, K. Kreher, G. de Leeuw, R. Leigh, A. Merlaud, M.M. Moerman, P. Monks, G.H. Mount, M. Navarro-Comas, H. Ötjen, A. Pazmino, E. Peters, A. du Piesanie, G. Pinardi, O. Puentedura, A. Richter, H.K. Roscoe, A. Schönhardt, B. Schwarzenbach, R. Shaiganfar, W. Sluis, E. Spinei, A.P. Stolk, K. Strong, D. Swart, H. Takashima, T. Vlemmix, M. Vrekoussis, T. Wagner, C. Whyte, K. Wilson, M. Yela, S. Yilmaz, P. Zieger, Y. Zhou, The Cabauw Intercomparison campaign for Nitrogen Dioxide Measuring Instruments (CINDI): Design, Execution, and First Results, *Atmos. Meas. Tech.*, **5**, 457-485, 2012.

<http://www.atmos-meas-tech.net/5/457/2012/amt-5-457-2012.html>

Merlaud, A., M. Van Roozendaal, J. Van Gent, C. Fayt, J. Maes, X. Toledo, O. Ronveaux, and M. De Mazière, DOAS measurements of NO<sub>2</sub> from an ultralight aircraft during the Earth Challenge expedition, *Atmos. Meas. Tech.*, **5**, 2057-2068, doi:10.5194/amt-5-2057-2012, 2012.

<http://www.atmos-meas-tech.net/5/2057/2012/amt-5-2057-2012.html>

Popp, C., D. Brunner, A. Damm, C. Fayt, M. Van Roozendaal, and B. Buchmann, High resolution NO<sub>2</sub> remote sensing from the Airborne Prism EXperiment (APEX) imaging spectrometer, *Atmos. Meas. Tech.*, **5**, 2211-2225, 2012.

<http://www.atmos-meas-tech.net/5/2211/2012/amt-5-2211-2012.html>

Koukouli, M. E., D. S. Balis, D. Loyola, P. Valks, W. Zimmer, N. Hao, J.-C. Lambert, M. Van Roozendaal, C. Lerot, and R. J. D. Spurr, Geophysical validation and long-term consistency between GOME-2/MetOp-A total ozone column and measurements from the sensors GOME/ERS-2, SCIAMACHY/ENVISAT and OMI/Aura, *Atmos. Meas. Tech.*, **5**, 2169-2181, doi:10.5194/amt-5-2169-2012, 2012.

<http://www.atmos-meas-tech.net/5/2169/2012/amt-5-2169-2012.html>

Hendrick, F., E. Mahieu, G. Bodeker, K. F. Boersma, M. P. Chipperfield, M. De Mazière, P. Demoulin, I. De Smedt, C. Fayt, C. Hermans, K. Kreher, B. Lejeune, G. Pinardi, C. Servais, J.-P. Vernier, and M. Van Roozendaal, Trend analysis of stratospheric NO<sub>2</sub> at Jungfraujoch (46.5°N, 8.0°E) using ground-based UV-visible, FTIR, and satellite nadir observations, *Atmos. Chem. Phys.*, **12**, 8851-8864, 2012.

<http://www.atmos-chem-phys.net/12/8851/2012/acp-12-8851-2012.html>

Kerzenmacher, T., B. Dils, N. Kumps, T. Blumenstock, C. Clerbaux, P.-F. Coheur, P. Demoulin, O. García, M. George, D. W. T. Griffith, F. Hase, J. Hadji-Lazaro, D. Hurtmans, N. Jones, E. Mahieu, J. Notholt, C. Paton-Walsh, U. Raffalski, T. Ridder, M. Schneider, C. Servais, and M. De Mazière, Validation of IASI FORLI carbon monoxide retrievals using FTIR data from NDACC, *Atmos. Meas. Tech.*, **5**, 2751-2761, 2012.

<http://www.atmos-meas-tech.net/5/2751/2012/amt-5-2751-2012.pdf>

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URL: <http://www.oma.be/BIRA-IASB/>  
<http://uv-vis.aeronomie.be/>  
<http://infrared.aeronomie.be>  
<http://nors.aeronomie.be/>  
<http://agacc.aeronomie.be>

Name of research institute or organization:

**Institute for Atmospheric and Climate Science**

Title of project:

Assessment of high altitude aerosol and cloud characteristics

Project leader and team:

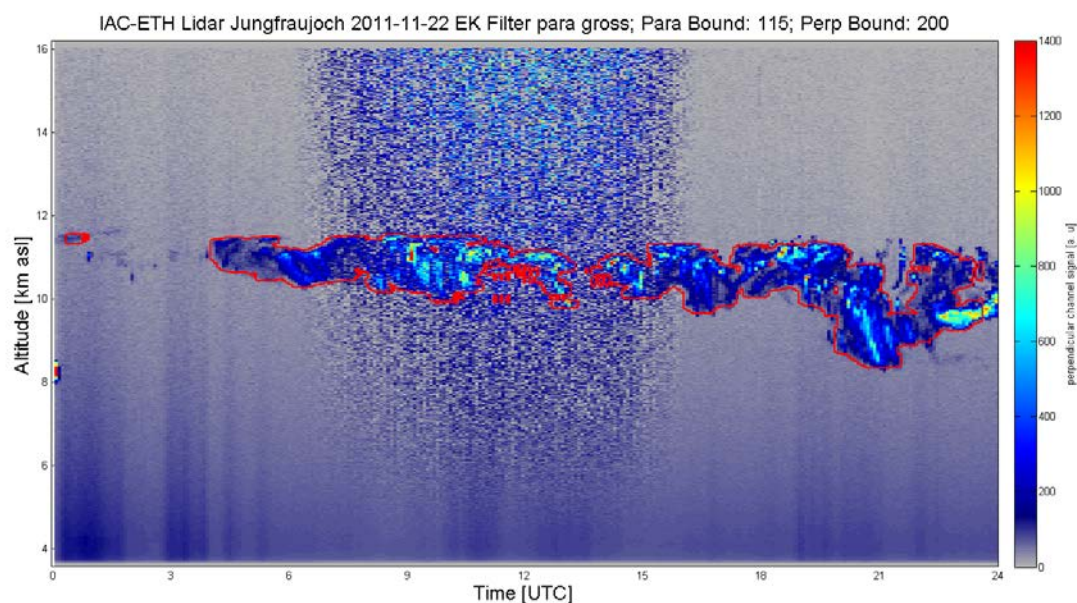
Prof. Thomas Peter, project leader  
Erika Kienast-Sjögren, Dr. Frank Wienhold, Dr. Ulrich Krieger  
Marco Vecellio, Uwe Weers

Project description:

We use a commercial Lidar (Leosphere model ALS 450) to measure aerosol and high altitude clouds. We retrieve attenuated backscatter polarized parallel and perpendicular to the laser emission (wavelength 355 nm) and determine the depolarization ratio. The depolarization ratio depends on particle sphericity and increases with increasing asphericity. Hence this channel provides information on whether liquid or ice clouds are observed.

In 2012, continuous measurements were carried out automatically until a major failure of the laser system of the Lidar on May 25<sup>th</sup>, 2012, making a repair at the manufacturer necessary.

To allow climatological analysis like occurrence frequency of clouds, we developed a cloud detection algorithm to detect the high altitude cirrus ice clouds without need of manual intervention. The algorithm uses a filter of 7x5 pixels combining both, the parallel and perpendicular channel. It allows not only identifying the presence of clouds but also measuring their temporal and vertical extent as illustrated in Fig. 1. Of particular concern are the daytime measurements, because photons from sunlight reaching the detector result in a considerable noise signal (cp. Fig. 1). As illustrated in Fig. 1 the filter used successfully suppresses this noise signal while retrieving even optically thin cirrus clouds during day time.



*Fig. 1: Lidar signal showing extended cirrus clouds on November 22<sup>th</sup>, 2011. Attenuated backscatter intensity (perpendicular polarization channel), red line: cloud identification using the filter as described in text.*

While our total observation time is still limited at present, we are confident to be able to retrieve a reliable cirrus occurrence statistic using the developed algorithm. This statistic shows distinct differences above Jungfrauoch in November 2011 compared with the long year statistics of Sassen and Comstock [2001] above Salt Lake City as illustrated in Fig. 2. At present the total number of observed cirrus does not allow to draw definite conclusions about these differences. However, we intend to continue measurements during 2013, which will improve the statistics of cirrus occurrence.

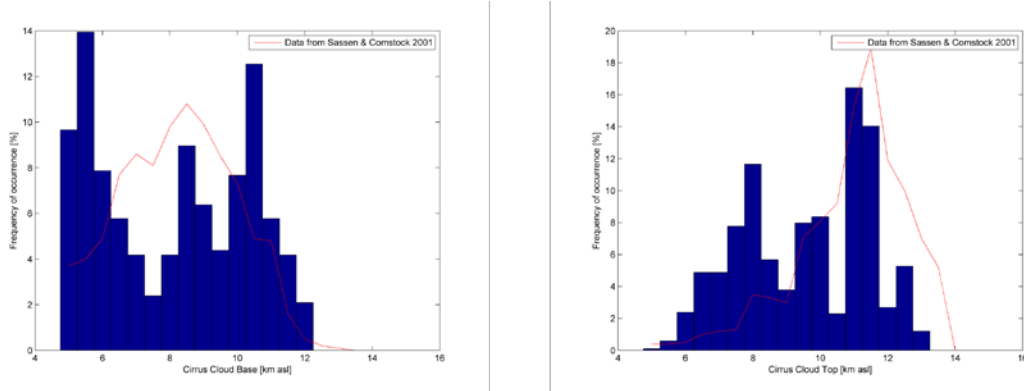


Fig. 2: Comparison on cirrus cloud occurrence frequency (left panel: cloud base, right panel: cloud top) above Jungfrauoch in November 2011 with the study by Sassen and Comstock [2001] above Salt Lake City.

One aim of the project is to evaluate how well state of the art weather prediction models perform with respect to high altitude cloud observations. We used the cloud detection scheme outlined above to compare the observed cirrus clouds with the reanalysis of the COSMO model. COSMO stands for Consortium for Small scale modeling (<http://www.cosmo-model.org/>) and is a nonhydrostatic limited-area atmospheric prediction model. Primitive thermo-hydrodynamical equations that describe a compressible flow in a moist atmosphere are implemented in the model and are fixed in rotated geographical coordinates and a generalized terrain following height coordinate. The model is designed to make numerical weather predictions, as well as to be used in different applications on the mesoscale. As an example we plot three different tropopause heights extracted from the model together with the Lidar observations in Fig. 3. The WMO tropopause height is defined as the height where the temperature gradient is smaller than 2 K/km over a range of 2 km, we also use the first temperature inversion and also a humidity tropopause (drop in relative humidity below 10%) to define the tropopause height.

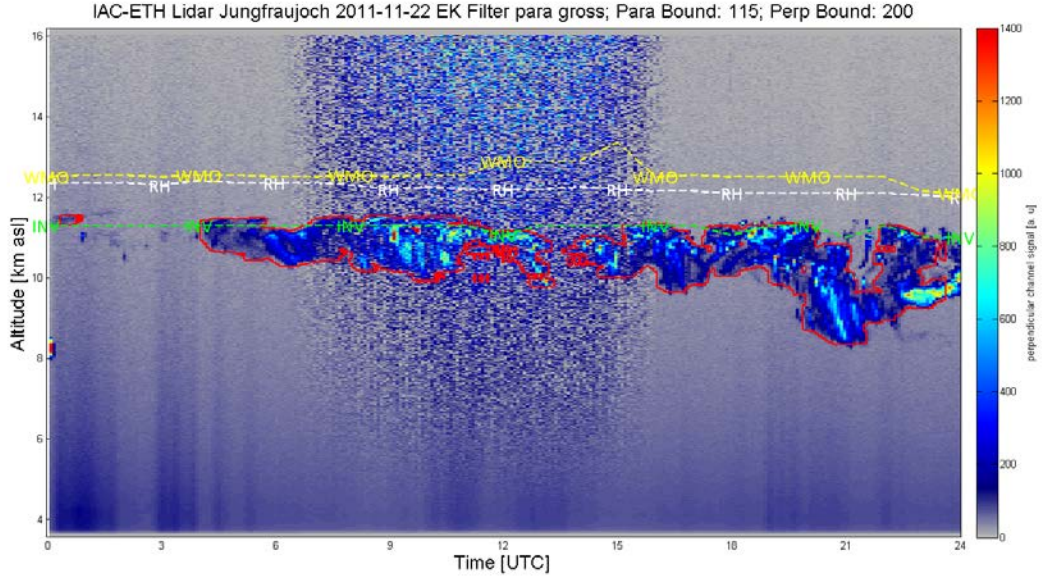


Fig.3: Same as Fig. 1 but supplemented by three different tropopause heights retrieved from the COSMO model. Tropopause height as defined by the WMO (yellow dashed line), as observed as the first temperature inversion (green dashed line) and as indicated by drop in relative humidity in the COSMO model (white dashed line). For a detailed description of the criteria see text.

For the day shown in Fig. 3 the cloud top of the cirrus clouds seem to coincide closely with the first temperature inversion based tropopause height.

To check whether this observation holds in general, we evaluated all data using the cloud detection scheme developed. The result is shown in Fig. 4.

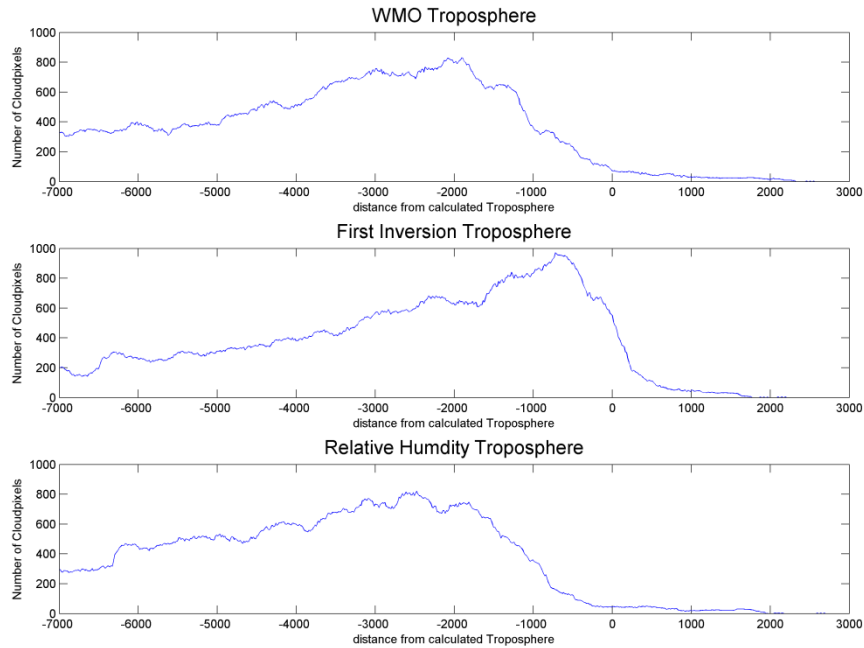


Fig. 4: Occurrence of cirrus clouds (as indicated by number of detected cloud pixels) relative to tropopause heights. Upper panel: WMO defined tropopause, middle panel: first temperature inversion tropopause height, lower panel: relative humidity derived tropopause.

Clearly the result of the single day shown is also representative for the majority of the cirrus clouds observed. The highest cloud tops observed by the Lidar above the Jungfrauoch coincide with the first temperature inversion tropopause height retrieved from the COSMO model whereas both, the WMO tropopause and the tropopause retrieved from relative humidity profiles are about 1 km higher in altitude compared to the clouds observed. The significance of this finding is currently under closer investigation.

References:

Sassen, K. and Comstock, J. M.: A midlatitude cirrus cloud climatology from the facility for atmospheric remote sensing. Part III: Radiative properties, *Journal of the Atmospheric Sciences*, 58, 2113–2127, doi: 10.1175/1520-0469(2001)058, 2001.

Key words:

Lidar, cirrus, tropopause, COSMO

Collaborating partners/networks:

Paul Scherrer Institut, Meteo Schweiz

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Zieger, P., E. Kienast-Sjögren, M. Starace, J. von Bismarck, N. Bukowiecki, U. Baltensperger, F.G. Wienhold, T. Peter, T. Ruhtz, M. Collaud Coen, L. Vuilleumier, O. Maier, E. Emili, C. Popp and E. Weingartner, Spatial variation of aerosol optical properties around the high-alpine site Jungfrauoch (3580 m a.s.l.), *Atmos. Chem. Phys.*, 12, 7231-7249, doi:10.5194/acp-12-7231-2012, 2012.

**Conference papers**

Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfrauoch, International Symposium on Tropospheric Profiling, Oral Presentation, L'Aquila, Italia, September, 2012.

Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfrauoch, International Conference on Clouds and Precipitation, Poster Presentation, Leipzig, Germany, July 2012.

Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfrauoch, WMO Cloud Modeling Workshop, Oral Presentation, Warsaw, Poland, July 2012.

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Name of research institute or organization:

**Institute for Atmospheric and Climate Science, ETH Zurich**

Title of project:

Field measurements of atmospheric ice nuclei and properties of mixed phase clouds

Project leader and team:

Dr. Olaf Stetzer and Prof. Ulrike Lohmann, project leaders  
Jan Henneberger, Yvonne Boose, Monika Kohn, PhD students

Project description:

The cloud physics group at ETH Zurich has developed the HOLographic Imager for Microscopic Objects II (HOLIMO II) to measure the micro-physical properties of mixed-phase clouds as reported in the 2011 report. In 2012 HOLIMO II was deployed to the Jungfraujoch during two campaigns for this purpose. HOLIMO II images *in-situ* single cloud particles larger than  $6.8 \mu\text{m}$  using digital holography. The measured size distributions were compared to a Fog Monitor (DMT FM-100) and agree quite well with this instrument (Figure 1). The development of the size distribution of a mixed phase cloud over eight hours was measured with a high temporal resolution and a bi-modal structure of liquid droplets and ice crystals could be observed (Figure 2).

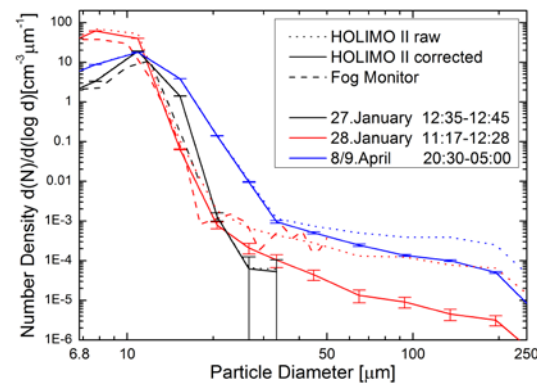


Figure 1: Cloud particle size distribution measured by the Fog Monitor (dashed) and HOLIMO II (dotted/solid). The raw HOLIMO II data (dotted) were corrected accounting for the inlet efficiency (solid).

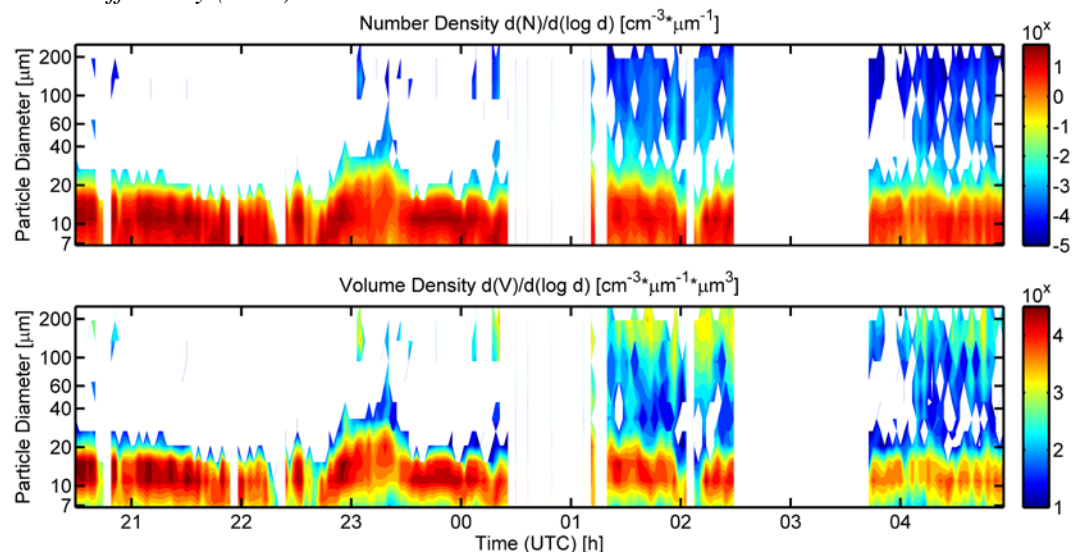


Figure 2: Development of the cloud particle size distribution between 6 April 20:00 and 04:00 (UTC) measured by HOLIMO II. Data gaps are due to icing on the windows.



In addition, further measurements of ice-nuclei concentrations with the portable ice nucleus counter (PINC) were performed in parallel during the campaign in January as reported in Figure 3. Since the concentrations of IN were very low (between 1 and 3 per liter) in this month the data was below the detection limit in many cases. To overcome this instrumental limitation, an aerosol concentrator was purchased for future campaigns. First tests with this concentrator were already performed and revealed, that a concentration ratio of 10:1 could be reached as was expected from the specifications of this device.

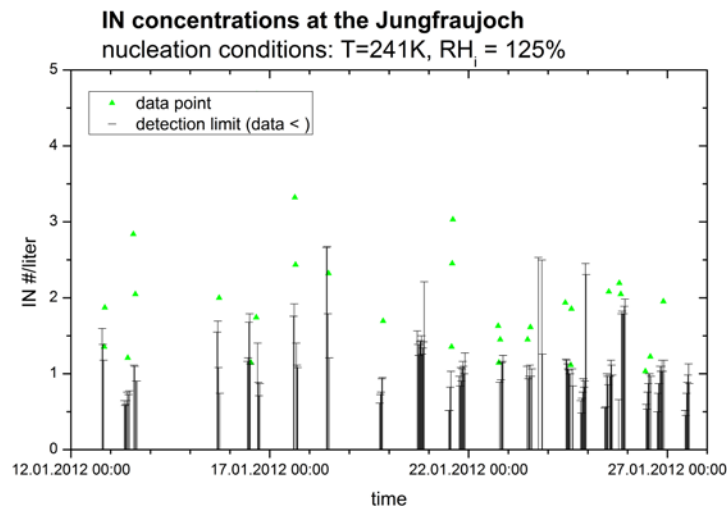


Figure 3: Ice nuclei concentrations at the Jungfraujoch in January 2012 at a temperature of 241K and a  $RH_i$  of 125%. For many occasions, the measured concentrations were below the detection limit, which is reported as black bars in these cases.

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Key words:

Ice nuclei, heterogeneous nucleation, aerosol particles, clouds, ice crystals, mixed phase clouds

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Collaborating partners/networks:

Ernest Weingartner, Martin Gysel, Nicolas Bukowiecki, PSI  
Jacob Fugal, MPI Mainz

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Scientific publications and public outreach 2012:

**Conference papers**

Henneberger J., O. Stetzer, U. Lohmann, Field measurements of the microstructure of mixed-phase clouds, 16<sup>th</sup> International Conference on Clouds and Precipitation, ICCP-2012, Leipzig, Germany, July 30 – August 3, 2012.

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URL: <http://www.iac.ethz.ch/>

Name of research institute or organization:

**Laboratory of Atmospheric Chemistry, Paul Scherrer Institute,  
CH-5232 Villigen PSI, Switzerland**

Title of project:

The Global Atmosphere Watch Aerosol Program at the Jungfraujoch

Project leader and team:

Prof. Dr. Urs Baltensperger, project leader

Dr. Ernest Weingartner, co-leader

Dr. Nicolas Bukowiecki\*, Emanuel Hammer, Dr. Paul Zieger, Dr. Martin Gysel,  
Günther Wehrle, Christine Ketterer (now at University of Freiburg, Germany)

Dr. Martine Collaud Coen (MeteoSwiss, Payerne)

\* reporting author

Project description:

Airborne aerosols affect our climate primarily by influencing the atmospheric energy budget through direct and indirect effects. Direct effects refer to the scattering and absorption of radiation and their influence on the planetary albedo and the climate system. Indirect effects refer to the increase in available cloud condensation nuclei (CCN) due to an increase in anthropogenic aerosol concentration. This leads to an increase in cloud droplet number concentration and a decrease in cloud droplet effective radius, when the cloud liquid water content (LWC) remains constant. The resulting cloud droplet spectrum leads to reduced precipitation and increased cloud lifetime. The overall result in the global atmosphere would be an increase in cloud albedo which cools the Earth's climate. Despite the uncertainty it is believed that in regions with high anthropogenic aerosol concentrations, aerosol forcing may be of the same magnitude but opposite in sign compared to the combined effect of all greenhouse gases.

The Global Atmosphere Watch (GAW) program is an activity overseen by the World Meteorological Organization (WMO). It is the goal of GAW to ensure long-term measurements in order to detect trends and to develop an understanding of these trends. With respect to aerosols the objective of GAW is to determine the spatio-temporal distribution of aerosol properties related to climate forcing and air quality up to multi-decadal time scales. Since the atmospheric residence time of aerosol particles is relatively short, a large number of measuring stations are needed. The GAW monitoring network consists of 27 global (including the Jungfraujoch) and about 300 regional stations. While global stations are expected to measure as many of the key variables as possible, the regional stations generally carry out a smaller set of observations.

The Jungfraujoch aerosol program is among the most complete ones worldwide. By the end of 2012 it has reached 18 years of continuous measurements. Table 1 shows the current GAW instrumentation that is continuously running at the Jungfraujoch. For these measurements, ambient air is sampled via a heated inlet (25°C), designed to prevent ice build-up and to evaporate cloud particles at an early stage, ensuring that the cloud condensation nuclei and/or ice nuclei are also sampled. This inlet is called the *total* inlet.

Hourly and daily averages are calculated and the data is visualized in real-time for different time periods in the internet, see

<http://aerosolforschung.web.psi.ch/onlinedata> or

<https://gawrtl.psi.ch>.

Table 1: Current GAW aerosol instrumentation

Instrument	Measured parameter
CPC (TSI 3010 or 3772)	Particle number density (particle diameter $D_p > 10$ nm)
Nephelometer (TSI 3563)	Scattering coefficient at three wavelengths
Aethalometer (AE-31)	Absorption coefficient at seven wavelengths; equivalent black carbon (BC) concentration
MAAP	Absorption coefficient at one wavelength; equivalent black carbon (BC) concentration
Filter packs	Aerosol major ionic composition (PM1 and TSP)
Betameter and HiVol <sup>1)</sup>	Aerosol mass, PM1 and TSP <sup>1)</sup>

<sup>1)</sup> measured by EMPA

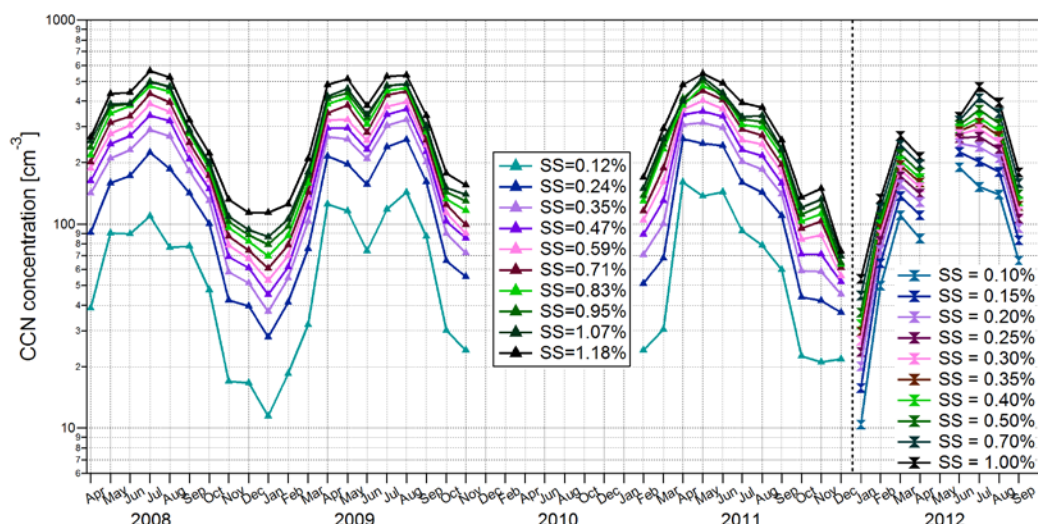
Since 2008, additional aerosol parameters have been continuously measured at the Jungfraujoch (see Table 2). These measurements were conducted as part of the “GAW plus” program and three EU Projects (EUSAAR, EUCAARI, and ACTRIS).

Table 2: Additional aerosol instrumentation operated in 2012

Instrument	Measured parameter	Measurement period
SMPS, OPC	Particle number size distribution, $D_p = 20 - 22'500$ nm	10.1.2008 - ongoing
CCNC	Number concentration of cloud condensation nuclei	10.1.2008 - ongoing

The number size distribution of aerosol particles plays a key role for direct and indirect aerosol climate interactions. A scanning particle mobility sizer (SMPS) and an optical particle counter (OPC) were installed at the JFJ in January 2008. These instruments have been fully operational since then and provide a complete size distribution from 20 nm to 20  $\mu$ m.

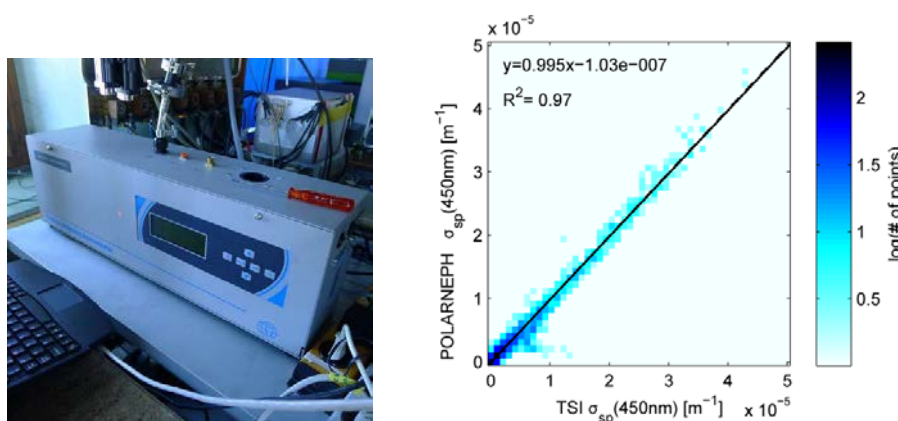
The cloud condensation nuclei counter (CCNC) exposes ambient aerosol particles to a defined water supersaturation (SS, in the range between  $SS = 0.12-1.18\%$ ) and measures the concentration of cloud droplets that were activated at this SS. This instrument was installed in January 2008 and has been running since then. It provides valuable information on the variation, absolute value and SS dependence of the CCN concentration (Jurányi et al., 2011). Figure 1 shows the temporal variation of the measured CCN concentration from 2008 to 2012. Since December 2011 the CCNC is also part of the ACTRIS (Aerosols, Clouds, and Trace gases Research Infra Structure) network. This required a standardization of the supersaturation range and thus was changed to 0.1 to 1.0 %.



**Fig. 1:** Time series of CCN concentrations from April 2008 to December 2012 at 10 different supersaturations. In December 2011 the supersaturation settings were changed in order to comply with the new standards set by ACTRIS. The gap in the time series from December 2009 to January 2011 is due to the commitment of the CCNC in another campaign (MEGAPOLI in Paris) and due to a servicing of the instrument at the manufacturer. The gap in May 2012 is due to a flow problem within the CCNC.

#### Angular aerosol scattering properties measured during one year at the Jungfraujoch

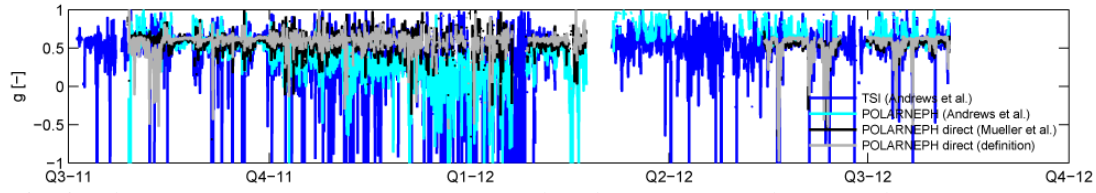
The angular distribution of the aerosol light scattering was measured during one year at the Jungfraujoch using a novel instrument (POLARNEPH, Aurora 4000, Ecotech Inc., Australia, see Fig. 2). This instrument measures the scattering coefficient for distinct angles using a high-precision backscatter shutter at three wavelengths. The aerosol phase function and the asymmetry parameter can be retrieved, which are important for aerosol climate forcing calculations. In a first step, the measurements at  $\lambda=450$  nm were compared to the standard TSI nephelometer, which has been operated at the JFJ since 1998. Figure 2 reveals a good agreement between both instruments, which is a positive finding with respect to quality assurance issues.



**Fig. 2:** Left Panel: The POLARNEPH Aurora 4000 installed at the Jungfraujoch. Right Panel: The aerosol scattering coefficient (at wavelength of 450 nm) of the POLARNEPH vs. the TSI nephelometer (GAW). The solid black line represents an orthogonal fit.

The asymmetry parameter  $g$  is defined as the intensity-weighted average of the cosine of the scattering angle. It values range from +1 (all light scattered completely to the forward scattering region) and -1 (all light scattering completely backwards). It is an important factor in radiative transfer calculations which are used to estimate the radiative forcing of anthropogenic aerosols and thus also the climate effects of aerosols. While approximations exist to derive  $g$  from standard TSI nephelometer measurements, the POLARNEPH allows

measuring the asymmetry parameter directly. Figure 3 shows the time series of the derived asymmetry parameter at the JFJ from the TSI and the novel POLARNEPH. Clear differences between the different approximations and the direct measurement can be observed and ongoing research will clarify the reasons for these discrepancies.



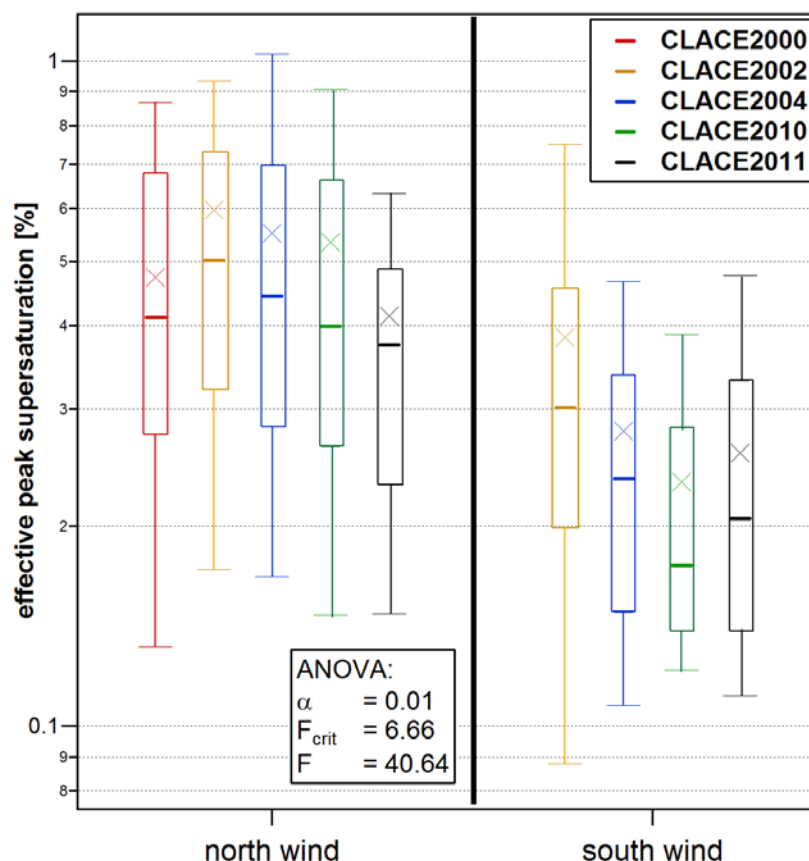
**Fig. 3:** The asymmetry parameter  $g$  measured at the Jungfraujoch from July 2011 to August 2012. Different algorithms and schemes have been applied to the measurements of the TSI and POLARNEPH instrument (see legend).

It is also planned to use the recorded data for intensive closure studies using the other recorded in-situ data (size distribution, absorption and chemical data) and Mie theory and discrete dipole approximation. Furthermore, this nephelometer intercomparison is a first step in the scheduled replacement of the TSI 3563 instrument with the Ecotech Aurora 3000 instrument.

### **The CLACE field campaigns: Investigation of effective peak supersaturations in liquid-phase clouds**

An important aerosol parameter for climate models is the critical supersaturation (described by Köhler theory), at which a particle forms a cloud droplet. This parameter depends on the particle's dry size and chemical composition. At ambient air conditions, the prevailing supersaturation determines the activation diameter of the aerosol particles (i.e. the diameter at which size a particle forms a cloud droplet). The highest supersaturation that a particle experiences in an ambient cloud, leading to a cloud droplet forming from that particle, is the so-called effective peak supersaturation ( $SS_{peak}$ ).

Since 2000, several Cloud and Aerosol Characterization Experiments (CLACE) have been conducted at the Jungfraujoch. In order to determine  $SS_{peak}$  in ambient clouds, the ambient activation diameter (diameter where 50% of the particles are activated to cloud droplets;  $D_{50}$ ) was retrieved from dry particle number size distribution measurements of the total and the interstitial (non-activated) aerosol. Two different inlet systems were used to retrieve the aerosol number concentration of (1) the total aerosol including the nuclei of the hydrometeors ( $N_{tot}$ ) and (2) the non-activated (interstitial aerosols;  $N_{int}$ ) ones. The difference of these two numbers leads to the number of cloud condensation nuclei (CCN) that were activated at the prevailing ambient air conditions. To retrieve the ambient  $D_{50}$ , the activated fraction ( $(N_{tot} - N_{int})/N_{tot}$ ) was calculated. The Köhler theory consists of two different laws: Raoult's law and Kelvin's law. The former is relying on the hygroscopic properties of the aerosol particles. To summarize Raoult's law with one parameter, Petters and Kreidenweis (2007) introduced the hygroscopicity parameter  $\kappa$ . To retrieve the prevailing ambient  $\kappa$  parameter, the activation diameter was compared to those retrieved from a cloud condensation nuclei (CCN) counter measuring at various controlled supersaturations. Therewith, the effective peak supersaturation can be calculated depending on the following parameters:  $D_{50}$ ,  $\kappa$  and the temperature where the activation of an aerosol to a cloud droplet occurs.



**Fig. 4:** Effective peak supersaturations for the two main wind fields present at the Jungfraujoch during several CLACE campaigns. North wind is classified as a horizontal wind direction between 270° to 90° and south wind in a range of 90° to 270° (Hammer et al., in prep.).

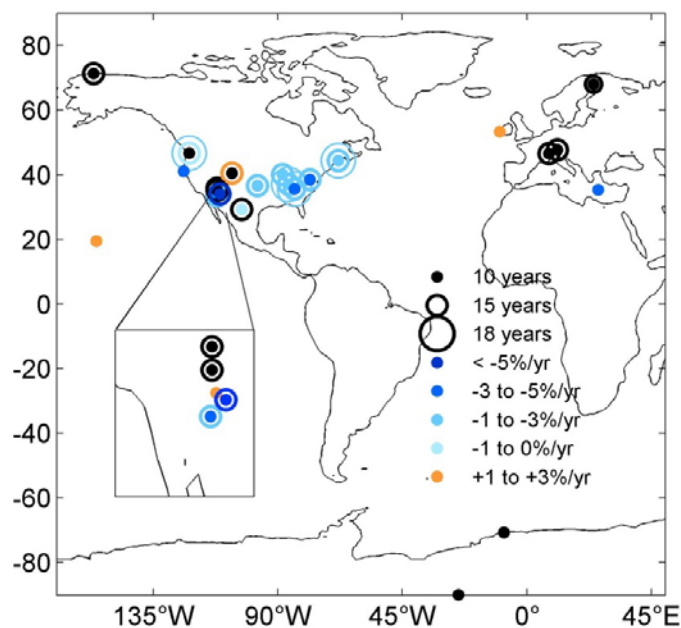
Figure 4 shows the results of  $SS_{peak}$  values for all performed CLACE campaigns during summer seasons. A range of  $SS_{peak}$  values between 0.09% (10<sup>th</sup> percentile) and 1.62% (90<sup>th</sup> percentile) has been observed during several CLACE campaigns. While air masses coming from the North showed a wide range of values,  $SS_{peak}$  values for air masses coming from the South were more constant at around 0.2%. This can most likely be explained by different topography from south and north of the Jungfraujoch causing different updraft velocities. While the south side of the Jungfraujoch has a rather smooth topography (Aletsch glacier) resulting in relatively low orographically induced updraft velocities, the north side is characterized by steep rock walls, with more turbulent wind conditions and high updraft velocities. The difference of  $SS_{peak}$  values between the two different wind conditions is statistically significant at  $\alpha=0.01$  with a variance analyses (ANOVA). Currently, the influence of particle number concentration and size distribution on the  $SS_{peak}$  as a function of updraft velocity is being investigated in detail with a cloud box model.

#### **Aerosol decadal trends: In-situ optical measurements and number concentration at GAW, IMPROVE and ACTRIS stations**

Ground-based, in-situ measurements placed in areas away from emission sources are most suited for studying the atmospheric spatial and temporal variability of aerosol properties as well as climate relevant changes and trends in the atmospheric composition of background air masses. Indication of trends in atmospheric composition is essential, not only for our knowledge of global to regional cycling of atmospheric constituents and natural and anthropogenic changes, but also to validate past and present emission inventories, and to test validity of models at different scales.



In two recent studies (Asmi et al., 2013, Collaud Coen et al., 2013), an analysis of in-situ aerosol trends has been performed within the framework of the WMO-GAW program, using quality-controlled information provided by the NOAA-affiliated monitoring network, the EMEP and EUSAAR/ACTRIS EU-based Research Infrastructure, and the US IMPROVE network, to provide indications of long-term changes in several climate-relevant aerosol variables. Long-term (> 10 years) aerosol measurement sites in the Northern Hemisphere and Antarctica allow analyzing the trends of the aerosol number concentration, the light scattering, backscattering, and absorption coefficients as well as of the derived light scattering Ångström exponent ( $\alpha$ ) and backscatter fraction (b).



**Fig. 5:** Trends results for the scattering coefficient. Black symbols correspond to stations with no significant trends. Blue and orange symbols correspond to statistically significant negative and positive trends, respectively, the magnitude of the trends (slope) being given by the colors as stipulated in the legend. The sizes of the circles are proportional to the length of the data sets; the trend for the whole period as well as the 10 years (dots) and, if possible, 15-year trends were calculated. The largest circles denote, therefore, the trend of the longest analyzed period (from Collaud Coen et al., 2013).

The scattering coefficient and number concentration statistically significant (s.s.) trends are predominantly negative. The trend slopes ranged between -1 and -85 %/10yr depending on the stations and the analyzing methods. Generally the absorption coefficient trends confirm the results found for the scattering coefficient. The main results are as follows:

- Over the continental US, scattering and absorption coefficients trends as well as number concentration are generally s.s. and negative. We can therefore conclude that, except for specific stations, there is a very general and robust decrease in aerosol optical parameters observed over the last 10 to 15 years in this area, detectable despite the high natural variability of the atmospheric aerosol.
- Few s.s. trends were observed for the five European sites. One Mediterranean site presents a scattering s.s. decreasing trend that can be related to regional conditions and was not confirmed by the absorption trend. In contrast, the analysis of long-term scattering measurements from two mountaintop sites (JFJ and HBP), and one site in a high latitude boreal region (PAL) revealed no s.s. trends for both the scattering and absorption coefficients for the last 10 years. For the number concentration, s.s. negative trends are found for 2 Scandinavian stations. Finally, a s.s. positive change in the scattering

coefficient is observed at the coastal Atlantic site (MHD) with only one out of the three analyzing methods, which is not observed for the absorption coefficient.

- We found no s.s. scattering trends for the Arctic or Antarctic sites. But two of the polar stations have s.s. negative absorbing aerosol trends. Number concentrations present no or negative s.s. trends for the whole measuring periods for both Arctic (13 yr) and Antarctic (37 yr), whereas positive trends are found for the last 10 yr in the Antarctic.
- The high altitude Mauna Loa (MLO) site in the middle of the Pacific Ocean has the only data set suggesting an increase of both the scattering and absorption coefficients over the last ten years. The most probable cause of the positive trends in absorption and scattering is the increased emission of pollutants in Asia being transported by high altitude winds to reach MLO. In contrast, a s.s. decreasing trend is found for the number concentration at MLO.
- No consistent, s.s. trends in  $b$  and  $a$  were observed for most of the stations. At the arctic station (BRW) and MLO s.s. negative trends in  $b$  and  $a$  were found for the 2001-2010 period. Negative  $b$  and  $a$  trends signify a relative shift towards larger particles at the lower end of the accumulation mode.

In summary, at most US continental sites, decreasing trends observed for aerosol optical properties are generally consistent with SO<sub>2</sub> and PM reductions. For continental European sites, the relation between aerosol optical properties and emissions reductions is less clear. The strong decreasing signal for SO<sub>2</sub> and, with a lower spatial homogeneity and statistical significance, for PM<sub>2.5</sub> was not reflected in the aerosol optical properties in Europe. The European discrepancy might also be due to under-representation of continental EU PBL sites in our study. Furthermore, the difference in the timing of SO<sub>2</sub> and PM trends for the two continents is another likely explanation for the decreasing trends in aerosol number concentration and optical parameters found for most American sites compared to the lack of trends observed in Europe. The European optical property time series may not go back far enough to reflect the time period with the largest emissions reductions.

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**Key words:**

Atmospheric aerosol particles, aerosol climatic effects, radiative forcing, light scattering, cloud condensation nuclei, hygroscopic growth, CCN concentration, aerosol size distribution, remote sensing of aerosol optical properties

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**Internet data bases:**

<http://www.psi.ch/lac>

<http://aerosolforschung.web.psi.ch>

<https://gawrtl.psi.ch>

[http://www.meteoschweiz.admin.ch/web/en/meteoswiss/international\\_affairs/GAW.html](http://www.meteoschweiz.admin.ch/web/en/meteoswiss/international_affairs/GAW.html)

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Scientific publications and public outreach 2012:

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**Refereed journal articles and their internet access**

Spiegel, J. K., P. Zieger, N. Bukowiecki, E. Hammer, E. Weingartner and W. Eugster, Evaluating the capabilities and uncertainties of droplet measurements for the fog droplet spectrometer (FM-100), *Atmospheric Measurement Techniques*, 5, 2237-2260, doi:10.5194/amt-5-2237-2012, 2012.  
<http://dx.doi.org/10.5194/amt-5-2237-2012>

Zieger, P., E. Kienast-Sjögren, M. Starace, J. von Bismarck, N. Bukowiecki, U. Baltensperger, F.G. Wienhold, T. Peter, T. Ruhtz, M. Collaud Coen, L. Vuilleumier, O. Maier, E. Emili, C. Popp and E. Weingartner, Spatial variation of aerosol optical properties around the high-alpine site Jungfraujoch (3580 m a.s.l.), *Atmospheric Chemistry and Physics*, 12, 7231-7249, doi:10.5194/acp-12-7231-2012, 2012.  
<http://dx.doi.org/10.5194/acp-12-7231-2012>

Kristiansen, N. I., A. Stohl, A.J. Prata, N. Bukowiecki, H. Dacre, D. Eckhardt, S. Henne, M.C. Hort, B.T. Johnson, F. Marengo, B. Neininger, O. Reitebuch, P. Seibert, D.J. Thomson, H.N. Webster and B. Weinzierl, Performance assessment of a volcanic ash transport model mini-ensemble used for inverse modeling of the 2010 Eyjafjallajökull eruption, *Journal of Geophysical Research*, 117, D00U11, doi:10.1029/2011JD016844, 2012.  
<http://dx.doi.org/10.1029/2011JD016844>

Wiedensohler, A., W. Birmili, A. Nowak, A. Sonntag, K. Weinhold, M. Merkel, B. Wehner, T. Tuch, S. Pfeifer, M. Fiebig, A.M. Fjæraa, E. Asmi, K. Sellegri, R. Depuy, H. Venzac, P. Villani, P. Laj, P. Aalto, J.A. Ogren, E. Swietlicki, P. Williams, P. Roldin, P. Quincey, C. Hüglin, R. Fierz-Schmidhauser, M. Gysel, E. Weingartner, F. Riccobono, S. Santos, C. Grüning, K. Faloon, D. Beddows, R. Harrison, C. Monahan, S.G. Jennings, C.D. O'Dowd, A. Marinoni, H.-G. Horn, L. Keck, J. Jiang, J. Scheckman, P.H. McMurry, Z. Deng, C.S. Zhao, M. Moerman, B. Henzing, G. de Leeuw, G. Löschau and S. Bastian, Mobility particle size spectrometers: harmonization of technical standards and data structure to facilitate high quality long-term observations of atmospheric particle number size distributions, *Atmos. Meas. Tech.*, 5, 657-685, doi:10.5194/amt-5-657-2012, 2012.  
<http://dx.doi.org/10.5194/amt-5-657-2012>

Collaud Coen, M., E. Andrews, A. Asmi, U. Baltensperger, N. Bukowiecki, D. Day, M. Fiebig, A.M. Fjæraa, H. Flentje, A. Hyvärinen, A. Jefferson, S.G. Jennings, G. Kouvarakis, H. Lihavainen, C. Lund Myhre, W.C. Malm, N. Mihopoulos, J.V. Molnar, C. O'Dowd, J.A. Ogren, B.A. Schichtel, P. Sheridan, A. Virkkula, E. Weingartner, R. Weller and P. Laj, Aerosol decadal trends – Part 1: In-situ optical measurements at GAW and IMPROVE stations, *Atmos. Chem. Phys.*, in press, 2013.

ACPD link: <http://dx.doi.org/10.5194/acpd-12-20785-2012>

Asmi, A., M. Collaud Coen, J.A. Ogren, E. Andrews, P. Sheridan, A. Jefferson, E. Weingartner, U. Baltensperger, N. Bukowiecki, H. Lihavainen, N. Kivekäs, E. Asmi, P. P. Aalto, M. Kulmala, A. Wiedensohler, W. Birmili, A. Hamed, C. O'Dowd, S. G. Jennings, R. Weller, H. Flentje, A. Mari Fjaeraa, M. Fiebig, C. Lund Myhre, A. G. Hallar, and P. Laj.: Aerosol decadal trends – Part 2: In-situ aerosol particle number concentrations at GAW and ACTRIS stations, *Atmos. Chem. Phys.*, in press, 2013.  
ACPD link: <http://dx.doi.org/10.5194/acpd-12-20849-2012>

### **Magazine and Newspapers articles**

P. Zieger, U. Baltensperger, To find warming's speed, scientists must see through clouds  
*Greenwire* (Journalist: Voosen, P.), November 13, 2012.  
<http://www.eenews.net/public/Greenwire/2012/11/13/1>

P. Kupiszewski, Die Mikrophysik der Wolken  
*Neue Zürcher Zeitung*, August 8, 2012.

E. Weingartner, Hochalpine Top-Wissenschaft  
*Neue Zürcher Zeitung*, June 12, 2012.

E. Weingartner, 75 Jahre Sphinx-Observatorium  
TEC21 ([www.tec21.ch](http://www.tec21.ch)), June 1, 2012.

E. Weingartner, Lungenschäden und Regenfälle  
*Engadiner Post*, May 8, 2012.

E. Weingartner, Den Puls der Atmosphäre messen  
*Walliser Bote*, May 5, 2012.

E. Weingartner, Prendre le pouls de l'atmosphère à 3500m  
*20minutes* français, [20min.ch/ro](http://20min.ch/ro) May 7, 2012.

E. Weingartner, Jungfrauoch: prendre le pouls de l'atmosphère à 3500 mètres  
ATS / Agence Télégraphique Suisse, May 7, 2012.

E. Weingartner, Le Sphinx mesure l'air depuis 75 ans à la Jungfrauoch  
*Tribune de Genève*, May 7, 2012.

E. Weingartner, Feinstaub: Lungenschäden und Regenfälle  
SDA / Schweizerische Depeschagentur, May 4, 2012.

### **Radio and television**

E. Hammer, «Lanzi...» auf dem Jungfrauoch  
*Zambo*, Schweizer Fernsehen SF1, December 11, 2012.  
<http://www.srf.ch/player/video?id=4ed8ce8a-c7c6-403f-b703-c389f9c5db60>

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Name of research institute or organization:

**Laboratory of Atmospheric Chemistry, Paul Scherrer Institute,  
CH-5232 Villigen PSI, Switzerland**

Title of project:

Aerosol Chemical Speciation Monitor (ACSM) measurements on the Jungfraujoch within the frame of the EU project ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network)

Project leader and team:

Dr. André Prévôt, project leader

Roman Fröhlich\*, Dr. Mike Cubison, Dr. Jay Slowik, Dr. Urs Rohner, Dr. Mark Gonin, Dr. Joel Kimmel, Prof. Douglas Worsnop, Dr. John Jayne, Prof. Urs Baltensperger

\*reporting author

Project description:

The project is comprised of two main goals: Firstly, the augmentation of knowledge about the aerosol present in the high-alpine atmosphere by monitoring its chemical composition over a period of at least one full year. Embedded in the framework of the ACTRIS (Aerosols,

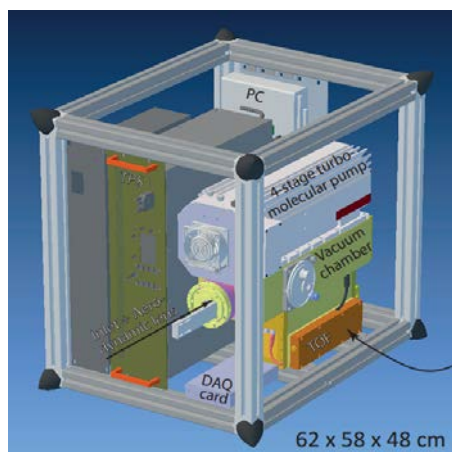


Fig. 1. Sketch of ToF-ACSM.

Clouds, and Trace Gases Research Infrastructure Network) network which encompasses about a dozen similar measurement stations all over Europe, these measurements are to contribute to a unique, chemically resolved dataset of the European aerosol. The second goal is the validation of a prototype of a new time of flight instrument (ToF-ACSM, see Fig. 1) suitable to monitor the chemical composition of the non-refractory, sub-micron aerosol with lower detection limits than the current quadrupole version (Q-ACSM). The specific conditions on the Jungfraujoch in terms of aerosol concentrations which are mostly very low but can still be highly variable in summer provide an ideal proving ground for both detection limits and temporal resolution of the instrument. Additionally,

the infrastructure and the large number of complementary measurements at the Sphinx Research Station allow for sanity tests of the recorded data and the testing of the prototype's remote control capability.

Work on the project was started in late June 2012. From the beginning of August until mid-November 2012 the ToF-ACSM prototype was operated in parallel with the current Q-ACSM version, which has already been validated and available on the market for about three years. The inter-comparison of the time series of the individual chemical species (organics, sulfate, nitrate, ammonium and chloride) recorded with the two instruments (see Fig. 2a and 2b) showed very good agreement in absolute concentrations ( $\pm 15\%$ ) as well as in capturing the variability ( $R^2 = 0.97$  (total mass)). Furthermore, an inter-comparison of the ToF-ACSM to a co-located instrument employing an optical method to estimate aerosol mass (nephelometer, see Fig. 2c) also showed a very good qualitative agreement ( $R^2 = 0.94$ ). These results are a very important step towards proving the validity of the ToF-ACSM data and therefore suitability for the market. A further comparison to the high-end aerosol mass spectrometer (AMS) during the CLACE campaign in the first quarter of 2013 will complete the validation and will be published soon.

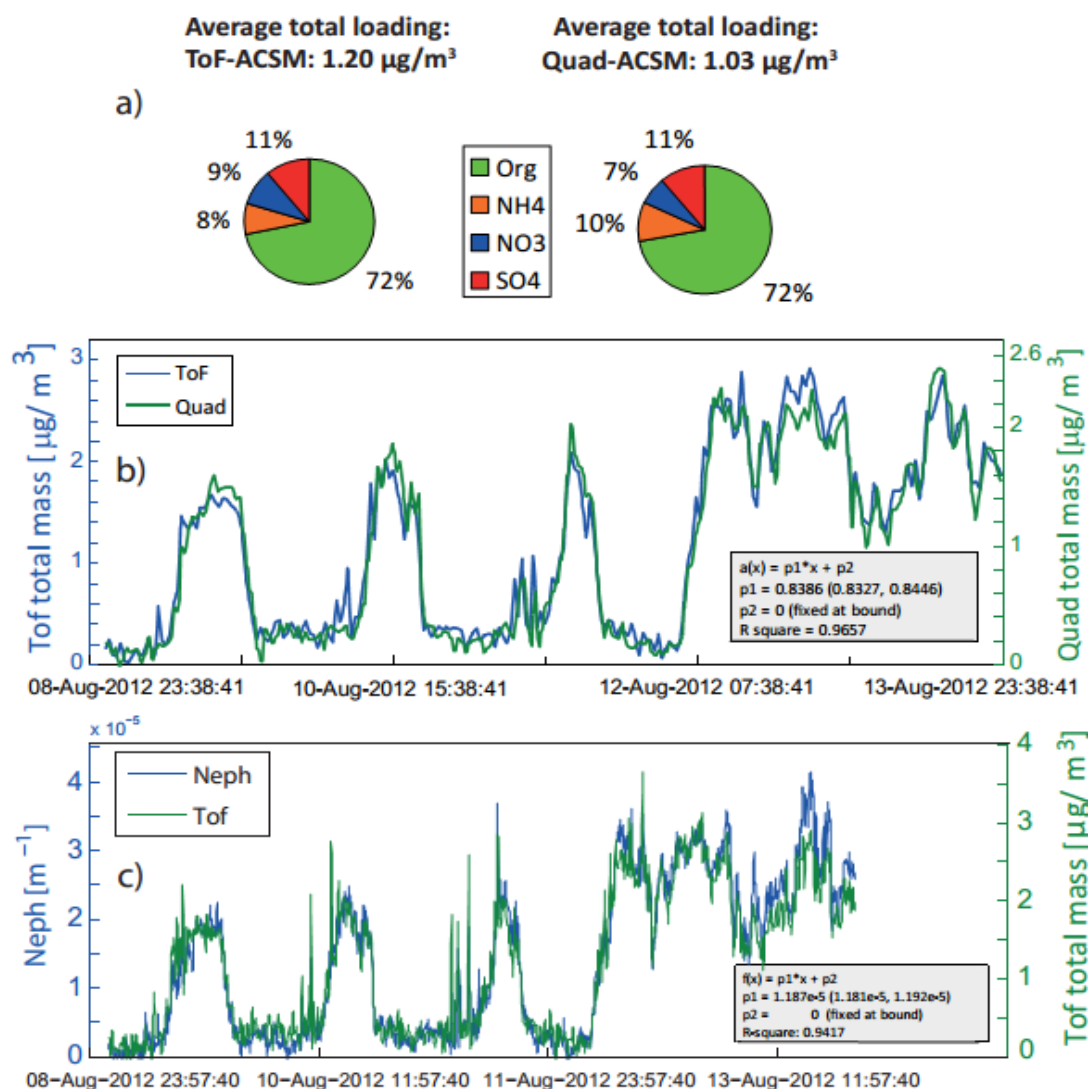


Fig. 2. a) Contribution of individual species to total mass loading of the ToF-ACSM (left) and the Q-ACSM (right) in the displayed period. b) Time series of the total mass concentration ( $\mu\text{g}/\text{m}^3$ ) recorded with the ToF-ACSM (blue) and the Q-ACSM (green) during five days in August 2012. c) Time series of the nephelometer at  $\lambda = 450\text{nm}$  in  $\text{m}^{-1}$  (blue) and time series of the total mass concentration measured with the ToF-ACSM in  $\mu\text{g}/\text{m}^3$  (green) during five days in August 2012. Results of a fit to scatter plot of same data are given in right corner for b) and c).

The aerosol concentrations at the Jungfraujoch typically go down to very low levels in winter. They are well below the detection limit of the Q-ACSM and therefore from mid-November on it was brought to another measurement station and only the ToF-ACSM remained on the Jungfraujoch. Because of these low concentrations this season is very well suited to test and explore the detection limits of the new instrument.

Fig. 3 shows most of the times-series recorded so far. The summer data was recorded with the Q-ACSM and the winter data with the ToF-ACSM. The aerosol concentration in summer follows the typical pattern of vertical exchange processes causing injections of planetary boundary layer air in the valleys or the Swiss Plateau into higher altitudes during the afternoon. This results in increasing aerosol concentrations starting around noon at Jungfraujoch and which decrease again at night. The peak concentrations in summer are usually around 5-8  $\mu\text{g}/\text{m}^3$  and occur around 5 pm. There were two days with extraordinarily high concentrations, the 30<sup>th</sup> of June and the 9<sup>th</sup> of September with peak concentrations of 21  $\mu\text{g}/\text{m}^3$  and 29  $\mu\text{g}/\text{m}^3$  respectively. The largest mass fraction of the non-refractory, submicron

aerosol in summer consists of organic compounds (58%) and sulfate (25%), additionally there is some ammonium (10%) and nitrate (7%). In winter the Jungfrauoch resides in the free troposphere, i.e. it is no longer under the influence of the planetary boundary layer and therefore the concentrations are much lower (generally below  $0.5 \mu\text{g}/\text{m}^3$ ). The chemical composition is also different, dominated by sulfate (54%). The other species contribute fractions of 30% (organics), 9% (ammonium) and 6% (nitrate) respectively.

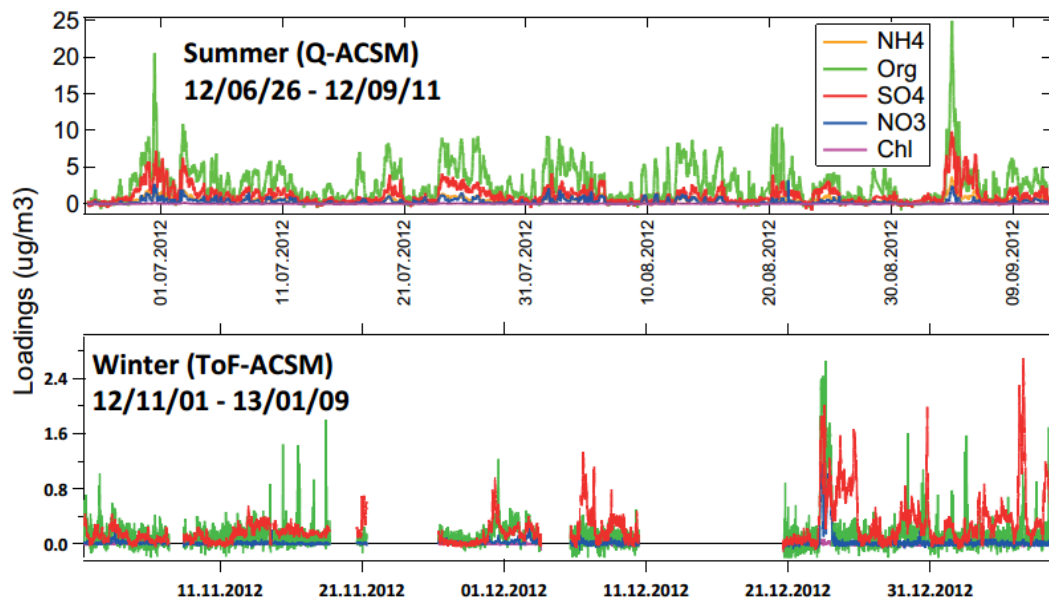


Fig. 3. Aerosol time series recorded at the Jungfrauoch. Top: 2.5 months in summer measured with the Q-ACSM. Bottom: 2 months in winter measured with the ToF-ACSM. Note the different scaling of the y-axis. (green: organics, red: sulfate, blue: nitrate, orange: ammonium, pink: chloride).

A more thorough analysis of the obtained data with inclusion of meteorology, back trajectories, data from additional measurements, etc. will be performed in 2013.

#### Key words:

Atmospheric aerosol particles, ACSM, Aerosol Chemical Speciation Monitor, Aerosol Mass Spectroscopy, Intercomparison, Prototype, ToF, Aerosol Chemical Composition, ACTRIS, Online Measurement, Aerosol Mass, Aerodyne, Tofwerk

#### Internet data bases:

<http://www.psi.ch/lac/>  
<http://www.psi.ch/acsm-stations/>  
<http://www.actris.net/>

#### Collaborating partners/networks:

Tofwerk AG, CH-3600 Thun, Switzerland  
European FP7 project ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network)  
Aerodyne Research, Inc., Billerica, MA-01821, United States

#### Scientific publications and public outreach 2012:

##### Conference papers

Fröhlich R., M. Cubison, J. Slowik, A. Prévôt, U. Baltensperger, U. Rohner, M. Gonin, J. Kimmel, D. Worsnop and J. Jayne, A novel compact aerosol mass spectrometer - the ToF-ACSM: Instrument performance and first field deployment, European Aerosol Conference (EAC), Granada, Spain, September 02-07, 2012.

Cubison M., R. Fröhlich, J. Slowik, A. Prévôt, U. Baltensperger, U. Rohner, M. Gonin, J. Kimmel, D. Worsnop and J. Jayne, A novel compact aerosol mass spectrometer - the ToF-ACSM: Instrument performance and first field deployment, AAAR 31<sup>st</sup> Annual Conference, Minneapolis, Minnesota, USA, October 08-12, 2012.

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Name of research institute or organization:

**Physikalisch-Meteorologisches Observatorium Davos,  
World Radiation Center (PMOD/WRC)**

Title of project:

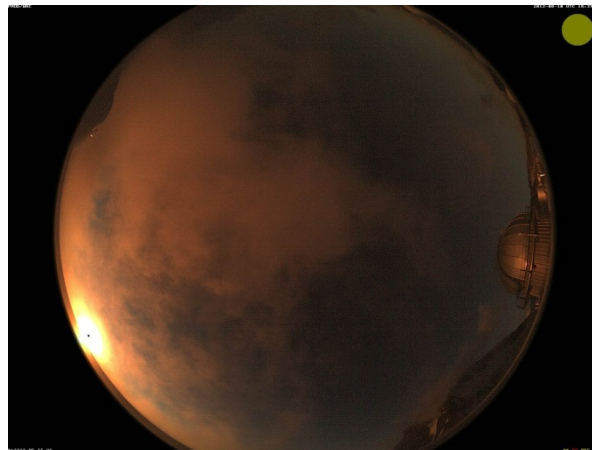
Cloud Climatology and Surface Radiative Forcing over Switzerland (CLASS)

Project leader and team:

Julian Gröbner  
Stefan Wacker  
Stephan Nyeki

Project description:

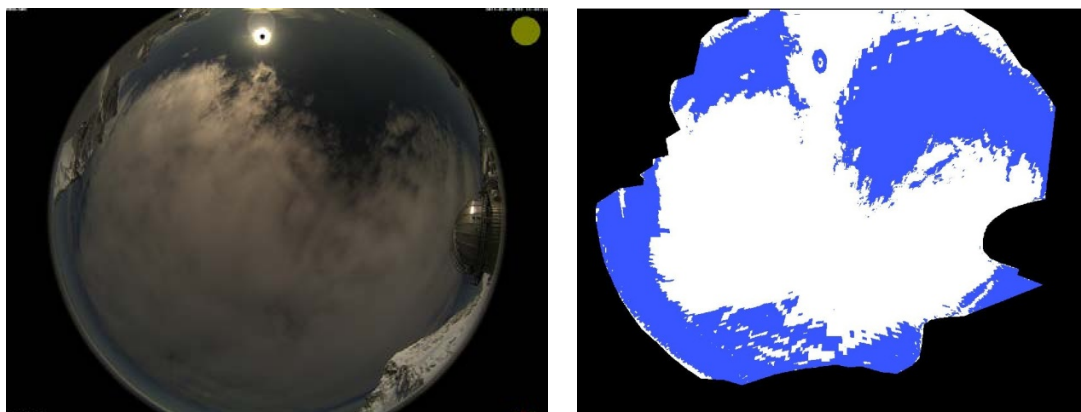
The CLASS project aims at quantifying changes in the short-wave and long-wave radiative fluxes and the effect of clouds on the surface radiation budget by differentiating between cloud types and cloud coverage using ancillary instrumentation and datasets. In order to discriminate between different cloud types and to calculate more precisely fractional cloud cover, hemispherical sky cameras were deployed at four stations across Switzerland. The systems at Davos, Payerne and Zimmerwald were already installed in 2010 and 2011. At Jungfraujoch, the installation was delayed due to technical problems with the camera system and the particular requirements at the high alpine station. Finally in July 2012, we were also able to successfully deploy a camera at this site (see Fig. 1). The camera delivers images from the sky during the daytime with a 1-minute cadence. The camera has been operational without any technical difficulties so far and data availability is at 100 %. Pictures from any particular day are stored for 10 days on the PMOD/WRC FTP server.



*Figure 1: Hemispherical sky image taken on the 10.8.2012 at sunset.*

The camera system allows the fractional cloud cover to be calculated on a routine basis. This is accomplished by calculating the ratios of the blue to the green channel and blue to the red channel for each pixel, which are then compared to a reference value. If the calculated value is higher than the reference value due to an atmosphere with no clouds which scatters more blue than red light, the pixel is classified as cloud-free. On the other hand, if the value is below the reference value due to clouds which scatter more red light compared to a cloud-free sky, the pixel is classified as cloudy (see Fig. 2). The validation of our results, however, is not trivial because alternative surface-based observations of the fractional cloud cover are limited at these stations. Therefore, we plan to compare our results to fractional cloud cover derived from Meteosat in the upcoming year.





*Figure 2: Original image of the sky over Jungfrauoch on the 5.1.2013 11:42 (left). The cloud cover algorithm produces a simplified image in which the cloud-free and cloudy sky is represented by blue and white pixels, respectively. The calculated cloud cover is 58 % for this image. Problematic is the cloud cover detection near the sun where the pixels due to the brightness of the sun are often misinterpreted as being cloudy.*

Besides the calculation of fractional cloud cover, we have developed and tested an algorithm to classify the images into seven different cloud classes: cirrus-cirrostratus (ci-cs), cirrocumulus-altocumulus (cc-ac), stratus-altostratus (st-as), cumulus (cu), stratocumulus (sc), cumulonimbus-nimbostratus (cb-ns) and cloud-free (cf). The cloud type classification algorithm is based on a set of statistical features describing the color and the texture of an image. For the actual classification of an image, the k-nearest-neighbor (kNN) classifier is used. The kNN method belongs to the “supervised”, non-parametric classifiers. “Supervised” implies that the separating classes are known and a training set is used to train the algorithm. We generated such a training sample from the Payerne data set by visual inspection of the images. This data set was chosen to train the algorithm because a large number of ancillary data including synoptic observations and ceilometer data have facilitated the generation of the training set. In order to correctly train the algorithm, the images of the training set may contain only one single cloud class as previously defined. The training set contains 200 pictures for each cloud class.

Eleven statistical features were computed for each pre-classified image of the training set and stored with its assigned cloud class. The eleven features consist of seven color features (mean of red and blue channel, standard deviation and skewness of blue channel, and difference of red and blue, red and green, and green and blue channel) and four textural features (energy, entropy, homogeneity and contrast of the blue channel).

We have tested the cloud type algorithm using independent test samples also containing images which do not necessarily show one unique cloud class as the training sample does. The score of the correctly classified images is currently between approximately 20 and 80 % (see Fig. 3). While the score of a correct classification for cumulonimbus-nimbostratus and cloud-free conditions is between 60 and 100 %, the classification of the other cloud classes is more problematic. The classification of cumulus, for example, is particularly difficult. Indeed, only every fifth and every third cumulus is correctly recognised by the algorithm at Davos and Payerne, respectively.

We are currently adapting the algorithm to the atmospheric conditions at Jungfrauoch. Indeed, clouds with a low cloud base such as stratus, stratocumulus, cumulus, cumulonimbus and nimbostratus no longer occur above but below the station due to its high altitude at 3580 meters above sea level. In addition, when the station is within these clouds their type cannot be discriminated. Therefore, a separate training set may be required for Jungfrauoch and the number of cloud classes has to be reduced.



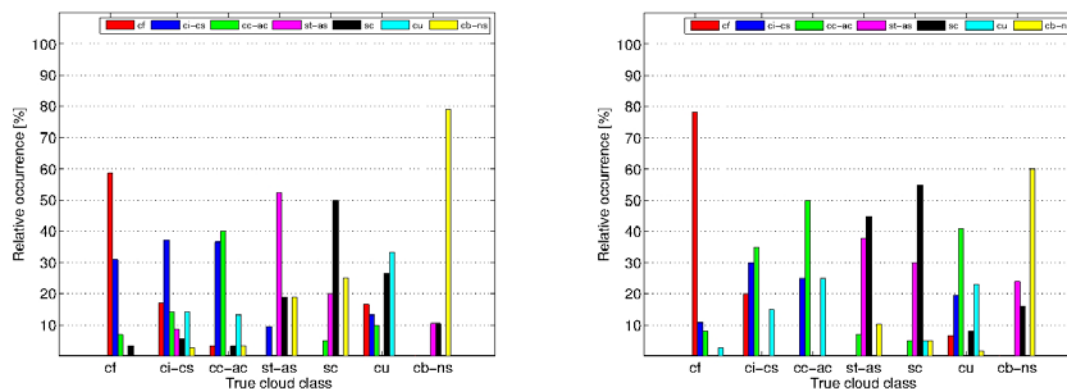


Figure 3: Scores of correct and incorrect classified cloud types for Payerne (left) and Davos (right). The Payerne and Davos test samples contain 184 and 204 pictures, respectively.

For the upcoming year, we plan to refine and to completely automate the cloud type algorithm. This will be the first time in Switzerland that a cloud algorithm will be operational on a routine basis which does not only calculate fractional cloud cover but also classifies the clouds into individual classes.

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Key words:

Hemispherical sky cameras, cloud cover, cloud type classification

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Internet data bases:

[ftp://ftp.pmodwrc.ch/stealth/002\\_payerne/liras/cloudcam/jf/](ftp://ftp.pmodwrc.ch/stealth/002_payerne/liras/cloudcam/jf/)

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Collaborating partners/networks:

MeteoSwiss

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Name of research institute or organization:

**Physikalisch-Meteorologisches Observatorium Davos,  
World Radiation Center**

Title of project:

Remote sensing of aerosol optical depth

Project leader and team:

Dr. Christoph Wehrli, project leader

Dr. Stephan Nyeki

Project description:

Aerosol optical depth (AOD) is derived from solar spectral irradiance measurements at Jungfraujoch since 1998. These measurements are made in the context of the Global Atmosphere Watch (GAW) program of the WMO by PMOD/WORCC in collaboration with MeteoSwiss. Quality controlled results are fed into the World Data Center Aerosols (WDCA) for public access. This project is a continuous monitoring activity.

Key words:

Solar radiation, Aerosol optical depth monitoring, calibration

Internet data bases:

<http://www.pmodwrc.ch/worcc>

<http://ebas.nilu.no/>

Collaborating partners/networks:

MeteoSwiss (MCH)

Global Atmosphere Watch (GAW), AOD network

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Nyeki, S., C. H. Halios, W. Baum, K. Eleftheriadis, H. Flentje, J. Gröbner, L. Vuilleumier, and C. Wehrli, Ground-based aerosol optical depth trends at three high-altitude sites in Switzerland and southern Germany from 1995 to 2010, *J. Geophys. Res.*, **117**, D18202, doi:10.1029/2012JD017493, 2012.

<http://www.agu.org/pubs/crossref/2012/2012JD017493.shtml>

**Conference papers**

Nyeki, S., C. Halios, K. Eleftheriadis, C. Wehrli, and J. Gröbner, Aerosol Optical Depth Trends in Switzerland from 1995 - 2010, American Geophysical Union Conference, San Francisco, USA, December 5-9, 2011.

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Name of research institute or organization:

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**Federal Office of Meteorology and Climatology MeteoSwiss, Payerne**

Title of project:

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Global Atmosphere Watch Radiation Measurements

Project leader and team:

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Dr. Laurent Vuilleumier, project leader

Mr. Gilles Durieux

Project description:

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Long-term monitoring of surface radiation flux at the Jungfraujoch in the framework of the GAW Swiss Alpine Climate Radiation Monitoring program (SACRaM) was conducted in 2012 with a high degree of data availability considering the challenging conditions at Jungfraujoch. In average, the data availability for radiation parameters reached 99%. Such continuous monitoring implies a constant effort to sustain the highest achievable accuracy, stability and continuity in the measurements.

The measurement program includes short-wave (solar spectrum) and long-wave (infrared thermal) broadband measurements as well as UV broadband measurements. Short- and long-wave measurement series are important for climate research, while UV measurements are of interest for both public health and exploring the relationship between the evolution of the ozone layer and radiation. Broadband radiation is measured both as global downward hemispheric irradiance and as direct sun irradiance. In addition, direct spectral irradiance is also measured, which allows the total column of several atmospheric constituents to be determined.

At the end of 2012 a Delta-T SPN1 instrument was installed at Jungfraujoch. This instrument has a special design that allows it to measure global and diffuse radiation and still be a very robust instrument able to resist harsh meteorological conditions. These measurements are less precise than measurements made with pyranometers, but until now it was not possible to implement diffuse short-wave measurements at Jungfraujoch. This new instrument will allow complementing the global and direct short-wave measurements that are already implemented at Jungfraujoch.

In 2012, a re-analysis of aerosol optical data from 2 stations of the SACRaM network (Jungfraujoch and Davos) and from one station in Southern Germany (Hohenpeissenberg) was concluded. This updated and re-homogenized data is for the period 1995–2010. Trend analysis revealed weak or non significant AOD trends ( $\lambda = 500$  nm): Jungfraujoch (JFJ; +0.007 per decade), Davos (DAV; +0.002 per decade) and Hohenpeissenberg (HPB; -0.011 per decade). When correcting for a recently available stratospheric AOD time series, accounting for Pinatubo (1991) and more recent volcanic eruptions, the 1995–2010 AOD trends decreased slightly at DAV and HPB (0.000 per decade and -0.013 per decade, respectively). The JFJ 1995–2005 AOD time series similarly decreased to -0.003 per decade.

SACRaM AOD data from Jungfraujoch were also included in a combined analysis of aerosol optical properties around the high-alpine site Jungfraujoch headed by the Laboratory of Atmospheric Chemistry of the Paul Scherrer Institute.

**Key words:**

Solar irradiance, ultraviolet, visible, infrared, spectral irradiance, precision filter radiometer (PFR), pyranometer, pyrhelimeter, UV biometer, total aerosol optical depth (AOD), integrated water vapor (IWV)

**Internet data bases:**

<http://wrdc-mgo.nrel.gov/> (World Radiation Data Centre – WRDC)  
<http://www.iapmw.unibe.ch/research/projects/STARTWAVE/database/> (IWV STARWAVE data)

**Collaborating partners/networks:**

Radiation data submitted to the World Radiation Data Centre (WRDC, St. Petersburg, Russian Federation) within the framework of the Global Atmosphere Watch.  
Study of solar photometry (aerosol optical depth) and long-wave infrared radiative forcing in collaboration with the "Physikalisch-Meteorologisches Observatorium Davos" (PMOD) World Radiation Center (WRC).

**Scientific publications and public outreach 2012:**

**Refereed journal articles and their internet access**

Nyeki, S., C. H. Halios, W. Baum, K. Eleftheriadis, H. Flentje, J. Gröbner, L. Vuilleumier, and C. Wehrli, Ground-based aerosol optical depth trends at three high-altitude sites in Switzerland and southern Germany from 1995 to 2010, *J. Geophys. Res.*, **117**, doi: 10.1029/2012JD017493, D18202, 2012.  
<http://dx.doi.org/10.1029/2012JD017493>

Zieger, P., E. Kienast-Sjögren, M. Starace, J. von Bismarck, N. Bukowiecki, U. Baltensperger, F.G. Wienhold, T. Peter, T. Ruhtz, M. Collaud Coen, L. Vuilleumier, O. Maier, E. Emili, C. Popp and E. Weingartner, Spatial variation of aerosol optical properties around the high-alpine site Jungfraujoch (3580 m a.s.l.), *Atmos. Chem. Phys.*, **12**, doi:10.5194/acp-12-7231-2012, 7231-7249, 2012.  
<http://dx.doi.org/10.5194/acp-12-7231-2012>

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URL:  
[http://www.meteosuisse.admin.ch/web/en/meteoswiss/international\\_affairs/GAW/GAW\\_CH.html](http://www.meteosuisse.admin.ch/web/en/meteoswiss/international_affairs/GAW/GAW_CH.html)

Name of research institute or organization:

**Bundesamt für Gesundheit, Sektion Umweltradioaktivität, Bern**

Title of project:

Aerosol radioactivity monitoring RADAIR and DIGITEL

Project leader and team:

Dr. Sybille Estier, project leader  
Philipp Steinmann, Pierre Beuret, Matthias Müller

Project description:

**Aerosol Radioactivity Monitoring at the Jungfrauoch:**

An automatic aerosol radioactivity monitor FHT59S (total alpha and total beta activity) is operated at Jungfrauoch research station by the Swiss Federal Office of Public Health. This monitor is part of the Radair Network and has the following particular features:

- Real-time (30 min) detection of any increase of radioactivity in the air at the altitude of 3400 m above sea level.
- A detection limit for artificial beta radioactivity as low as 0.1 Bq/m<sup>3</sup>. Such a high sensitivity is made possible due to the very low Radon daughter concentration at this altitude.

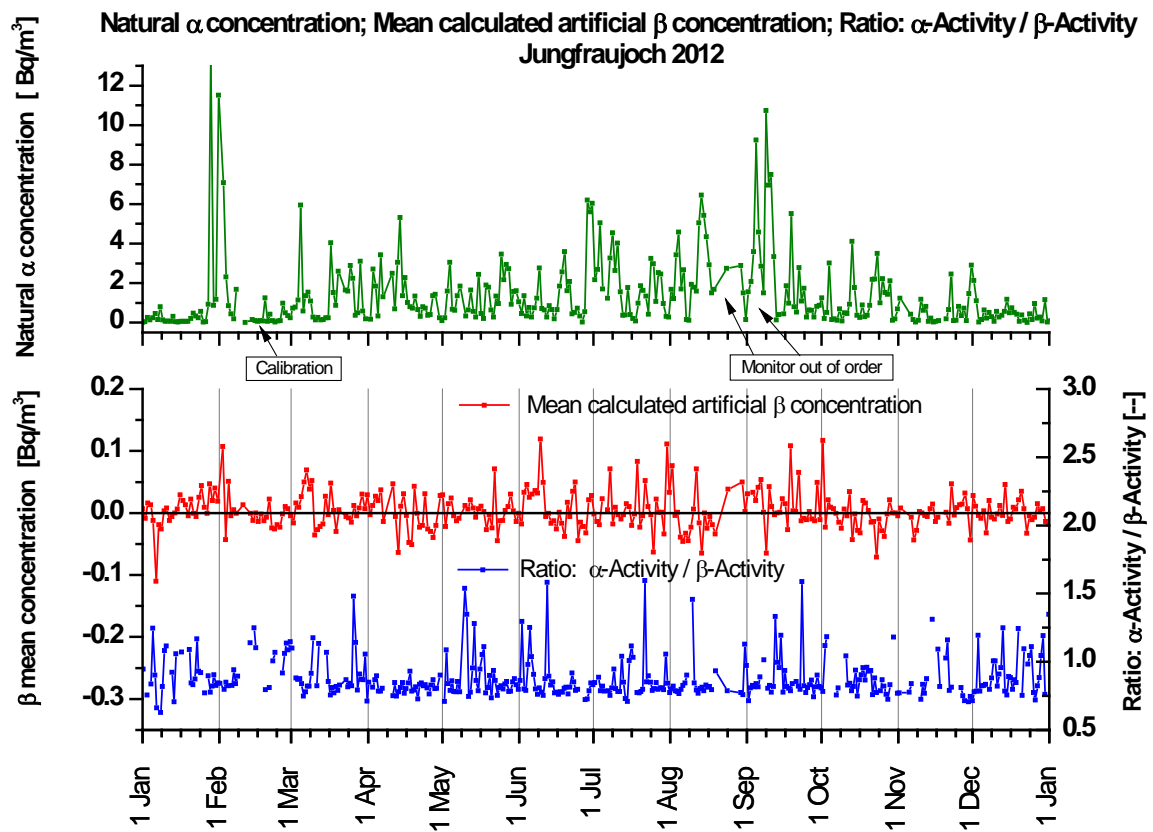
Additional aerosol samples are taken using a Digitel High-Volume-Sampler. These samples are sent to the laboratory in Bern and are analyzed for radioisotopes using HPGe-Gamma-spectrometry.

**Comments on the alpha/beta (Radair) measurements performed in 2012:**

Figure 1 shows the natural alpha radioactivity, the calculated artificial beta radioactivity and the ratio between  $\alpha$  and  $\beta$  activities during the period January 1 to December 31, 2012.

This figure shows that:

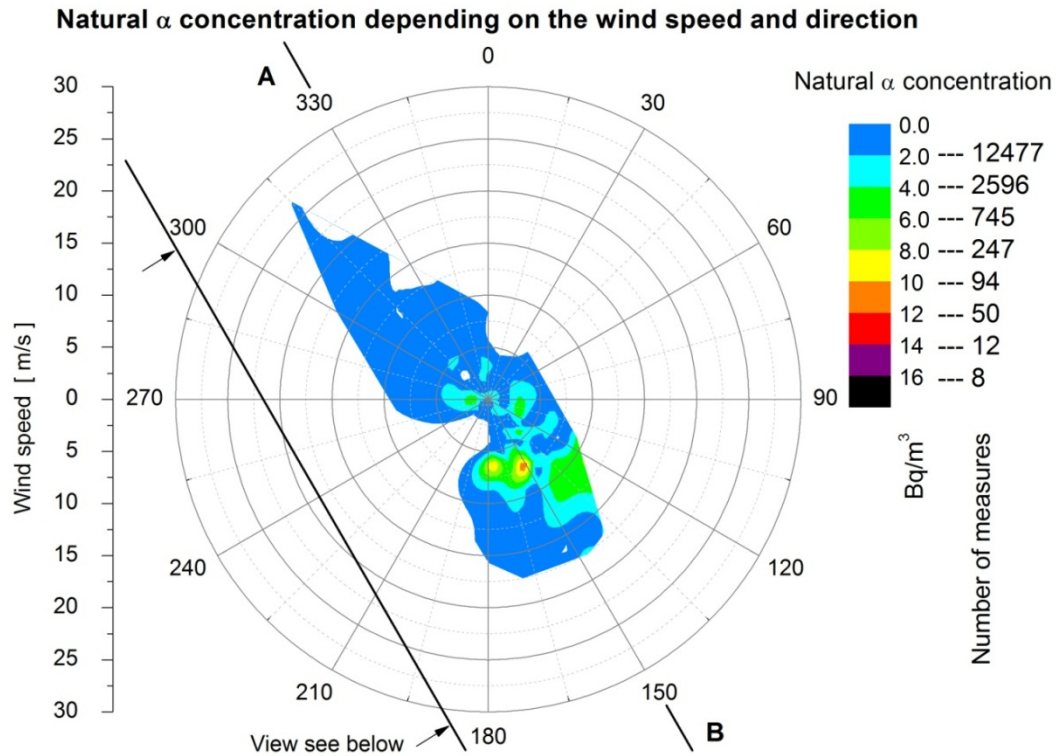
- Alpha radioactivity – i.e. Radon daughter products - is mainly transported up to the Jungfrauoch by air masses from the lowlands, since the highest values are usually observed in summer (from April to September) when thermal air convection is higher than in winter (see upper part of Figure 1).
- The highest  $\alpha/\beta$  activities ratios are observed when the (natural) alpha radioactivity concentrations are the lowest. The  $\alpha/\beta$  activities ratio fluctuates then between -50 and +50. The values lower than 0.55 and greater than 1.5 were removed, since those are not significant.
- At the end of January, the values of alpha concentration, relatively high for the season, are due to the passage of a cold front where the air of the plain, relatively rich in Radon, was transported to the high altitude. This phenomenon was also observed with a same monitor situated at Weissfluhjoch (Davos).



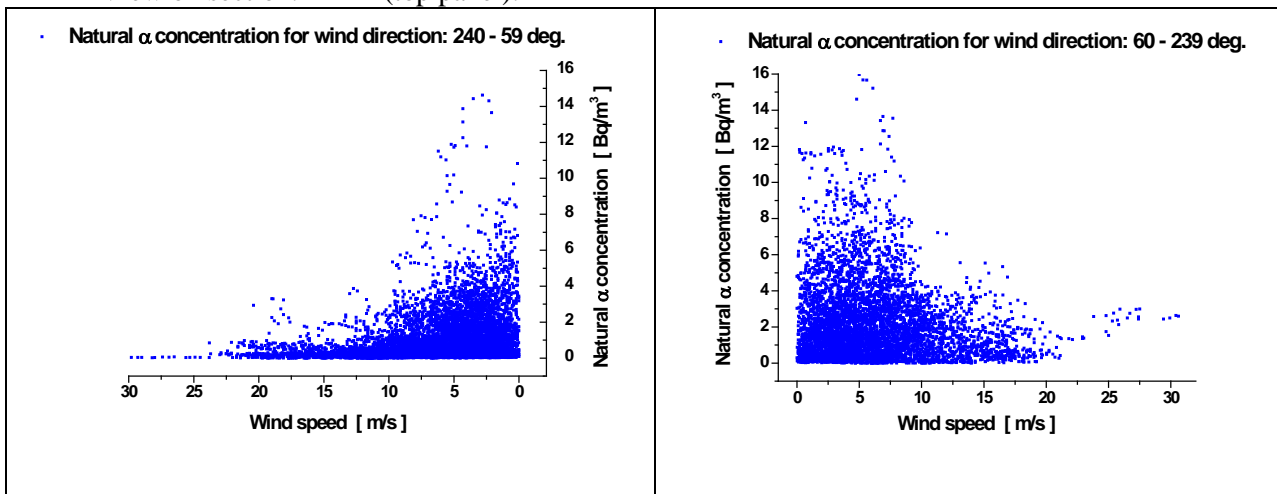
**Figure 1:** Results of Radair measurements in 2012.

Note: For a question of clarity of the graph, not all values are represented.

Figure 2 (top panel) shows the natural alpha concentration as a function of the wind direction and wind speed. We observe that when the main winds blow strongly, the natural radioactivity decreases due to strong mixing of the Radon-rich low altitude air with Radon-poor high altitude air. The highest concentrations are recorded with more gentle South-South-Easterly winds.

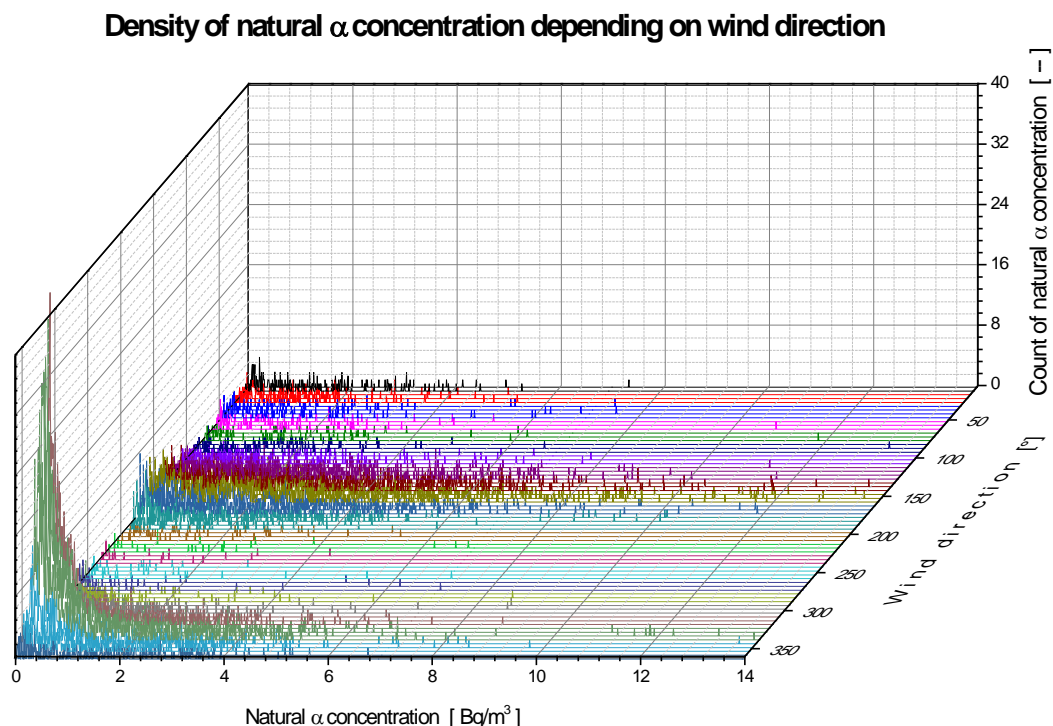


View on section: A – B (top panel):



**Figure 2:** Natural alpha concentrations and prevailing winds.

Figure 3 shows the density of the natural alpha concentration as a function of the wind direction. We observe that the density of natural alpha concentration is more important when the prevailing wind comes from North-North-East. On the other hand, the highest values of concentration meet when the wind comes from South-South-Easterly.

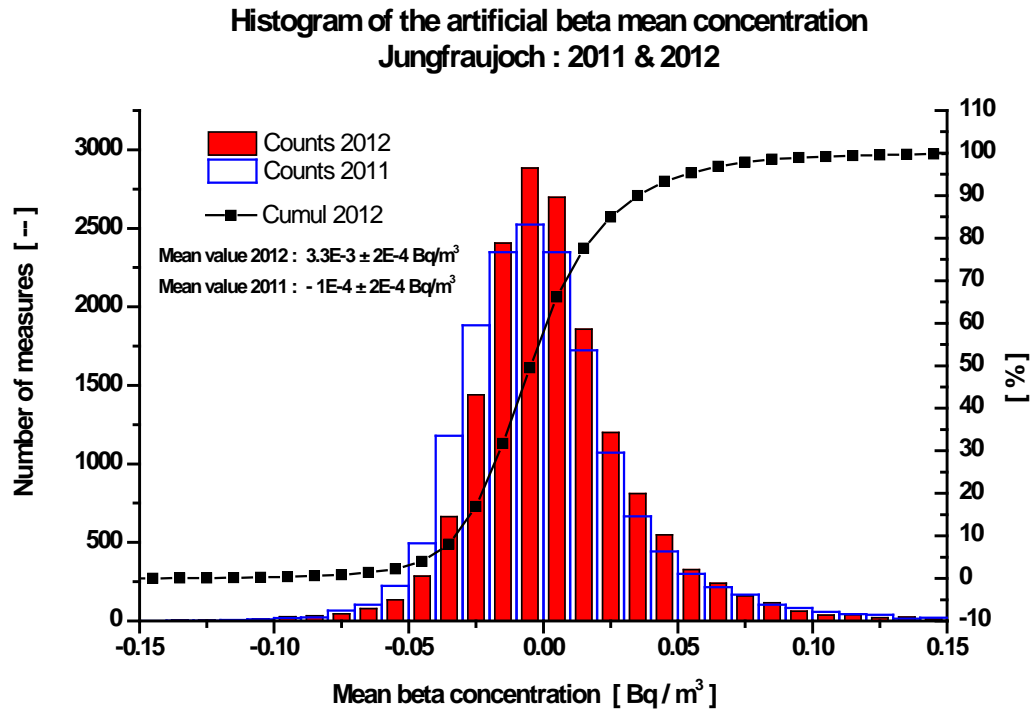


**Figure 3:** Density of natural alpha concentrations and prevailing winds

Figure 4 shows the histogram of the calculated artificial beta radioactivity in aerosol for 2012 (and 2011). The calculation is done automatically by the monitor by applying an  $\alpha/\beta$ -compensation technique (see below for more details).

- No calculated artificial beta concentration above the detection limit (i.e. the background signal) was observed.
- 95 percent of the beta concentrations recorded in 2012 were below  $0.08 \text{ Bq/m}^3$ .
- The histogram recorded for 2012 is rather symmetric; this shows that the automatic compensation technique was good. Note that even if the histogram recorded for 2012 is slightly less symmetric than the one recorded for 2011, the compensation technique can however be generally considered as adequate.
- The values of the histogram 2012 are better centered than those of 2011, thanks to the application of the new mean factor  $\alpha/\beta$  used in the formula of compensation. See below, under “Technical improvement”.
- The tail on the right side has to do with the fact that beta concentrations are more difficult to compensate when the alpha concentrations are a little higher than normal. When the alpha concentration decreases quickly, the compensation technique can’t follow. Some values are therefore greater than  $0.1 \text{ Bq/m}^3$ .





**Figure 4:** Histogram of calculated artificial beta concentrations

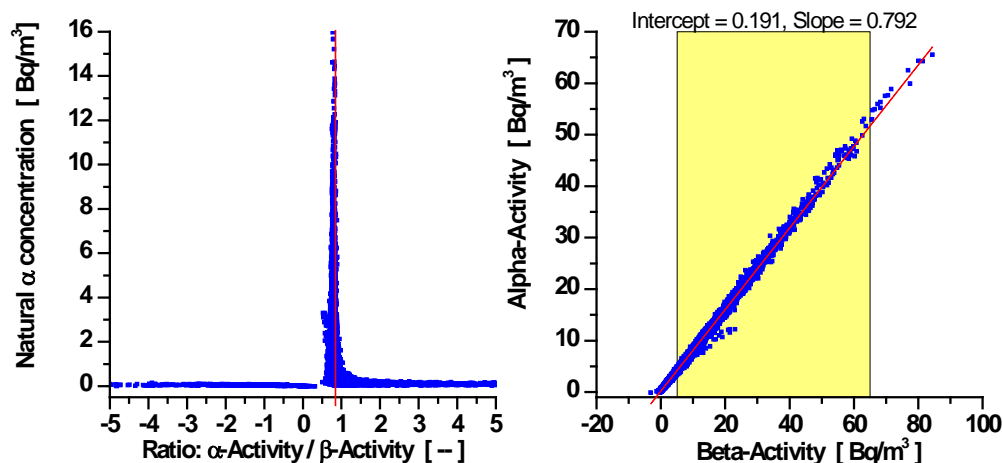
For normal situations, i.e. with no artificial radioactivity in the air, the net Beta radioactivity at the Jungfrauoch, calculated using the Alpha-Beta compensation technique, is less than  $0.15 \text{ Bq/m}^3$ . At the top of Europe, a radiation incident causing an increase of the artificial beta radioactivity in the atmosphere of as low as  $0.15 \text{ Bq/m}^3$  could therefore be detected.

*Automatic  $\alpha/\beta$ -compensation:* this technique applied by our aerosol monitoring stations is based on the simultaneously measurements of gross Alpha ( $A_g$ ) and gross Beta ( $B_g$ ) radioactivity of the aerosols collected on a filter. The net (artificial) Beta radioactivity ( $B_n$ ) is then calculated by the following formula:  $B_n = B_g - (A_g / F)$ . The constant factor  $\alpha/\beta$  ( $F$ ) can be adapted either by the software program or by the operator. The factor  $\alpha/\beta$  ( $F$ ) was periodically adjusted for each monitor in the previous year. This is no longer necessary with the new algorithm, see below.

#### Technical improvement:

Figure 5 shows how the factor  $\alpha/\beta$  ( $F$ ) is determined.

We observe that the ratio: [  $\alpha$ -Activities /  $\beta$ -Activities ] is relatively constant and yields approximately 0.8. On the other hand, we see that the lower the natural  $\alpha$  concentration is, the larger is the dispersal. On the right part of the graph, the ratio ( $A_g/B_g$ ) corresponds to the slope of the curve of the  $\alpha$ -Activities depending on  $\beta$ -Activities.



**Figure 5:** Correlations between:

- The ratio of  $\alpha$ -Activity /  $\beta$ -Activity with the 2012 measurements of natural  $\alpha$  concentration. (left)
- The  $\alpha$ -Activity and  $\beta$ -Activity. (right)

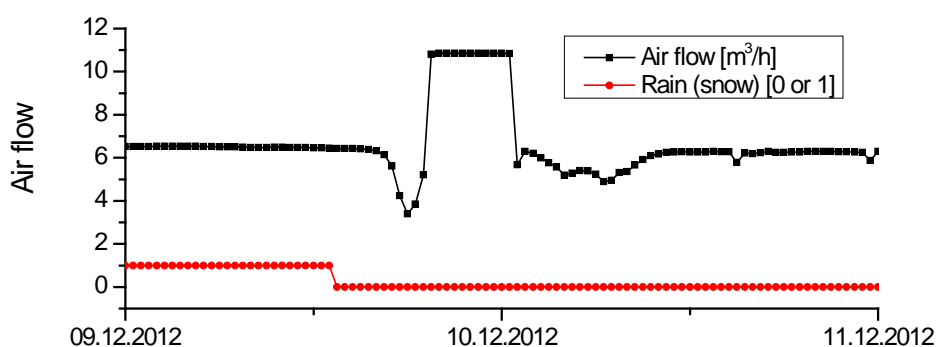
The idea is to have a factor  $F$  which predicts the ratio ( $A_g/B_g$ ) of the current measurements. With the improved version, the monitor calculates the average of  $n$  ( $n > 10$ ) last ratios, as far as this latter is included between threshold values (here 0.6 and 1.2). This mean ratio will give the factor  $F_m$  with which the net (artificial) Beta radioactivity ( $B_n$ ) will be calculated.

This gives a new correction equation:  $B_n = B_g - (A_g / F_m)$

#### Comments on technical aspects (Radair):

In August, the computer of the monitor shut down several times because of the too high temperature of the small room.

In December, the flow decreased strongly after the introduction of snow in the suction line. Subsequently, the monitoring system of the flow opened the bypass until the line was free again (see figure 6).



**Figure 6:**

Except some power cuts and a problem of automatic restart of the computer after a power outage, there was no major breakdown of the aerosol monitor in 2012.

### **Digitel High-Volume-Sampler: Introduction**

The Digitel DHA-80 High Volume Sampler (HVS) is an automatic air sampler with a typical air flow rate  $0.6 \text{ m}^3/\text{min}$ . Aerosols are collected on glass fibre filters of 150 mm in diameter. The pump maintains a constant flow rate independent of dust load on the filter. Filter change intervals are programmed in advance and the sampler is controlled remotely by an internet connection.

The filters are automatically changed once a week and are measured at the end of the month in the laboratory using a coaxial high purity germanium gamma-ray detector during 1-2 days. Thereafter activities of radioactive isotopes are calculated by considering corresponding half-life's and time between sampling and measuring.

$^7\text{Be}$  and  $^{210}\text{Pb}$  are naturally occurring nuclides.  $^7\text{Be}$  has a cosmogenic origin. Around 70% of  $^7\text{Be}$  is produced in the stratosphere by spallation of carbon, nitrogen and oxygen.  $^{210}\text{Pb}$  is a long-lived decay product of uranium series ( $^{238}\text{U}$ ) which gets into the air from radioactive noble gas  $^{222}\text{Rn}$  exhaled from the Earth's Crust [Sykora et al. 2009-2010].

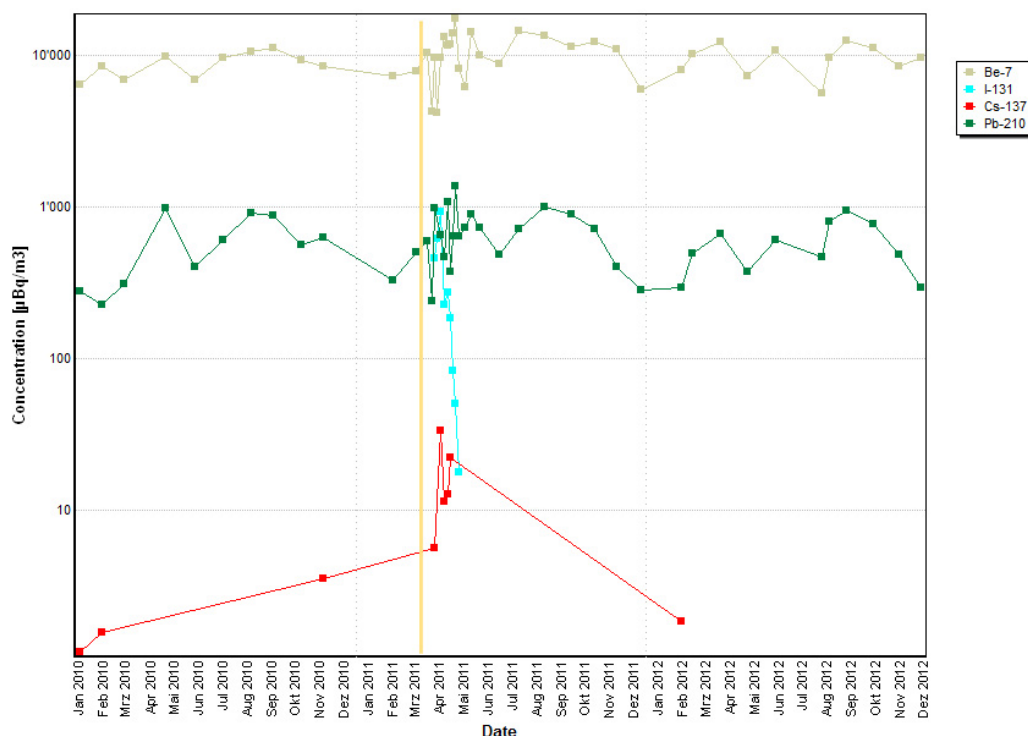
### **Results**

Fig. 7 shows the concentration ( $\mu\text{Bq}/\text{m}^3$ ) of  $^7\text{Be}$ ,  $^{210}\text{Pb}$ ,  $^{131}\text{I}$  and  $^{137}\text{Cs}$  between 2010 and 2012.

Concentrations of  $^7\text{Be}$  and  $^{210}\text{Pb}$  remained quasi constant. A slight increase of  $^{210}\text{Pb}$  during summer can be observed, which is due to convection of  $^{210}\text{Pb}$ -rich air masses.  $^7\text{Be}$  concentration seems to be slightly increased during summer too. This can be related to the tropopause thinning at mid-latitudes resulting in air exchange between stratosphere and troposphere [Sykora et al. 2009-2010].

As a consequence of the nuclear accident of Fukushima in March 2011, filters were measured directly after changing (once a week) in order to detect radioactive isotopes released by the nuclear power plant more quickly. Therefore time between sampling and measuring was significantly smaller than before.

The increased concentration of  $^{131}\text{I}$  and  $^{137}\text{Cs}$  can be clearly related to the nuclear accident of Fukushima. First increased concentrations were measured by the end of March 2011 and achieved a maximum at the beginning of April.  $^{131}\text{I}$  could never be detected at Jungfraujoch before the nuclear accident and haven't been since the end of April 2011.  $^{137}\text{Cs}$  is rarely detected before and after March/April 2011.



**Fig.7:** Concentration ( $\mu\text{Bq}/\text{m}^3$ ) of  $^7\text{Be}$ ,  $^{210}\text{Pb}$ ,  $^{131}\text{I}$  and  $^{137}\text{Cs}$  between 2010 and 2012, Station Jungfrauoch. The yellow line indicates the date of nuclear accident at the Fukushima Daiichi plant (March 11<sup>th</sup> 2011).

Key words:

RADAIR, Digitel, Radon, radioactivity, aerosols, radioisotope

Internet data bases:

<http://www.radair.ch>

<http://www.bag.admin.ch/themen/strahlung/00043/00065/02239/index.html?lang=de>

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Name of research institute or organization:

**Eawag**

Title of project:

$^7\text{Be}$  and  $^{10}\text{Be}$  in monthly precipitation

Project leader and team:

Prof. Jürg Beer, project leader  
Silvia Bollhalder

Project description:

$^7\text{Be}$  ( $T_{1/2}$ : 53.2 days) and  $^{10}\text{Be}$  ( $T_{1/2}$ : 1.4 million years) are continuously produced by the interaction of cosmic rays with the atmosphere. They represent a kind of natural neutron monitor. Instead of counting the neutrons, the Be-atoms are counted. Since these atoms are stored in natural archives such as ice sheets and sediments,  $^{10}\text{Be}$  offers the unique opportunity to trace back the past cosmic ray intensity for many millennia. An important aspect in the interpretation of the archived  $^{10}\text{Be}$  signal is the “noise” introduced by the transport of Be from the atmosphere where it is produced to the site where it is archived. Simultaneous monitoring of  $^{10}\text{Be}$  and  $^7\text{Be}$  at two stations (Jungfraujoch and Dübendorf) provides the means to better understand the transport and deposition processes. A new topic of interest which was brought up during an ISSI team meeting is the question to what extent cosmogenic radionuclides can be used to trace back in time very large solar flares or strong gamma ray bursts. A monthly monitoring program as carried out at Jungfraujoch has the potential to answer this question.

Key words:

$^{10}\text{Be}$ ,  $^7\text{Be}$ , long-term cosmic ray record, atmospheric transport processes, solar energetic particles, gamma ray bursts

Collaborating partners/networks:

K. G. McCracken, Australia

Scientific publications and public outreach 2012:

**Books**

Beer, J., McCracken, K.G., von Steiger, R., *Cosmogenic Radionuclides: Theory and Applications in the Terrestrial and Space Environments*, Springer-Verlag, 2012.

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Name of research institute or organization:

**Physikalisches Institut, Universität Bern**

Title of project:

Neutron monitors - Study of solar and galactic cosmic rays

Project leader and team:

Dr. Rolf Bütikofer

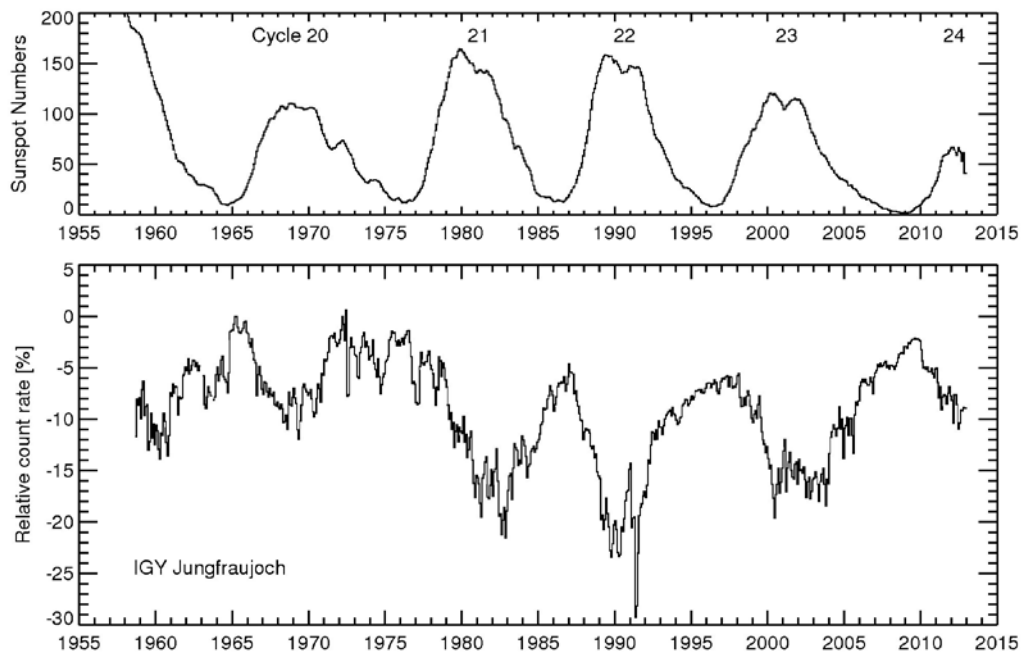
Project description:

The Physikalisches Institut at the University of Bern, Switzerland, operates two standardized neutron monitors (NM) at Jungfraujoch: an 18-IGY NM (since 1958) and a 3-NM64 NM (since 1986). NMs provide key information about the interactions of galactic cosmic radiation (GCR) with the plasma and the magnetic fields in the heliosphere and about the production of energetic CRs at or near the Sun (solar cosmic rays, SCR), as well as about geomagnetic, atmospheric, and environmental effects. They ideally complement space observations. The NMs at Jungfraujoch are part of a worldwide network of standardized CR detectors. By using the Earth's magnetic field as a giant spectrometer, this network determines the energy dependence of primary CR intensity variations in the GeV range. Furthermore, the high altitude of Jungfraujoch provides good response to solar protons  $\geq 3.6$  GeV and to solar neutrons with energies as low as  $\sim 250$  MeV. Neutron monitors play increasingly an important role in the space weather domain.

In 2012, operation of the two NMs at Jungfraujoch was pursued without major problems. No significant technical modifications were necessary. The recordings of the NM measurements are published in near-real time in the neutron monitor database NMDB ([www.nmdb.eu](http://www.nmdb.eu)). Figure 1 shows the measurements of the IGY neutron monitor at Jungfraujoch (lower panel) since it was put into operation in 1958. This unique dataset reflects the variations of the CR intensity in the near Earth space over four full solar sunspot cycles. The GCR are always present, and their intensity shows an 11-year variation in anti-correlation with the solar activity characterized by the smoothed sunspot number plotted in the upper panel of Figure 1. SCR events having an effect at Earth, so-called Ground Level Enhancements (GLE), are rare, they occur sporadically, and are generally of a duration of up to a few hours.

On 17 May 2012, 01:25 UT, the active region NOAA 11476 produced a moderate (GOES class M5.1) flare. The active region was located at N07 W88 at the Sun, i.e. at or close to the foot points of the interplanetary magnetic field lines that connect the Sun with the Earth. As the solar cosmic ray protons propagate along the interplanetary magnetic field lines, the SCR protons during the event on 17 May 2012 reached the near Earth space. As the solar protons had energies larger than the atmospheric cutoff energy for sea level NMs ( $\sim 2$  GeV), some high latitude NMs of the worldwide network detected an enhancement in the counting rate at around 02 UT. The last GLE was observed on 13 December 2006. Figure 2 shows the time profile of the data from selected neutron monitor stations provided by the NMDB network. The maximum increase of the 1-minute data of the NM stations Apatity and Oulu was about 17 % and  $\sim 5$  % at Kiel NM station. The NM stations at mid-latitudes, as e.g. Jungfraujoch and Rome, did not show an increase in the counting rate. The different signatures of the records of the neutron monitors of the worldwide network give information on the energy spectrum of the solar protons and on the anisotropy of the solar particle flux. The fact that the NM stations Jungfraujoch and Rome did not see the event gives information on the maximum energies of the solar protons during this GLE. The combination of the data of all NM stations of the network and of satellite measurements in space is needed to understand the characteristics of the energetic particles and to understand the acceleration processes at or near the Sun. In addition, the characteristics of the SCR particle flux near Earth deduced from NM measurements play an important role in the radiation dose rates at flight altitudes. The

dose rate can increase by orders of magnitude for a short time during energetic SCR events at high latitudes. Therefore, the working group WG11 “High energy radiation fields” of EURADOS (association for promoting research and development and European cooperation in the field of the dosimetry of ionising radiation) investigates the radiation dose rates at flight altitudes during GLEs in detail. Prof. Erwin Flückiger and Rolf Bütikofer are members of this EURADOS working group. During the GLE on 17 May 2012 the additional contribution of SCR to the radiation dose caused by cosmic rays at flight altitudes is negligible.



*Figure 1: Smoothed sunspot numbers (top panel), pressure corrected monthly average counting rates of IGY neutron monitor at Jungfraujoch (bottom panel) for the years 1958-2012. The neutron monitor count rate is expressed in relative units with respect to May 1965.*

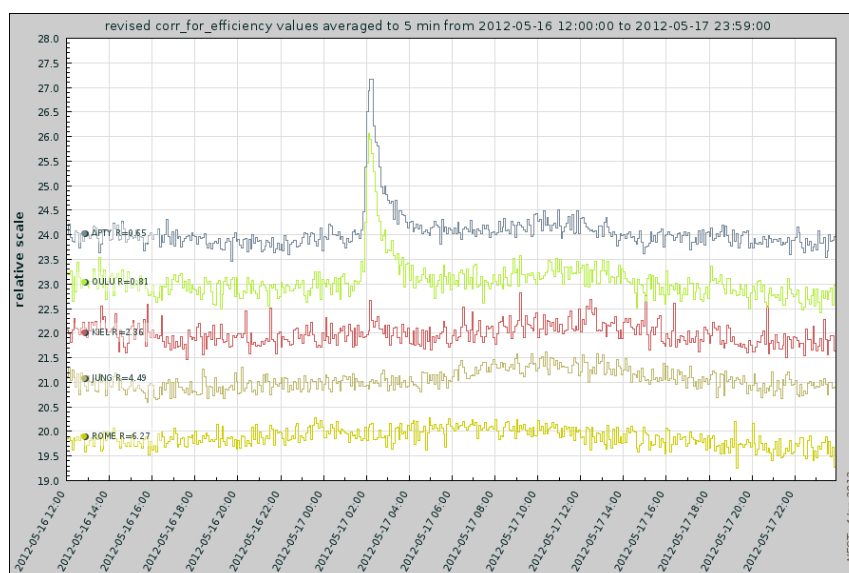


Figure 2: Relative pressure corrected 5-minute values of the European neutron monitor stations Apatity, Oulu, Kiel, Jungfraujoch, and Rome during the solar cosmic ray event on 17 May 2012 for the time interval 2012-05-16, 1200 UT until 2012-05-17, 2400 UT. Plotted with NEST ([www.nmdb.eu](http://www.nmdb.eu)).

#### Key words:

Astrophysics, cosmic rays, neutron monitors; solar, heliospheric and magnetospheric phenomena

#### Internet data bases:

<http://cosray.unibe.ch>

#### Collaborating partners/networks:

International Council of the Scientific Union's (ICSU) Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)

World Data Centers A (Boulder), B (Moscow), C (Japan), International GLE database

European FP7 Project Real-Time Database for High Resolution Neutron Monitor Measurements (NMDB): <http://www.nmbd.eu>

#### Scientific publications and public outreach 2012:

##### Conference papers

Bütikofer, R. and Flückiger, E.O., Differences in published characteristics of GLE60 and their consequences on computed radiation dose rates along selected flight paths, 23rd European Cosmic Ray Symposium, Moscow, Russia, Conference Proceedings, 2012.

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URL: <http://cosray.unibe.ch>



Name of research institute or organization:

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**Department of Physics, University of Rome La Sapienza**

Title of project:

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Test for a new concept of EAS detectors for UHE neutrinos

Project leader and team:

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Prof. Maurizio Iori, project leader

Prof. Jim Russ, Prof. Haluk Denizli, Ali Yilmaz, Prof. Mithat Kaya

Project description:

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The detector installed at the Sphinx is a prototype of an element of large array (TAUWER) designed to measure large extensive showers with energy greater than  $10^{17}$  eV produced by the tau-neutrinos that interact with the Earth crust. The tau particle from interaction decays in a shower produced mainly at large zenith angles (about 90 degrees). Each detector station, shown in Fig. 1, consists of two pairs of scintillator counters (20 x 20 cm<sup>2</sup>, 1.4 cm thick) named 'towers' separated by 60 cm. The distance of one pair is 160 cm corresponding to 5.3 ns of time of flight (TOF) of a horizontal track crossing the two scintillating tiles. The scintillating light produced by the cosmic rays passing through the counter, is detected by a Photomultiplier (PMT). To be able to select the track direction with more efficiency we need to select only events where longitudinal or diagonal tracks are selected by OR-AND logic. In our experiment we only need to collect the longitudinal or diagonal tracks because we have to reconstruct tau horizontal showers. In order to enhance the coincident triggering rate of these longitudinal or diagonal tracks, we developed an electronics board, trigger board (TB). This board provides:

- low-level, ultra-fast differential low threshold discriminator channels to select signals above noise
- coincident trigger under the desired conditions
- low-power consumption.

In 2012, we have done extensive tests with a 4-channel preamplifier-shaper-discriminator board (TB). These test results of the trigger board were presented in Turkish Physical Society 29<sup>th</sup> International Physics Congress [4].

In November 2012, we changed the read-out system of the station by installing a new generation of solid state photodetector, SiPM, that provides high time resolution (300 ps) and has high detection efficiency (few photoelectrons detection). These performances give us the possibility to reduce the thickness of the scintillating tile and to improve the measurement of TOF. The current produced into the depletion junction of SiPM depends on the temperature, hence we have to monitor by a sensor the temperature inside the counter and change the bias Voltage. In November we installed the SiPMs with an amplifier in one tower and started the data taking with and without trigger board. A device to adjust the bias voltage according to the variation of temperature is ready to be installed.

Key words:

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Cosmic rays, neutrino, silicon photomultiplier, time of flight

Internet data bases:

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<http://pciori13.roma1.infn.it/>



*Figure 1: Detector located at the Sphinx. The four black boxes contain the tiles, SiPM and amplifier. They are 60 cm apart and 160 cm along the path of flight of horizontal tracks.*

Scientific publications and public outreach 2012:

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**Refereed journal articles and their internet access**

[1] Yilmaz, A., H. Denizli and M. Iori, Preliminary Test Results of a Prototype at Sphinx Observatory Center, BPL, 19, 191050, 438-444, 2011.

**Conference papers**

[2] Yilmaz A., H. Denizli and M. Iori, Preliminary Test Results of a Prototype Detector at Sphinx Observatory Center, Turkish Physical Society, 27th International Physics Congress, Istanbul, Turkey, September 14-17, 2010.

[3] Yilmaz A. et al, Turkish Physical Society, 28th International Physics Congress, Bodrum, Turkey, September 6-9, 2011.

[4] Yilmaz A., A. Aydemir, H. Denizli and M. Iori, Test Results of Low-Level Discriminator Board for TAUWER Experiment, Turkish Physical Society, 29th International Physics Congress, Bodrum, Turkey, September 5-8, 2012.

[5] Iori M. et al., Test of a new concept of EAS detector for UHE neutrinos, European Cosmic Ray Conference, Moscow, Russia, July, 2012. To be published in JPCS.

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Name of research institute or organization:

**Bundesamt für Strahlenschutz, Freiburg i.Br.  
Climate and Environmental Physics, University of Bern**

Title of project:

<sup>85</sup>Kr Activity Determination in Tropospheric Air

Project leader and team

Clemens Schlosser Martina Konrad, and Sabine Schmid, *Bundesamt für Strahlenschutz, D-79098 Freiburg, Germany*

Roland Purtschert, *Climate and Environmental Physics, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern*

Project description:

Monitoring of tropospheric Kr-85 activity concentrations at Jungfraujoch (JFJ) continued in 2012. Krypton is separated from about 10 m<sup>3</sup> of air continuously collected during one week and sent to the Bundesamt für Strahlenschutz in Freiburg i.Br. for measuring the Kr-85 activity concentration.

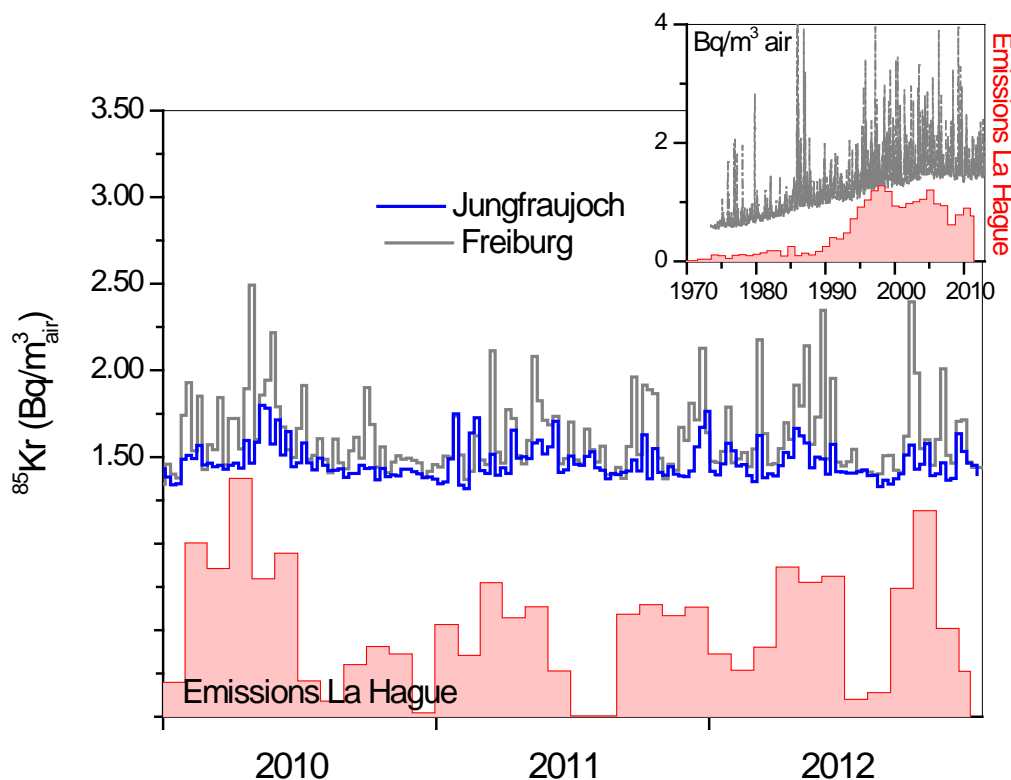


Figure 1: Measured atmospheric <sup>85</sup>Kr activity concentrations in weekly air samples, collected at Jungfraujoch (3500 m asl) and Freiburg i.Br. (280 m asl), during the last three years. Inset: Values for Freiburg i.Br. over the last 40 years. The red columns represent the monthly emissions from La Hague in arbitrary units (the order of magnitude is 10<sup>16</sup> Bq Kr-85 per month).

The major sources of atmospheric Kr-85 are nuclear reprocessing plants which are characterized by pulsed releases. The resulting plumes can be detected at sampling stations located in downwind direction even at distances of a few hundred kilometres (spikes in

Figure 1). The frequency and amplitude of spikes measured at the observation stations Freiburg and JFJ correlate therefore with the monthly emissions of the closest reprocessing facility in La Hague (Figures 1+2). However, above the planetary boundary layer, as the case for the JFJ station, amplitude and frequency of such spikes are reduced and the correlation with La Hague is weaker ( $R^2=0.20$ ) compared to stations at lower altitude (Freiburg  $R^2=0.47$ ; Figure 2). Due to a half life of 10.76 years Kr-85 accumulates in the atmosphere. Since the start of massive reprocessing it had created a baseline which was characterized by a continuous mean increase rate of about  $0.03 \text{ Bq/m}^3$  per year during the past four decades. It has reached a maximal value of about  $1.50 \text{ mBq/m}^3$  at the stations located at mid northern latitudes (Figure 1, inset). Over the last 5 years almost steady state emission-decay equilibrium was established. The slopes of the averaged baseline activities in Freiburg and at JFJ are zero within statistical uncertainties. This implies that the world wide reprocessing activities do not increase any longer as reflected in the release data of La Hague (Figure 1, red areas).

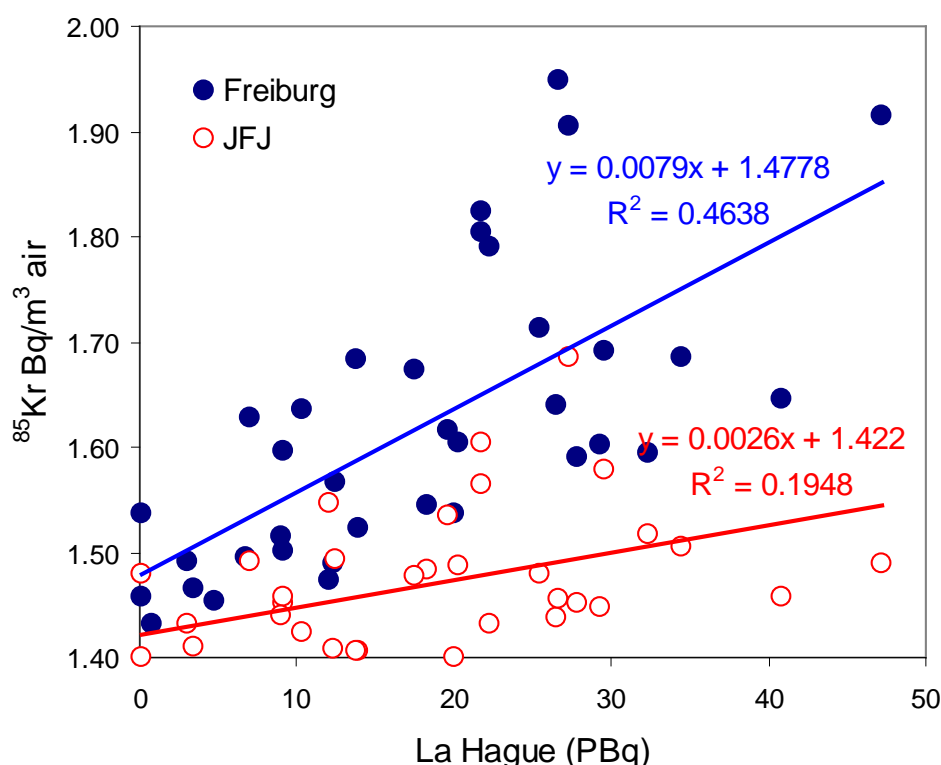


Figure 2: Relation between monthly averaged emissions at the reprocessing facility in La Hague (France) and the activity concentrations measured in Freiburg and at JFJ. A reduced (factor  $\sim 2$ ) slope and correlation factor is observed at JFJ due to the high altitude location above the planetary boundary layer.

The location of the JFJ sampling site is crucial because of its altitude. The data are representative for the northern tropospheric background level and are important for the assessment and quantification of environmental radioactivity and radiation exposure in Switzerland.

Key words:

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Krypton, <sup>85</sup>Kr, radioactivity in air, reprocessing plants

Collaborating partners/networks:

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Climate and Environmental Physics, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern

Scientific publications and public outreach 2012:

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**Data books and reports**

[1] Umweltradioaktivität und Strahlendosen in der Schweiz, Bundesamt für Gesundheit, Abteilung Strahlenschutz, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012 (in preparation).

[2] Umweltradioaktivität und Strahlenbelastung, Deutschland, Jahresberichte 2007, 2008, 2009, 2010, 2011, 2012 (in preparation); Reihe Umweltpolitik; Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit.

[3] Aktueller Bericht der Leitstellen: Umweltradioaktivität in der Bundesrepublik Deutschland Stand 2011, ISSN 1864-2810, März 2012.

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Name of research institute or organization:

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**Physik Institut, Universität Zürich**

Title of project:

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Cosmogenic Activation of ultra-pure Xenon

Project leader and team:

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Dr. Marc Schumann, Prof. Laura Baudis, Dr. Alfredo Ferella, Dr. Alexander Kish,  
Francesco Piastra

Project description:

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Ultra-pure xenon is a widely used target material in experiments which aim to directly detect particle dark matter in low background experiments. Potential cosmogenic activation of the target material during transport etc. is yet unknown, but might be a relevant source of background. With this experiment at the research station Jungfraujoch we aim to quantify cosmogenic activation after exposing a xenon sample to cosmic rays at the high altitude of the Jungfraujoch.

The intrinsic radioactive background of ultra-pure xenon gas (~2 kg), which had been stored underground in the Gran Sasso Underground Laboratory (LNGS, Italy) for more than one year, was measured with a high-purity Germanium detector. This facility is also installed underground at LNGS and is owned and operated by the UZH group. After the measurement, the xenon sample was brought up to the Jungfraujoch at the end of October 2012, where it is now continuously exposed to the increased cosmic ray flux.

We plan to activate the sample until spring 2013. Then it will be brought back to LNGS, transferred into a low-radioactivity steel bottle that was not exposed to cosmic rays, and measured again for radioactive impurities. The comparison of the two measurements, before and after activation, together with the neutron flux data from the research station Jungfraujoch, will allow us to quantify the potential activation of xenon due to the cosmic-ray induced reactions.

Key words:

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Cosmogenic activation, low background physics

Collaborating partners/networks:

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The results will be used for background predictions of the XENON dark matter experiment.

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Name of research institute or organization:

**Institut für Umweltphysik, Universität Heidelberg**

Title of project:

Long-term observations of  $^{14}\text{CO}_2$  at Jungfraujoch

Project leader and team:

Ingeborg Levin, project leader

Samuel Hammer, Bernd Kromer, Dietmar Wagenbach

Project description:

Atmospheric  $^{14}\text{CO}_2$  observations at Jungfraujoch are used as clean air background for other observational sites in Central Europe to estimate the regional fossil fuel  $\text{CO}_2$  component; they are also applied as reference for carbon cycle studies or bomb radiocarbon dating of young organic material. Our measurements have started in 1986 and are continued without interruption until today. The available data from the last decade have been submitted for publication, together with those from the Schauinsland station in the Black Forest (Levin et al., 2012). Figure 1 shows the comparison of these two  $\Delta^{14}\text{C}$  records. It is obvious that generally the Jungfraujoch data are slightly higher than those from the Schauinsland site in the Black Forest, particularly in winter. This clearly demonstrates that Schauinsland, compared to Jungfraujoch, is slightly more influenced by regional and large scale European fossil fuel  $\text{CO}_2$  emissions.

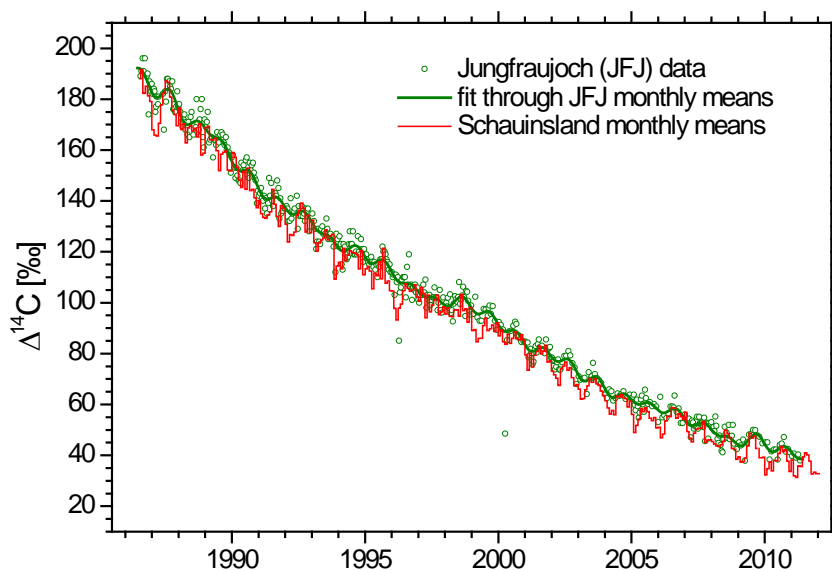


Figure 1: Comparison of  $^{14}\text{CO}_2$  measurements at Jungfraujoch (green open circles) with monthly mean values from Schauinsland station in the Black Forest (red line). The green line is a harmonic fit curve calculated through the Jungfraujoch data

Our quasi-continuous  $^{14}\text{CO}_2$  observations at Jungfraujoch will be continued in the framework of the European ICOS (Integrated Carbon Observation System) Atmospheric Station network, and continue to serve as reference for estimates of the fossil fuel  $\text{CO}_2$  component over Europe.

Key words:

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Carbon dioxide, carbon cycle modelling, radiocarbon, fossil fuel CO<sub>2</sub>, climate, Kyoto Protocol

Internet data bases:

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<http://www.iup.uni-heidelberg.de/institut/forschung/groups/kk/>  
<http://www.iup.uni-heidelberg.de/institut/forschung/groups/fa/radiokohlenstoff/radiometrie-web-html>

Collaborating partners/networks:

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ICOS (<http://www.icos-infrastructure.eu>)

Scientific publications and public outreach 2012:

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**Refereed journal article:**

Levin, I., B. Kromer and S. Hammer, Atmospheric  $\Delta^{14}\text{CO}_2$  trend in Western European background air from 2000 to 2012, submitted to Tellus B., 2012.

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URL: <http://www.iup.uni-heidelberg.de/institut/forschung/groups/kk/>



Name of research institute or organization:

**Empa, Swiss Federal Laboratories for Materials Science and Technology**

Title of project:

National Air Pollution Monitoring Network (NABEL)

Project leader and team:

Dr. Martin Steinbacher, Dr. Christoph Hüglin (project leader)

Project description:

The National Air Pollution Monitoring Network (NABEL) is run by Empa together with the Swiss Federal Office for the Environment (BAFU/FOEN). The NABEL network was established in 1978 with initially 8 sites emerging from activities that started already in 1968 as contributions to international WMO and OECD observation networks. In-situ measurements by Empa at Jungfraujoch began in 1973. Early activities mainly focused on sulphur dioxide and particulate matter. In 1990/1991 the NABEL network was extended to 16 monitoring stations that are distributed all over Switzerland. These monitoring stations represent the most important air pollution levels from kerbside to remote free tropospheric background. The NABEL site at Jungfraujoch is a very low polluted site, representing a background station for the lower free troposphere in central Europe.

The current measurement program at Jungfraujoch includes continuous *in-situ* analyses of ozone (O<sub>3</sub>), carbon monoxide (CO), nitrogen monoxide (NO), nitrogen dioxide (NO<sub>2</sub>), the sum of nitrogen oxides (NO<sub>y</sub>), sulphur dioxide (SO<sub>2</sub>), methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>). These data are stored as 10-min averages. Furthermore, the concentrations of CH<sub>4</sub> are also measured in 24 min intervals along with nitrous oxide (N<sub>2</sub>O) and sulphur hexafluoride (SF<sub>6</sub>). Molecular hydrogen (H<sub>2</sub>) is also semi-continuously monitored in 30-min intervals. An extended set of halocarbons and a selection of volatile organic compounds (VOCs) (alkanes, aromatics) are measured with a time resolution of two hours. The concentrations of particulate matter < 10 µm (PM10) are determined both continuously and in 24-hour integrated samples. Daily samples are taken to quantify particulate sulphur.

The long-term evolution of tropospheric ozone mole fractions at Jungfraujoch (see Figure 1) and other elevated measurement stations is of vivid scientific interest as ozone is an efficient greenhouse gas and plays a crucial role in tropospheric chemistry. Being a so-called secondary air pollutant produced in the atmosphere from precursors such as VOCs and nitrogen oxides under the presence of sunlight, its variations over time mainly reflect the response to the pronounced changes in the ozone precursors during the past decades. Various international efforts were recently made to analyze the long-term changes of ozone over the Alpine region [Gilge *et al.*, 2010], over Europe [Logan *et al.*, 2012], and over the Northern Hemisphere [Parrish *et al.*, 2012].

Gilge *et al.* [2010] focused on the measurement stations of the DACH-cooperation (Germany: D, Austria: A, Switzerland: CH), namely Zugspitze, Hohenpeissenberg, Sonnblick and Jungfraujoch. Data from 1995 till 2007 were considered in this publication to have a consistent dataset for all stations. Linear trend analyses were performed for a variety of percentile classes. Jungfraujoch (the most elevated of the stations) reveals consistent but insignificant negative trends for all percentiles while the lower percentiles at the other less elevated stations slightly increase and the upper percentiles come down. The different patterns can be explained by the more dominant influence of ozone loss due to NO titration at lower altitudes. This loss process mainly plays a role in polluted environments in the atmospheric boundary layer (ABL) while air masses from the ABL only occasionally reach the Jungfraujoch. Reduced NO emissions in the ABL make the loss process less prevalent and thus favour positive ozone trends. The specific analysis by Gilge *et al.* [2010] for

Jungfraujoch also pointed out that the 1986-1994 trend at Jungfraujoch was (insignificantly) negative due to the observation of high mole fractions in the early years of the time series.

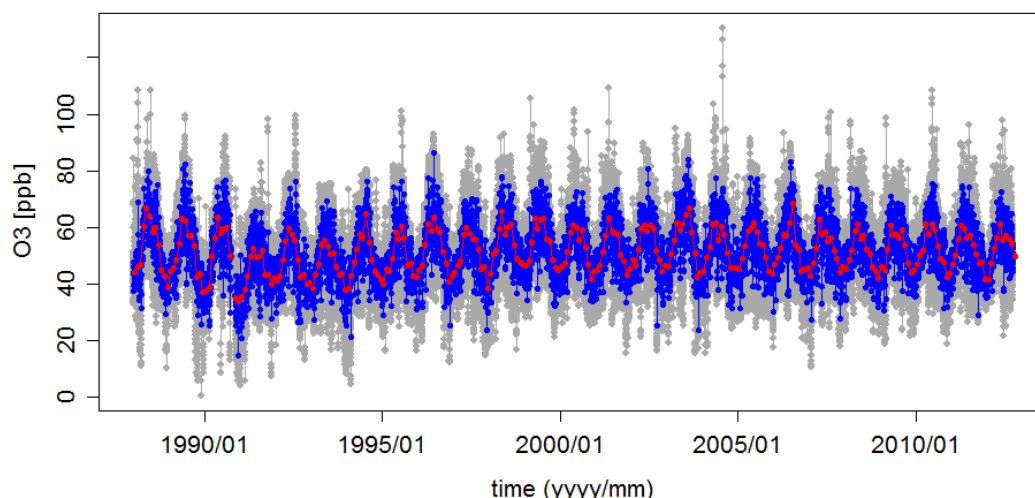


Figure 1. Time series of hourly (grey), daily (blue) and monthly (red) averages of continuously measured in-situ ozone at Jungfraujoch from 1988 to 2012.

Logan et al. [2012] carefully analysed ozone time series in the free troposphere from various networks (ozone sondes, aircrafts, and Alpine surface sites) back to the 1970ies. Intercomparison of the various datasets revealed very coherent features above Europe since about 1998, providing good confidence in the data quality of the various measurements. Prior to 1998, differences between the time series were more pronounced due to less precise measurement equipment and less sophisticated quality control procedures. Within NABEL, a complete traceability chain for ozone was established in 1993 when purchasing a standard reference photometer while the measurements before relied on comparison with transfer instruments that were calibrated by the manufacturer. Overall, Logan et al. [2012] state that the trends in ozone precursor emissions and of ozone in the lowermost stratosphere (from where ozone can be transported into the free troposphere) cannot fully explain the observed ozone evolution. More dedicated modeling efforts might be needed to get better insight in the underlying processes.

A similar point is made by Parrish et al. [2012] who also aim at providing robust ozone datasets for comparison with model outputs. They studied time series from six European low polluted and elevated measurement sites along with three North American and two Asian long-term ozone time series. The authors state that systematic long-term measurement-model comparisons covering various decades are necessary to fully understand the ozone budget. Parrish et al. [2012] conclude that the ozone time series increased rather linearly at all sites in the last decades of the last century while a remarkable slow down can be observed afterwards leading to decreasing growth rates. The slowdown of the growth rate can particularly be seen over Western and Central Europe while it is less pronounced over North America and Japan. Within this study, NABEL's continuous ozone time series since 1990 were jointly analyzed with sporadic historic data taken in summer 1934 and 1938 at Jungfraujoch (taken from Crutzen [1988] and Staehelin et al. [1994]) (see Figure 2). This combined view confirms the significant increase of ozone at Jungfraujoch in the last century with an approximate doubling of the ozone burden between the 1930ies and the year 2000.

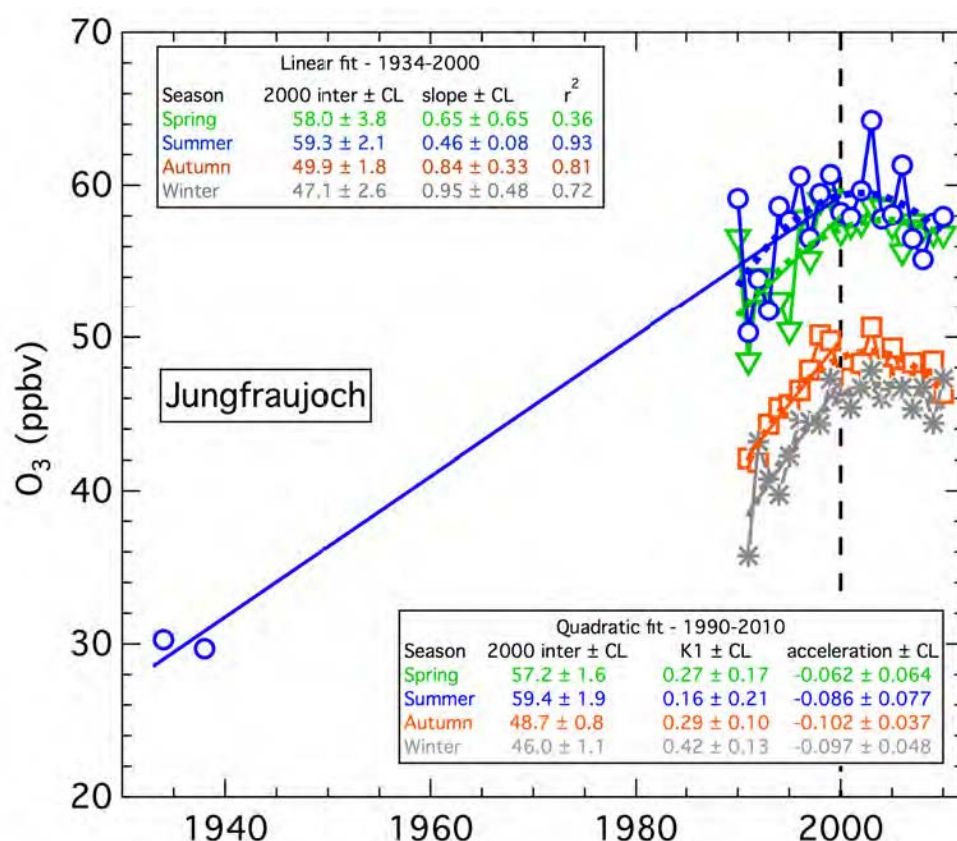


Figure 2. Time series of seasonal ozone averages at Jungfraujoch from 1990 to 2010 along with sporadic historic data from summer 1934 and summer 1938. The solid lines illustrate linear regressions for the data prior to 2001, the dotted lines indicate the quadratic regressions for the 1990 to 2010 datasets. Figure courtesy of David Parrish [Parrish et al., 2012].

#### References

- Crutzen, P. J. (1988), Tropospheric ozone: an overview, in *Tropospheric Ozone*, edited by I. S. A. Isaksen, pp. 47-56, Reidel Publishing Co., Dordrecht.
- Gilge, S., C. Plass-Duelmer, W. Fricke, A. Kaiser, L. Ries, B. Buchmann, and M. Steinbacher (2010), Ozone, carbon monoxide and nitrogen oxides time series at four Alpine GAW mountain stations in Central Europe, *Atmos. Chem. Phys.*, *10*, 12295-12316.
- Logan, J. A., et al. (2012), Changes in ozone over Europe: analysis of ozone measurements from sondes, regular aircraft (MOZAIC) and alpine surface sites, *J. Geophys. Res.*, *117*, D09301, doi: 09310.01029/02011JGD016952.
- Parrish, D. D., et al. (2012), Long-term changes in lower tropospheric baseline ozone concentrations at northern mid-latitudes, *Atmos. Chem. Phys.*, *12*, 11485-11504.
- Staehelin, J., J. Thudium, R. Buehler, A. Volz-Thomas, and W. K. Graber (1994), Trends in surface ozone concentrations at Arosa (Switzerland), *Atmos. Environ.*, *28*(1), 75-87.

Key words:

Atmospheric chemistry, air quality, trace gases, long-term monitoring

Internet data bases:

<http://www.empa.ch/nabel>

[http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg\\_luft/luftbelastung/index.html](http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg_luft/luftbelastung/index.html)

Collaborating partners/networks:

Bundesamt für Umwelt (BAFU)/ Federal Office for the Environment (FOEN)

Global Atmosphere Watch (GAW)

Labor für Atmosphärenchemie, Paul Scherrer Institut

MeteoSchweiz

Climate and Environmental Physics, University of Bern

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Brunner, D., Henne, S., Keller, C. A., Reimann, S., Vollmer, M. K., O'Doherty, S., Maione, M., An extended Kalman-filter for regional scale inverse emission estimation, *Atmospheric Chemistry and Physics*, **12**(7), 3455-3478, 2012.

<http://www.atmos-chem-phys.net/12/3455/2012/acp-12-3455-2012.html>

Buchmann, B., Research at Jungfrauoch supports policy, Public Service Review: European Science & Technology 2012, **14**, 190-191, 2012.

[http://www.publicservice.co.uk/article.asp?publication=European%20Science%20and%20Technology&id=554&content\\_name=Environment%20and%20Energy&article=18998](http://www.publicservice.co.uk/article.asp?publication=European%20Science%20and%20Technology&id=554&content_name=Environment%20and%20Energy&article=18998)

Conen, F., Henne, S., Morris, C. E., Alewell, C., Atmospheric ice nucleators active  $\geq -12$  °C can be quantified on PM10 filters, *Atmospheric Measurement Techniques*, **5**(2), 321-327, 2012.

<http://www.atmos-meas-tech.net/5/321/2012/amt-5-321-2012.html>

Keller, C. A., Hill, M., Vollmer, M. K., Henne, S., Brunner, D., Reimann, S., O'Doherty, S., Peter, T., Maione, M., Ferenczi, Z., Haszpra, L., Manning, A. J., Peter, T., European emissions of halogenated greenhouse gases inferred from atmospheric measurements. *Environmental Science & Technology*, **46**(1), 217-225, 2012. <http://pubs.acs.org/doi/full/10.1021/es202453j>

Kristiansen, N. I., Stohl, A., Prata, A. J., Bukowiecki, N., Dacre, H., Eckhardt, S., Henne, S., Hort, M. C., Johnson, B. T., Marenco, F., Neininger, B., Reitebuch, O., Seibert, P., Thomson, D. J., Webster, H. N., Weinzierl, B., Performance assessment of a volcanic ash transport model mini-ensemble used for inverse modeling of the 2010 Eyjafjallajökull eruption, *Journal of Geophysical Research*, **117**, D00U11, doi:10.1029/2011JD016844, 2012.

<http://onlinelibrary.wiley.com/doi/10.1029/2011JD016844/abstract>

Logan, J. A., Staehelin, J., Megretskaia, I. A., Cammas, J. P., Thouret, V., Claude, H., De Backer, H., Steinbacher, M., Scheel, H. E., Stübi, R., Fröhlich, M., Derwent, R., Changes in ozone over Europe: Analysis of ozone measurements from sondes, regular aircraft (MOZAIC) and alpine surface sites, *Journal of Geophysical Research*, **117**, D09301, doi: 09310.01029/02011JD016952, 2012.

<http://www.agu.org/pubs/crossref/2012/2011JD016952.shtml>

Pandey Deolal, S., Brunner, D., Steinbacher, M., Weers, U., Staehelin, J., Long-term in situ measurements of NO<sub>x</sub> and NO<sub>y</sub> at Jungfrauoch 1998–2009: time series analysis and evaluation, *Atmospheric Chemistry and Physics*, **12**(5), 2551-2566, 2012.

<http://www.atmos-chem-phys.net/12/2551/2012/acp-12-2551-2012.html>

Parrish, D. D., Law, K. S., Staehelin, J., Derwent, R., Cooper, O. R., Tanimoto, H., Volz-Thomas, A., Gilge, S., Scheel, H.-E., Steinbacher, M., Chan, E., Long-term changes in lower tropospheric baseline ozone concentrations at northern mid-latitudes, *Atmospheric Chemistry and Physics*, **12**, 11485-11504, <http://dx.doi.org/10.5194/acp-12-11485-2012>, 2012.

<http://www.atmos-chem-phys.net/12/11485/2012/acp-12-11485-2012.html>

Ruckstuhl, A. F., Henne, S., Reimann, S., Steinbacher, M., Vollmer, M. K., O'Doherty, S., Buchmann, B., Hueglin, C., Robust extraction of baseline signal of atmospheric trace species using local regression, *Atmospheric Measurement Techniques*, **5**(11), 2613-2624, 2012.

<http://www.atmos-meas-tech.net/5/2613/2012/amt-5-2613-2012.html>

Thevenon, F., Chiaradia, M., Adatte, T., Hueglin, C., Poté, J., Characterization of modern and fossil mineral dust transported to high altitude in the western alps: saharan sources and transport patterns, *Advances in Meteorology*, Article ID 674385, doi:10.1155/2012/674385, 2012.

<http://www.hindawi.com/journals/amet/2012/674385/>

Wilson, R. C., Fleming, Z. L., Monks, P. S., Clain, G., Henne, S., Konovalov, I. B., Szopa, S., Menut, L., Have primary emission reduction measures reduced ozone across Europe? An analysis of European rural background ozone trends 1996–2005, *Atmospheric Chemistry and Physics*, **12**(1), 437-454, 2012.  
<http://www.atmos-chem-phys.net/12/437/2012/acp-12-437-2012.html>

### **Conference papers**

Hueglin, C., Measurements of ambient air in Switzerland (NABEL) and Europe (EMEP), HS\_Course Oeschgerzentrum/Medizinische Fakultät Uni Bern/Empa, Dübendorf, Switzerland, January 23-26, 2012.

Parrish, D. D., K.S. Law, J. Staehelin, R. Derwent, O.R. Cooper, H. Tanimoto, A. Volz-Thomas, S. Gilge, H.-E. Scheel, M. Steinbacher, E. Chan, Earlier seasonal maximum in lower tropospheric ozone at northern mid-latitudes, 2012 AGU Fall Meeting, San Francisco, USA, December 3-7, 2012.

Steinbacher, M., Long-term continuous ground-based in-situ trace gas observations at Jungfraujoch, NDACC-IRWG/TCCON 2012 Meeting, Wengen, Switzerland, June 11-13, 2012.

Steinbacher, M., Neues von der DACH-Station Jungfraujoch, Sitzung der GAW-DACH-Arbeitsgruppe, Munich, Germany, September 12-13, 2012.

Steinbacher, M., Ozone in the free troposphere - Results from recent JFJ studies, Sitzung der GAW-DACH-Arbeitsgruppe, Munich, Germany, September 12-13, 2012.

Sturm, P., B. Tuzson, S. Henne, D. Brunner, J. Mohn, M. Steinbacher, B. Buchmann, L. Emmenegger, Tracking isotopic signatures of CO<sub>2</sub> at Jungfraujoch with laser spectroscopy: analytical improvements and exemplary results, JESIUM 2012, Leipzig, Germany, September 2-7, 2012.

### **Data books and reports**

BAFU 2012: NABEL – Luftbelastung 2011. Messresultate des Nationalen Beobachtungsnetzes für Luftfremdstoffe (NABEL). pp. 128, Bundesamt für Umwelt, Bern. Umwelt-Zustand Nr. 1221, 2012.

### **Magazine and Newspapers articles**

“Hochalpine Top-Wissenschaft, 75 Jahre Sphinx-Observatorium auf dem Jungfraujoch”, Neu Zürcher Zeitung, June 12, 2012.

“FCKW-Ersatzstoffe: Gut für die Ozonschicht, schlecht für das Klima”, SVG-Journal, April 20, 2012.

“Forscher: FKW ins Montrealer Protokoll aufnehmen”, chemie plus, March 08, 2012.

“Auf 3500 Metern den Puls der Atmosphäre messen”, Espazium, May 04, 2012.

“Auf 3500 Metern den Puls der Atmosphäre messen”, [www.bluewin.ch](http://www.bluewin.ch), May 04, 2012.

“Den Puls der Atmosphäre messen”, Walliser Bote, May 05, 2012.

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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 2012 the combined online CO<sub>2</sub> and O<sub>2</sub> measurements at Jungfraujoch, which had been initiated in late 2004 at Jungfraujoch, were continued. Long-term changes in CO<sub>2</sub> and O<sub>2</sub> contents in the atmosphere were calculated from hourly averages of night time data (2am to 6am) to assure that only background values are considered. The thick line corresponds to a two harmonic spline calculation that was applied to the data for which values beyond 2.7  $\sigma$  were excluded. This means that, if the data is normally distributed, 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<sub>2</sub> and O<sub>2</sub> change were calculated. CO<sub>2</sub> increases at a rate of  $1.94 \pm 0.01$  ppm / yr, O<sub>2</sub> and APO decreases at a rate of  $-26.6 \pm 0.2$  per meg / and of  $-16.4 \pm 0.2$  per meg / yr respectively, in which the uncertainty is the error of the linear component of the fit. The accuracy and precision of the oxygen and APO decrease rates are less robust and should be taken with care due to increasing variability of the analyser during 2011 and 2012. A replacement of the oxygen paramagnetic cell is planned for 2013.

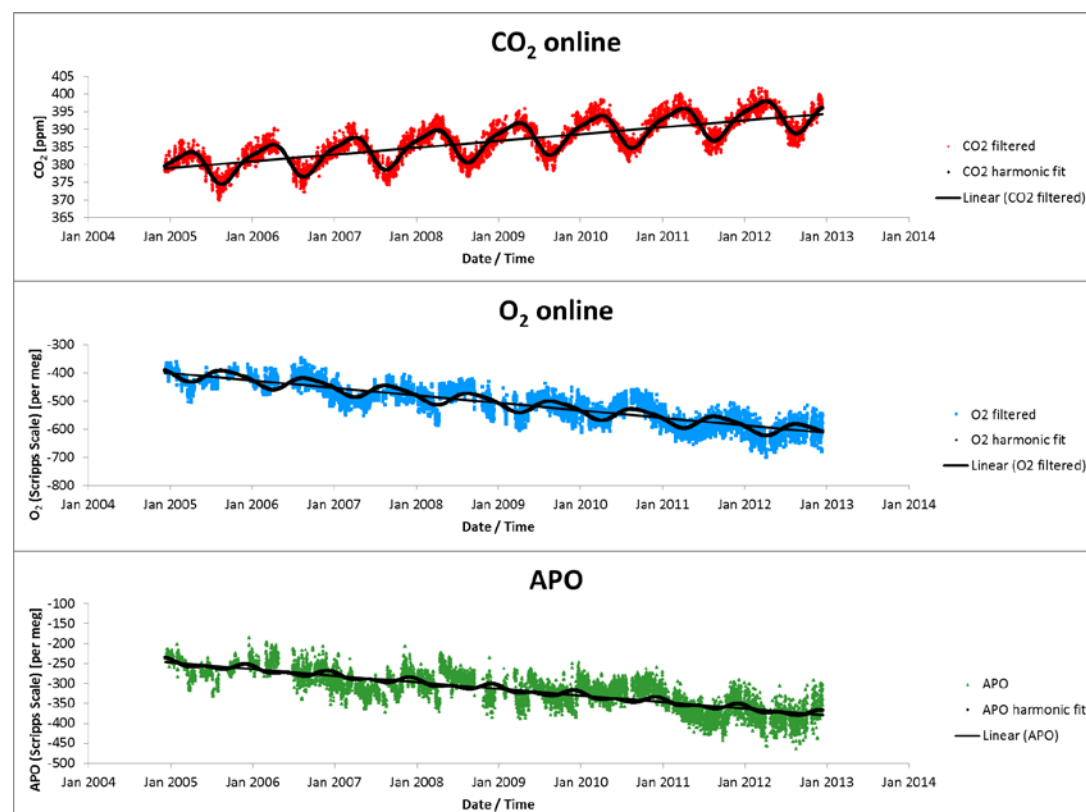


Figure 1: Filtered CO<sub>2</sub> (red), O<sub>2</sub> (blue) and APO (green) values at Jungfraujoch with linear and harmonic fits.

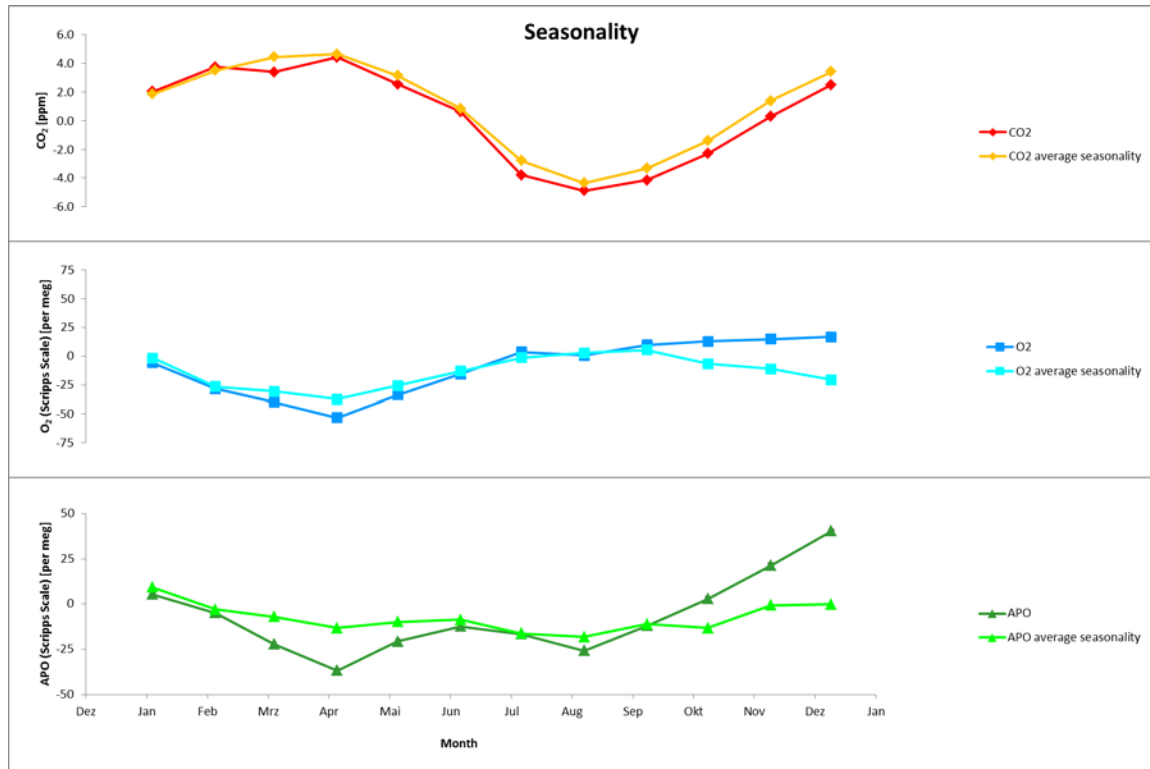


Figure 1: Seasonalities at Jungfraujoch for CO<sub>2</sub> in 2012 (red) and averaged since 2005 (orange) first panel; for O<sub>2</sub> in 2012 (blue) and averaged (turquoise) second panel; for APO in 2012 (green) and averaged (lime) third panel.

The seasonal changes of CO<sub>2</sub> and O<sub>2</sub> 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<sub>2</sub> seasonality as documented by the upper panel. The situation is different for O<sub>2</sub> and APO as obvious from the middle and lower panel. The variability of seasonal amplitudes is large for our O<sub>2</sub> measurements. Part of which has to do with the larger uncertainty of O<sub>2</sub> measurements.

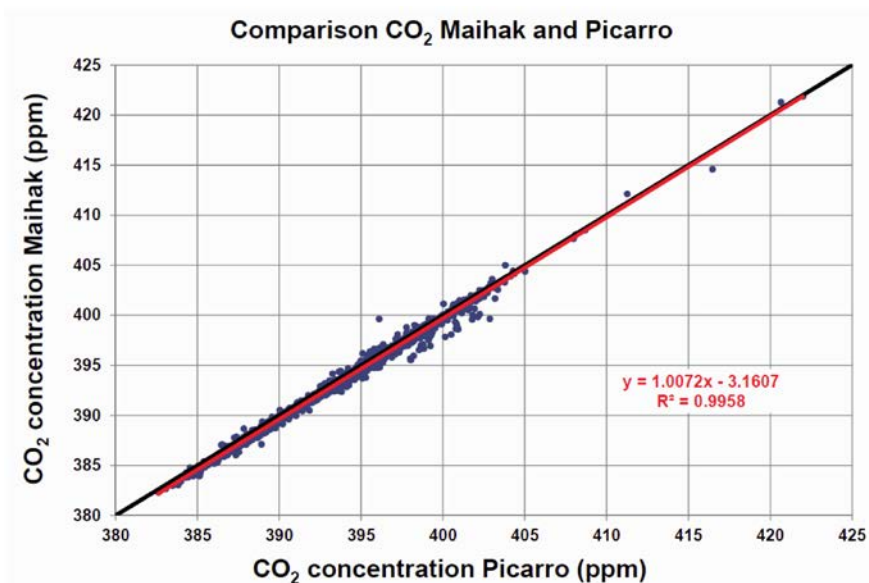


Figure 3: Plot of the Maihak data versus the Picarro data. The indicated fit equation is based on all data.



The comparison between the CO<sub>2</sub> measurements performed by Empa and ours was continued. The agreement is good as documented in Figure 3. As agreed we will focus on a technical publication regarding this CO<sub>2</sub> intercomparison at Jungfraujoch in 2013. The responsibility of the continuous CO<sub>2</sub> measurements will be moved from the University of Bern (Climate and Environmental Physics Division) to Empa according to the agreement made between the Swiss GCOS office, the Empa and the University of Bern.

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**Key words:**

Greenhouse gas, climate change, CO<sub>2</sub> emissions

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**Internet data bases:**

The Jungfraujoch data can be downloaded from our homepage ([http://www.climate.unibe.ch/?L1=research&L2=atm\\_gases](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 since 1.3.2011)

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**Collaborating partners/networks:**

IMECC partners, Swiss GCOS office, EMPA

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**Scientific publications and public outreach 2012:**

**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 CO<sub>2</sub>, δ(O<sub>2</sub>/N<sub>2</sub>) and δ<sup>13</sup>CO<sub>2</sub> measurements at Jungfraujoch, Switzerland: results from a flask sampling intercomparison program, *Atmos. Meas. Tech. Discuss.*, 5, 7293-7322, doi:10.5194/amtd-5-7293-2012, 2012.  
<http://www.atmos-meas-tech-discuss.net/5/7293/2012/>

**Data books and reports**

Leuenberger M., S. van der Laan, I.T. van der Laan-Luijkx, M.F. Schibig, Comparison of continuous in-situ CO<sub>2</sub> observations at Jungfraujoch using two different measurement techniques, Third GCOS interim report, 2012.

Leuenberger M., WMO World Data Centre for Greenhouse Gases, c/o Japan Meteorological Agency 1-3-4, Otemachi, Chiyoda-ku Tokyo 100-8122, Japan, CO<sub>2</sub> Data from Jungfraujoch (downloaded 182 times since 1.3.2011).

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Name of research institute or organization:

**Centre for Isotope Research (CIO), Groningen**

Title of project:

Flask comparison on Jungfraujoch

Project leader and team:

Prof. Harro Meijer, project leader, Groningen, and Bert Kers

Prof. M. Leuenberger, Ingrid and Sander Van der Laan, Peter Nyfeler (all UBern), Martin and Joan Fischer, Urs and Maria Oetz (HFSJG)

Project description:

The European project IMECC (Infrastructure for Measurements of the European Carbon Cycle) was finished last year. This project included an activity called Transnational Access activity (TA). It was designed to broaden and improve access to European Carbon Cycle measurement facilities. One of these facilities is the Research Station at Jungfraujoch. CIO Groningen had submitted a proposal to get access to this research station which was approved in 2009. The goal behind this TA activity is to compare combined flask takings in regard to CO<sub>2</sub> and O<sub>2</sub> concentrations at Jungfraujoch. Parallel flask samples are taken for CIO Groningen (Netherlands) and MPI-BGC Jena (Germany), in order to check the consistency of CO<sub>2</sub> and O<sub>2</sub> measurements.

As summarized in van der Laan-Luijkx et al., [2012], the results were well comparable for CO<sub>2</sub> regarding both the trend as well as the amplitude.

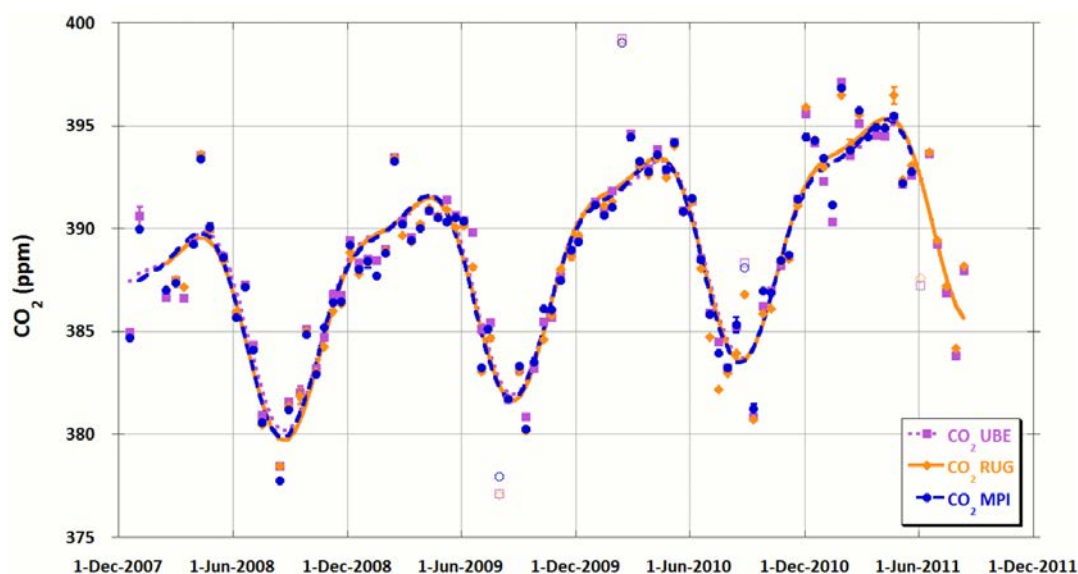


Figure 1: CO<sub>2</sub> concentration at Jungfraujoch, Switzerland from flask samples measured by three laboratories: University of Bern (UBE) (pink squares), University of Groningen (RUG) (orange diamonds) and Max Planck Institute in Jena (MPI) (blue circles). The values are the averages of 1, 2 or 3 flasks. The fits through the data are linear trends and double harmonic seasonal components. Open symbols represent those values that are outliers to the fit of the individual data set. The error bars represent the standard error of the average value of 2 or 3 flasks. For single flask measurements error bars are not shown.

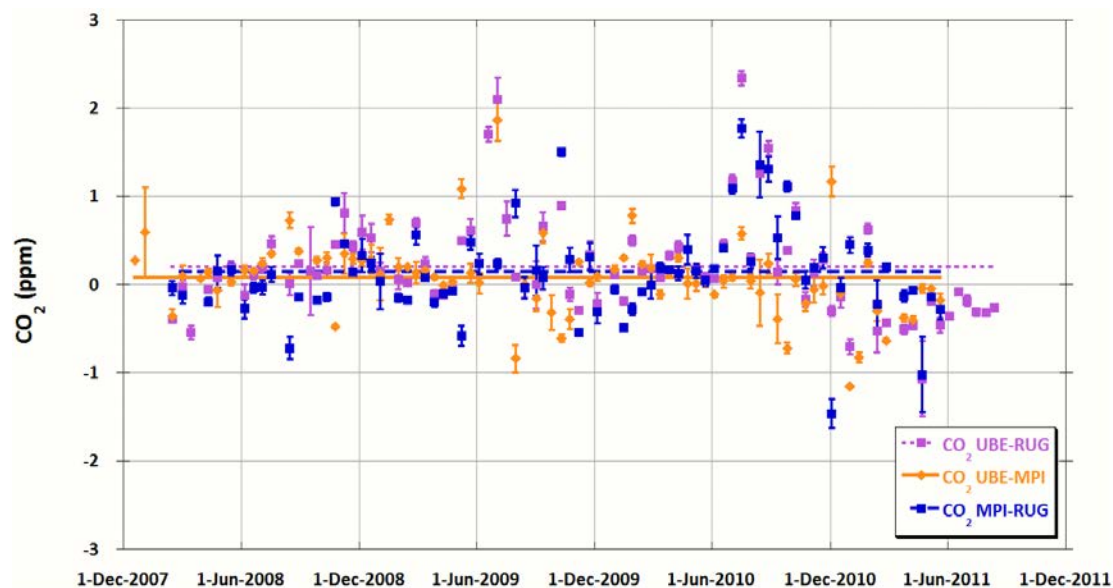


Figure 2: Differences of the  $\text{CO}_2$  concentration measured by each set of two laboratories. Also indicated are the average differences. These are: 0.20 ppm for UBE-RUG, 0.08 ppm for UBE-MPI and 0.14 ppm for MPI-RUG. The error bars represent the quadratically added standard errors of the measurements of the two laboratories.

It is obvious from Figure 1, that the agreement for the  $\text{CO}_2$  concentration is fairly good with a mean offset between the laboratories of around 0.2 ppm, Bern values being higher. Even high values (regional or local contamination) deviating significantly from the background values are in rather good agreement (Figure 2). The largest deviations are about 2 ppm in absolute.

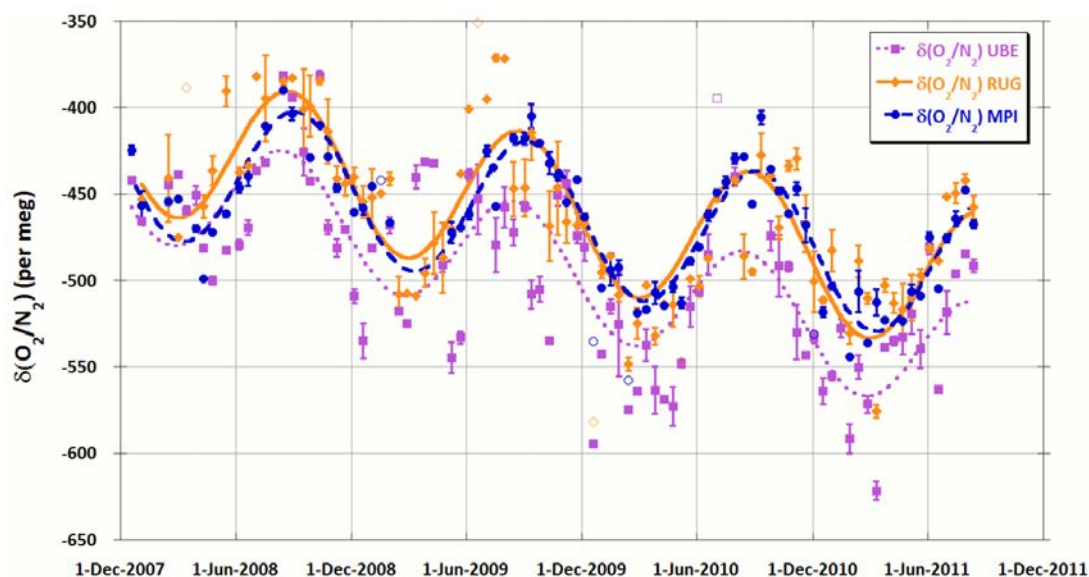


Figure 3:  $(\text{O}_2/\text{N}_2)$  observations from Jungfraujoch, Switzerland from flask samples measured by three laboratories: UBE (pink squares), RUG (orange diamonds) and MPI (blue circles). The values are the averages of 1, 2 or 3 flasks. The fits through the data are linear trends and single harmonic seasonal components. Open symbols represent those values that are outliers to the fit of the individual data set. The error bars represent the standard error of the average value of 2 or 3 flasks. For single flask measurements error bars are not shown.

The agreement is much less robust for oxygen (Figure 3). The mean difference is small but statistically significant with about 35 permeg, Bern values being lower. However, the variation of the difference between the two labs is high and around 40 permeg. This is

significantly larger than the internal precision of both labs. However, the better agreement between the Max Planck institute in Jena and CIO Groningen point – at least partly – to a measuring deficiency at Bern. Despite the fact that the IMECC project was finished in the meantime, the comparison is still ongoing in order to learn more about the difficulties of flask takings.

Key words:

Flask measurements, inter-comparison, oxygen and carbon dioxide measurements, greenhouse gas

Collaborating partners/networks:

IMECC partners

Scientific publications and public outreach 2012:

**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 CO<sub>2</sub>, δ(O<sub>2</sub>/N<sub>2</sub>) and δ<sup>13</sup>CO<sub>2</sub> measurements at Jungfraujoch, Switzerland: results from a flask sampling intercomparison program, Atmos. Meas. Tech. Discuss., 5, 7293-7322, doi:10.5194/amtd-5-7293-2012, 2012.  
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**Max Planck Institut für Biogeochemie, Jena**

Title of project:

Flask comparison on Jungfraujoch

Project leader and team:

Dr. Willi Brand, project leader, Armin Jordan (Jena)

Prof. M. Leuenberger, Ingrid and Sander Van der Laan, Peter Nyfeler (all UBern), Martin and Joan Fischer, Urs and Maria Otz (all HFSJG)

Project description:

The European project IMECC (Infrastructure for Measurements of the European Carbon Cycle) that finished some time ago had an activity called Transnational Access (TA). It was designed to enable high-precision measurements for European research institutions and, thus, to broaden and improve access to European Carbon Cycle measurement facilities. One of these facilities is the Research Station at Jungfraujoch.

MPI-BGC Jena had submitted a proposal to get access to this research station which was approved in 2008. The goal behind this TA activity is to compare CO<sub>2</sub> and O<sub>2</sub> concentrations of air samples taken simultaneously at Jungfraujoch station via combined flask filling. The Jena MPI has supplied the research station at Jungfraujoch with a flask sampling unit of the typical MPI-BGC design. This is run in conjunction with the Groningen (project Bert Kers, Groningen) as well as UBern (project Markus Leuenberger, Bern) flask sampling programmes.

The main outcome of the collaborative flask sampling was summarized by Ingrid van der Laan-Luijkx et al., published in AMTD [2012]. The three laboratories report the following average standard errors in the mean of the duplicate or triplicate for CO<sub>2</sub>, δO<sub>2</sub>/N<sub>2</sub> and δ<sup>13</sup>CO<sub>2</sub>. These numbers are of similar quality for UBE and RUG and better for MPI. Regarding δ<sup>13</sup>CO<sub>2</sub> this has to do with the different techniques and very different sample amounts that are used for the analyses. For UBE, only 0.5 ml STP of air is used for the carbon isotope determination whereas for the other two laboratories amounts of up to 600 ml are used.

	UBE	RUG	MPI
CO <sub>2</sub> (ppm)	0.05	0.06	0.06
δ (O <sub>2</sub> /N <sub>2</sub> ) (per meg)	6	8	3
δ <sup>13</sup> CO <sub>2</sub> (‰)	0.08	0.07	0.009

*Table 1: Average standard errors in the mean of the duplicate or triplicate flasks for the CO<sub>2</sub>, δ(O<sub>2</sub>/N<sub>2</sub>) and δ<sup>13</sup>CO<sub>2</sub> measurements from each of the three laboratories.*

It is obvious from Table 2, that the agreement for the CO<sub>2</sub> concentration is fairly good with a mean offset between the laboratories of around 0.2 ppm, Bern values being higher. Even high values (regional or local contamination) deviating significantly from the background values are in rather good agreement. The largest deviations are about 2 ppm in absolute (not shown). However, the offsets are significantly larger for oxygen between the three laboratories. For δ<sup>13</sup>CO<sub>2</sub> it looks rather good regarding the offsets but the noise of the data among the three institutes is large as shown in Figure 2. Most probably the different measuring technique with the extremely low amount used at UBE is not fully adequate for such high precision measurements, it was originally developed for ice core measurements for which the focus was on very small sample amounts in order to minimize the ice sample size.

	UBE – RUG		UBE – MPI		MPI – RUG	
	average	stdev	average	stdev	average	stdev
CO <sub>2</sub> (ppm)	0.20 ± 0.06	0.6	0.08 ± 0.05	0.4	0.14 ± 0.06	0.5
CO <sub>2</sub> (part 1)	0.18 ± 0.06	0.3	0.21 ± 0.05	0.3	0.042 ± 0.07	0.3
CO <sub>2</sub> (part 2)	0.21 ± 0.09	0.7	0.01 ± 0.07	0.5	0.19 ± 0.08	0.6
δ (O <sub>2</sub> /N <sub>2</sub> ) (per meg)	−33 ± 4	40	−31 ± 4	30	−3 ± 3	26
δ (O <sub>2</sub> /N <sub>2</sub> ) (part 1)	−33 ± 6	30	−14 ± 6	30	−16 ± 4	20
δ (O <sub>2</sub> /N <sub>2</sub> ) (part 2)	−37 ± 5	40	−38 ± 4	30	1 ± 4	27
δ <sup>13</sup> CO <sub>2</sub> (‰)	−0.03 ± 0.04	0.3	−0.02 ± 0.03	0.22	−0.02 ± 0.03	0.20
δ <sup>13</sup> CO <sub>2</sub> (part 1)	−0.06 ± 0.05	0.25	0.00 ± 0.07	0.20	−0.13 ± 0.04	0.10
δ <sup>13</sup> CO <sub>2</sub> (part 2)	−0.02 ± 0.05	0.3	−0.02 ± 0.03	0.23	−0.00 ± 0.03	0.21

Table 2: Average CO<sub>2</sub>, δ(O<sub>2</sub>/N<sub>2</sub>) and δ<sup>13</sup>CO<sub>2</sub> differences between each set of two laboratories and their standard errors in the mean. Also given are the standard deviations. The results are given for the entire data set as well as for the two sub-periods: before March 2009 (part 1) and after March 2009 (part 2).

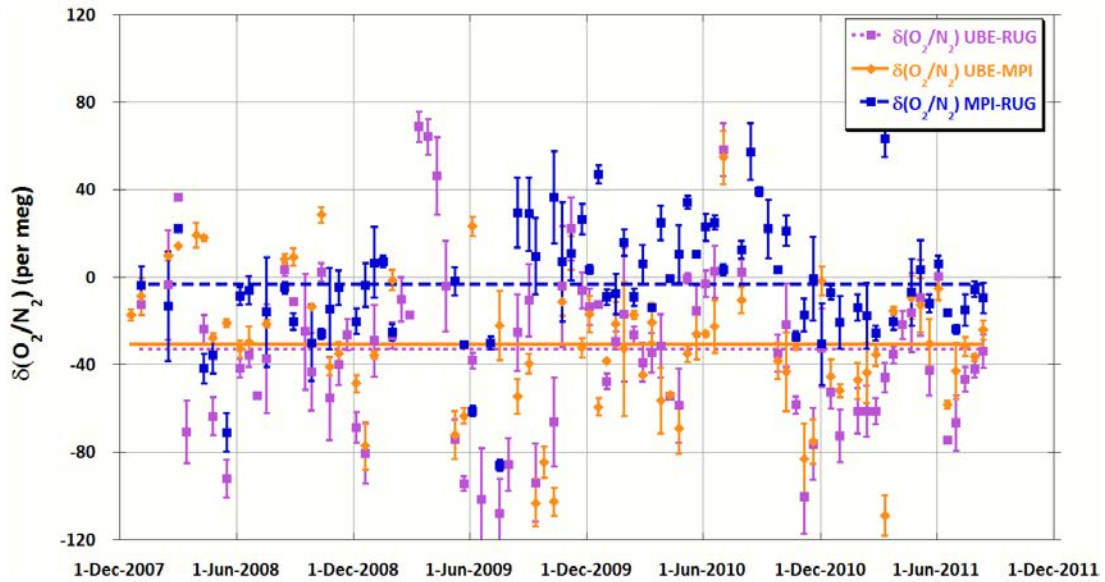


Figure 1: Differences of the δ(O<sub>2</sub>/N<sub>2</sub>) values measured by each set of two laboratories. Also indicated are the average differences. These are: −33 per meg for UBE-RUG, −31 per meg for UBE-MPI and −3 per meg for MPI-RUG. The error bars represent the quadratically added standard errors of the measurements of the two laboratories.



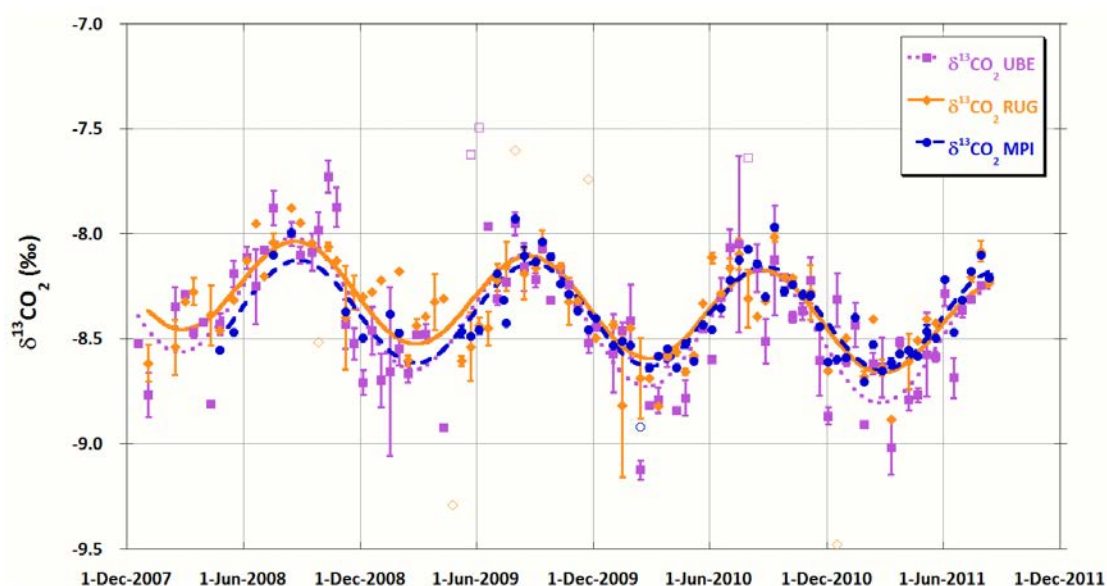


Figure 2:  $\delta^{13}\text{CO}_2$  observations from Jungfraujoch, Switzerland from flask samples measured by three laboratories: UBE (pink squares), RUG (orange diamonds) and MPI (blue circles). The values are the averages of 1, 2 or 3 flasks. The fits through the data are linear trends and single harmonic seasonal components. Open symbols represent those values that are outliers to the fit of the individual data set. The error bars represent the standard error of the average value of 2 or 3 flasks. For single flask measurements error bars are not shown.

The trend analysis revealed significant differences among the three laboratory data sets. The best agreement was obtained for the  $\text{CO}_2$  concentrations for which the average trend lies within the uncertainties of all three labs. Similar results are obtained for the amplitude of  $\text{CO}_2$ . The view is very different for oxygen. A too large negative trend was observed by UBE data set. Since this data set shows the highest variability it is worthwhile applying a stronger filtering process. If this is done as noted in the footnote a) of table 3, a more realistic number of  $-21 \pm 2$  per meg per year is obtained. This value compares much better with the RUG and MPI values of  $-23 \pm 3$  and  $-17.3 \pm 1.5$  per meg per year. The amplitude remains lower even after this stronger filtering with  $73 \pm 3$  per meg for UBE compared to  $85 \pm 3$  and  $84.1 \pm 2.2$  per meg for RUG and MPI. Trends for  $\delta^{13}\text{CO}_2$  are very different (Table 3) but strongly influenced by the noise of the corresponding data sets. This is documented by the UBE values when comparing the full data set that gives a trend of  $-0.013 \pm 0.004$  ‰ to the restricted data set of parallel flask measurements yielding  $-0.081 \pm 0.018$  ‰.

	UBE	RUG	MPI
Trend $\text{CO}_2$ ( $\text{ppm yr}^{-1}$ )	$1.76 \pm 0.17$	$1.94 \pm 0.18$	$1.83 \pm 0.17$
Amplitude $\text{CO}_2$ (ppm)	$10.3 \pm 0.3$	$10.6 \pm 0.4$	$10.7 \pm 0.3$
Trend $\delta(\text{O}_2/\text{N}_2)$ (per meg $\text{yr}^{-1}$ )	$-29^a \pm 3$	$-23 \pm 3$	$-17.3 \pm 1.5$
Amplitude $\delta(\text{O}_2/\text{N}_2)$ (per meg)	$69^a \pm 5$	$85 \pm 4$	$84.1 \pm 2.2$
Trend $\delta^{13}\text{CO}_2$ ( $\text{‰ yr}^{-1}$ )	$-0.081^b \pm 0.018$	$-0.069 \pm 0.015$	$-0.016 \pm 0.014$
Amplitude $\delta^{13}\text{CO}_2$ (‰)	$0.592 \pm 0.028$	$0.455 \pm 0.022$	$0.485 \pm 0.018$

<sup>a</sup> More realistic values are obtained when a stronger filter is applied to the data:  $-21 \pm 2$  per meg  $\text{yr}^{-1}$  and  $73 \pm 3$  per meg for the linear trend and seasonal amplitude respectively. <sup>b</sup> The trend estimate based on the complete record available for UBE between 2000 and 2012 is:  $-0.013 \pm 0.004$  ‰.

Table 3:  $\text{CO}_2$ ,  $\delta(\text{O}_2/\text{N}_2)$  and  $\delta^{13}\text{CO}_2$  trends and seasonal amplitudes based on the fit of the data sets from each laboratory: UBE, RUG and MPI. The used fit is a linear combination of a linear trend and a double (for  $\text{CO}_2$ ) or single (for  $\delta(\text{O}_2/\text{N}_2)$  and  $\delta^{13}\text{CO}_2$ ) harmonic seasonal component.

Key words:

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Flask measurements, inter-comparison, oxygen and carbon dioxide measurements, greenhouse gas

Collaborating partners/networks:

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IMECC partners

Scientific publications and public outreach 2012:

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**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 CO<sub>2</sub>,  $\delta(\text{O}_2/\text{N}_2)$  and  $\delta^{13}\text{CO}_2$  measurements at Jungfraujoch, Switzerland: results from a flask sampling intercomparison program, Atmos. Meas. Tech. Discuss., 5, 7293-7322, doi:10.5194/amtd-5-7293-2012, 2012.  
<http://www.atmos-meas-tech-discuss.net/5/7293/2012/>

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Name of research institute or organization:

**Empa – Materials Science and Technology**

Title of project:

Continuous measurement of stable CO<sub>2</sub> isotopes at Jungfraujoch, Switzerland

Project leader and team:

Lukas Emmenegger, project leader

Patrick Sturm

Béla Tuzson

Brigitte Buchmann

Project description:

The analysis of the isotopic composition of atmospheric CO<sub>2</sub> is a major tool to study the source- and sink strengths, as well as the fate of anthropogenically emitted CO<sub>2</sub> at local, regional and global scales. Discrete samples, analyzed by isotope ratio mass spectroscopy, have been used in atmospheric research for many years. Even more insight into a wide range of processes and their dynamics can be obtained by real-time measurements with high temporal resolution. For this purpose, we developed a quantum cascade laser based absorption spectrometer (QCLAS) to perform in-situ and high precision isotope ratio measurements of CO<sub>2</sub> in the free troposphere at Jungfraujoch. The three main CO<sub>2</sub> isotopologue mixing ratios (<sup>12</sup>C<sup>16</sup>O<sub>2</sub>, <sup>13</sup>C<sup>16</sup>O<sub>2</sub> and <sup>12</sup>C<sup>18</sup>O<sup>16</sup>O) have simultaneously been monitored since December 2008, providing the first long-term, continuous time series at a remote location.

In 2012, mainly two goals were accomplished. First, significant updates on the instrument and the calibration procedures were implemented to further improve the data quality (Figure 1). A precision of 0.02 ‰ for both isotope ratios ( $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ ) is now obtained for an averaging time of 10 minutes. The long-term accuracy is assured through a set of secondary and working standards calibrated against VPDB by IRMS.

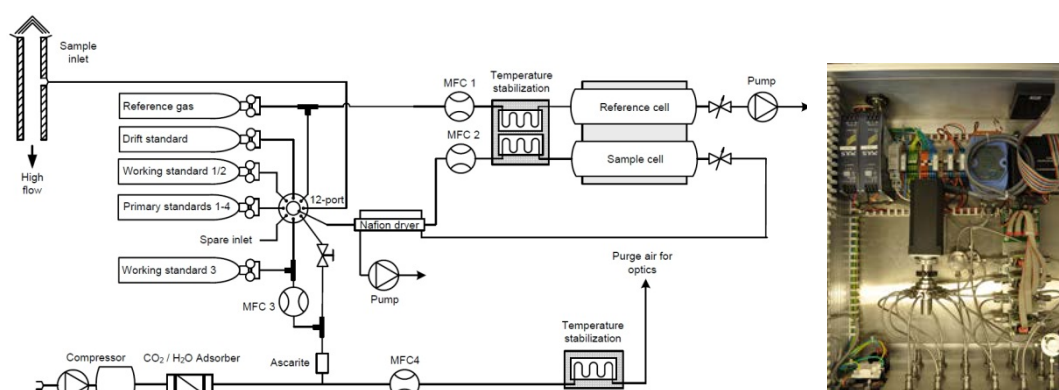


Figure 1. Schematic of the gas sampling setup and photograph of the newly developed gas handling and calibration module.

Second, the whole time series of the four year period was processed (Figure 2). Its analysis reveals mean annual cycles between December 2008 and September 2012 with peak-to-peak amplitudes of 11  $\mu\text{mol}\cdot\text{mol}^{-1}$  for CO<sub>2</sub>, 0.60 ‰ for  $\delta^{13}\text{C}$  and 0.81 ‰ for  $\delta^{18}\text{O}$ . The high temporal resolution of the measurements also allows capturing variations on hourly and diurnal time scales. For CO<sub>2</sub>, the mean diurnal peak-to-peak amplitude is about 1  $\mu\text{mol}\cdot\text{mol}^{-1}$  in spring, autumn and winter, and about twice as high in summer. The mean diurnal



variability in the isotope ratios is largest during the summer months too, with an amplitude of 0.1 ‰ for both  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$ , and a smaller or not discernible diurnal cycle during the other seasons. The day-to-day variability, however, is much larger and depends on the origin of the air masses arriving at Jungfraujoch.

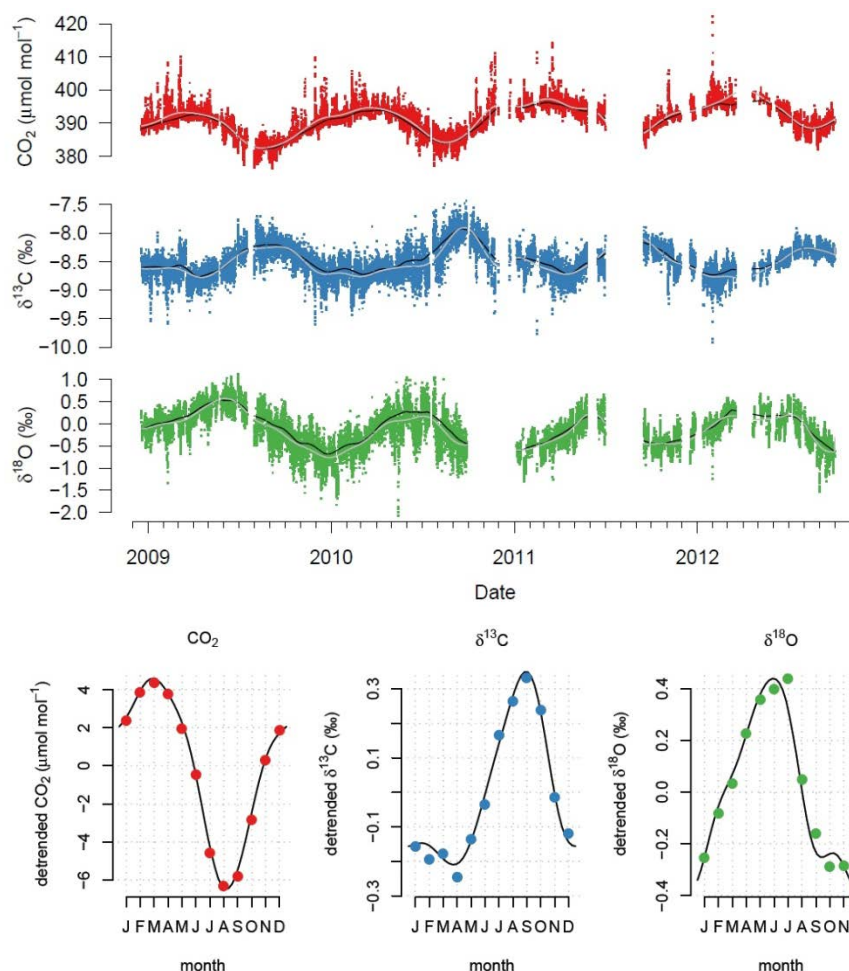


Figure 2. Overview of the data records from December 2008 to September 2012 (top). Hourly averaged data of  $\text{CO}_2$ , and isotopic ratios  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  as well as fitted background curves (black: local regression, grey: smooth curve fit) are shown. Mean seasonal cycles from detrended and monthly bin-averaged data and the annual harmonic part of the smoothed curve fit (bottom).

A major benefit of the high-time resolution measurements compared to the traditional flask sampling is that, in addition to seasonal variations and long-term trends, also variations on hourly and diurnal time scales can be captured. This allows for combining the measurements with meteorology and to interpret the data in terms of atmospheric dynamics. Using backward Lagrangian particle dispersion model simulations, a close link between air composition and prevailing transport regimes has been established, which explains much of the observed variability in terms of transport history and influence region. A footprint clustering shows significantly different wintertime  $\text{CO}_2$ ,  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values, depending on the origin and surface residence times of the air masses.

Key words:

Isotope ratio measurements, carbon dioxide, laser spectroscopy, quantum cascade laser

Collaborating partners/networks:

Max-Planck-Institute for Biogeochemistry, Jena, Germany  
ETHZ - Inst. for Quantum Electronics, Switzerland  
Alpes Lasers SA, Switzerland  
University of Bern, Switzerland

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Sturm, P., B. Tuzson, S. Henne, and L. Emmenegger, Tracking isotopic signatures of CO<sub>2</sub> at Jungfraujoch with laser spectroscopy: analytical improvements and exemplary results, accepted for Atmos. Meas. Tech. Discuss, 2012.

**Conference papers**

Emmenegger, L., J. Mohn, P. Sturm, S. Henne, P. Wunderlin, J. R. Köster, S. Eyer and B. Tuzson, Application of direct absorption mid IR laser spectroscopy for isotope specific detection of greenhouse gases, 15<sup>th</sup> International Conference on Laser Optics, St. Petersburg, Russia, June 25-29, 2012.

Sturm, P., B. Tuzson, S. Henne, and L. Emmenegger, Tracking isotopic signatures of CO<sub>2</sub> at Jungfraujoch with high-precision laser spectroscopy: analytical improvements, calibration and exemplary results, Joint European Stable Isotope Users group Meeting (JESIUM 2012), Leipzig, Germany, September 02-07, 2012.

Sturm, P., B. Tuzson, S. Henne, and L. Emmenegger, Tracking isotopic signatures of CO<sub>2</sub> at Jungfraujoch with high-precision laser spectroscopy, Fall Meeting of the Swiss Chemical Society, Zürich, Switzerland, September 13, 2012.

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Name of research institute or organization:

**Empa, Swiss Federal Laboratories for Materials Science and Technology**

Title of project:

Halogenated Greenhouse Gases at Jungfraujoch

Project leader and team:

Martin K. Vollmer, Stefan Reimann (project leader), Angelina Wenger, Matthias Hill, Brigitte Buchmann, Fabian Schoenenberger, Lukas Emmenegger

Project description:

Halogenated ozone-depleting substances (ODSs) and greenhouse gases (GHGs) have been monitored at Jungfraujoch since 2000. These measurements are combined with atmospheric transport models for identifying and quantifying national and regional emissions (Switzerland and neighboring countries). These "top-down" estimates are then used to verify "bottom-up" estimates of the international reporting agencies, which are based on industry information (import/export/manufacture). Furthermore, the measurements help to track global trends of these compounds in the "background" air. Measurements at Jungfraujoch comprise a suite of about 50 compounds, such as chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs and SF<sub>6</sub>), hydrofluorocarbons (HFCs), and additional halogenated hydrocarbons, which are regulated under the Montreal and Kyoto Protocols. In 2012 we implemented several instrumental and technical improvements to obtain high-quality, hourly measurements, typically with a precision < 1 % and an accuracy < 3 %. These measurements are tightly linked to the international AGAGE program (Advanced Global Atmospheric Gases Experiment).

As an example of this year's activities, results from measurements of several PFCs are presented. The figures show atmospheric abundances at Jungfraujoch, at Mace Head (Ireland, northern hemisphere), and at Cape Grim (Tasmania, southern hemisphere). These PFCs are almost entirely of anthropogenic origin, with emissions from the semiconductor industry and from aluminium smelters (mainly CF<sub>4</sub> and PFC-116). All of the presented PFC concentrations are growing. With atmospheric lifetimes >3'000 yrs and continuing emissions, the detected trends are virtually irreversible over a time horizon of a few generations – a truly long-term atmospheric disturbance by humans.

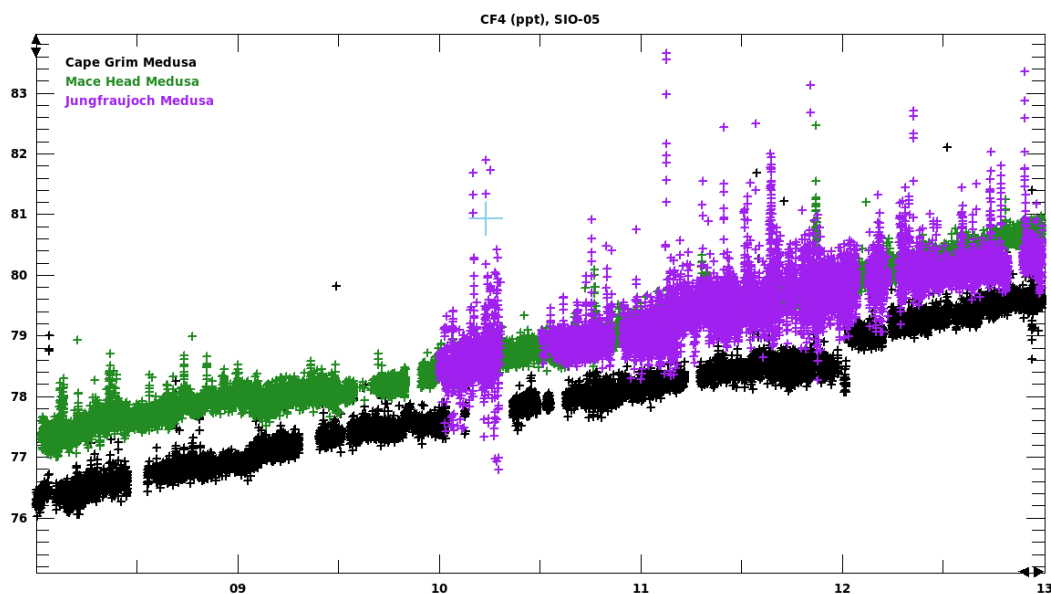


Figure 1. PFC-14 ( $\text{CF}_4$ ) at three AGAGE stations for the period 2008 – 2012. The x-label defines years, the y-label dry-air mole fractions in parts per trillion (ppt). Measurements are shown for Cape Grim (southern hemisphere) in black, for Mace Head (east coast Ireland) in green, and Jungfraujoch (Switzerland) in purple.  $\text{CF}_4$  is an extremely long-lived anthropogenic gas (50'000 – 100'000 yrs) in the atmosphere.

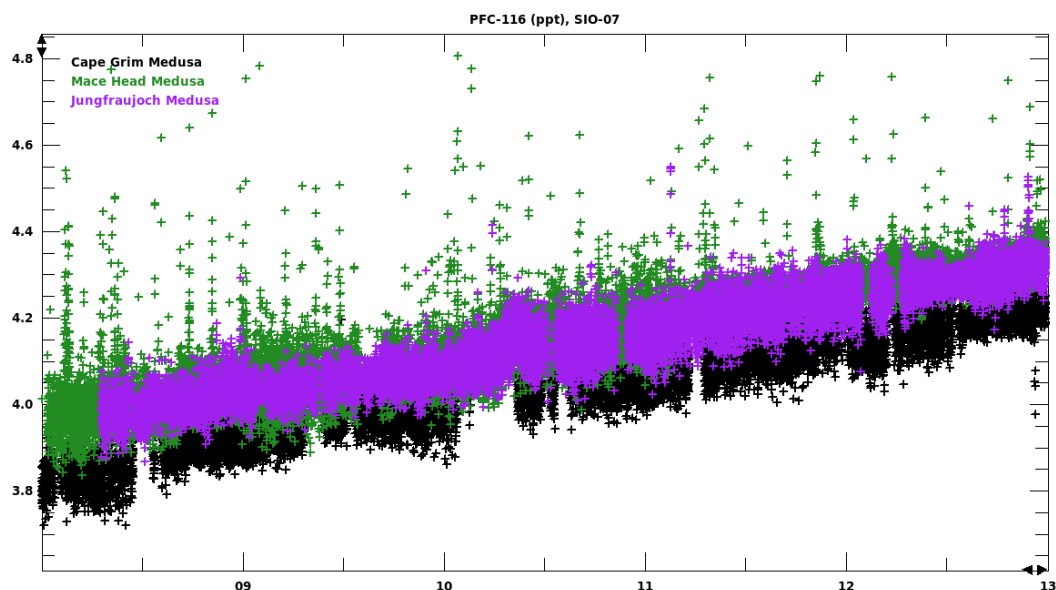


Figure 2. Same as Fig. 1 but for the long-lived PFC-116 ( $\text{C}_2\text{F}_6$ ). As opposed to  $\text{CF}_4$  (Fig. 1), there are virtually no regional emissions detected at Jungfraujoch.

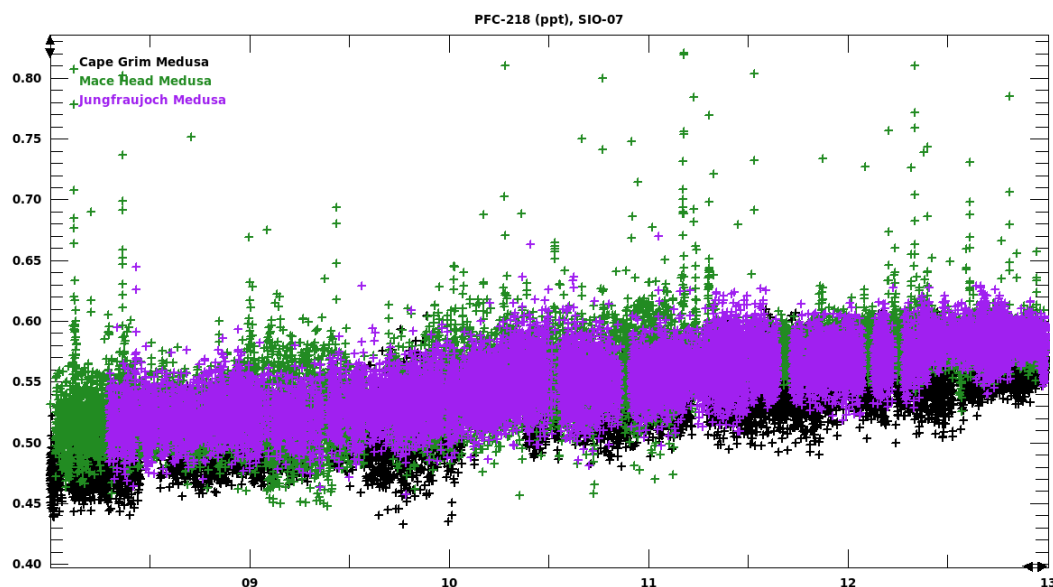


Figure 3. Same as Fig. 1 but for the long-lived PFC-218 ( $\text{C}_3\text{F}_8$ ). There are virtually no regional emissions detected at Jungfraujoch. Compared to the compounds shown in Fig. 1 and 2, atmospheric growth and the inter-hemispheric gradients are small.

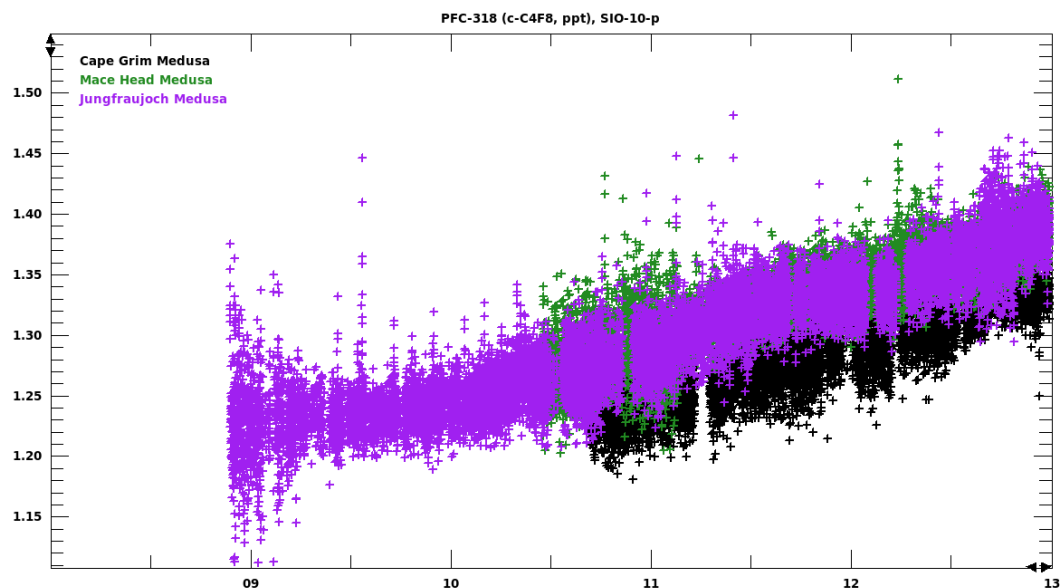


Figure 4. Same as Fig. 1 but for the long-lived PFC-318 (cyclo- $C_4F_8$ ). There are virtually no regional emissions detected at Jungfraujoch. Jungfraujoch has the longest in-situ measurement record of all the AGAGE stations. Measurements before mid-2009 were of lower precision (hence the pronounced vertical spread) due to lower atmospheric abundance and instrumental limitations.

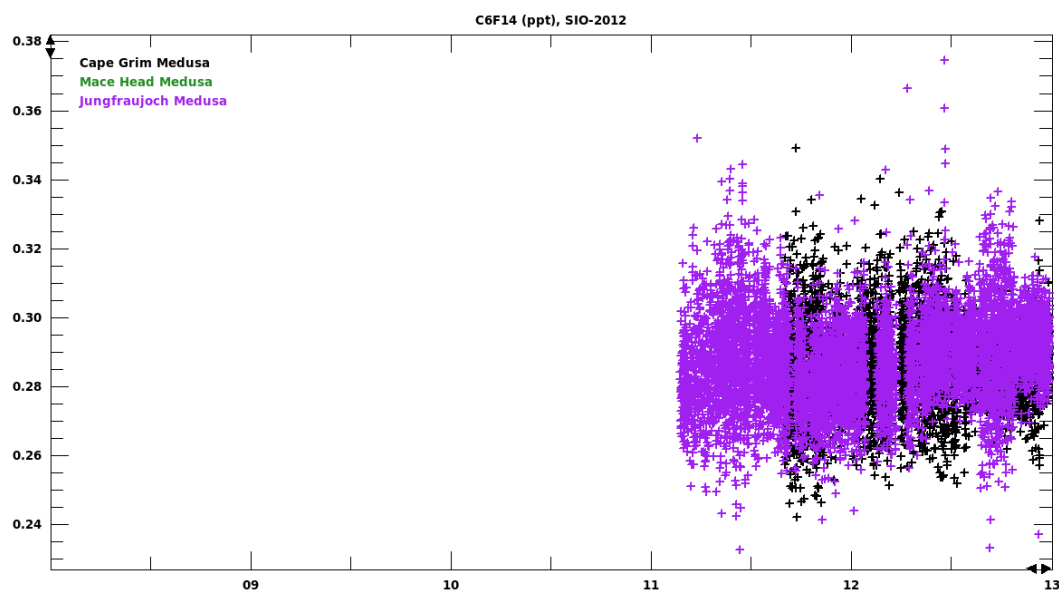


Figure 5. Same as Fig. 1 but for the long-lived  $C_6F_{14}$ . There are virtually no regional emissions detected at Jungfraujoch. So far, no significant growth and inter-hemispheric gradient can be seen.

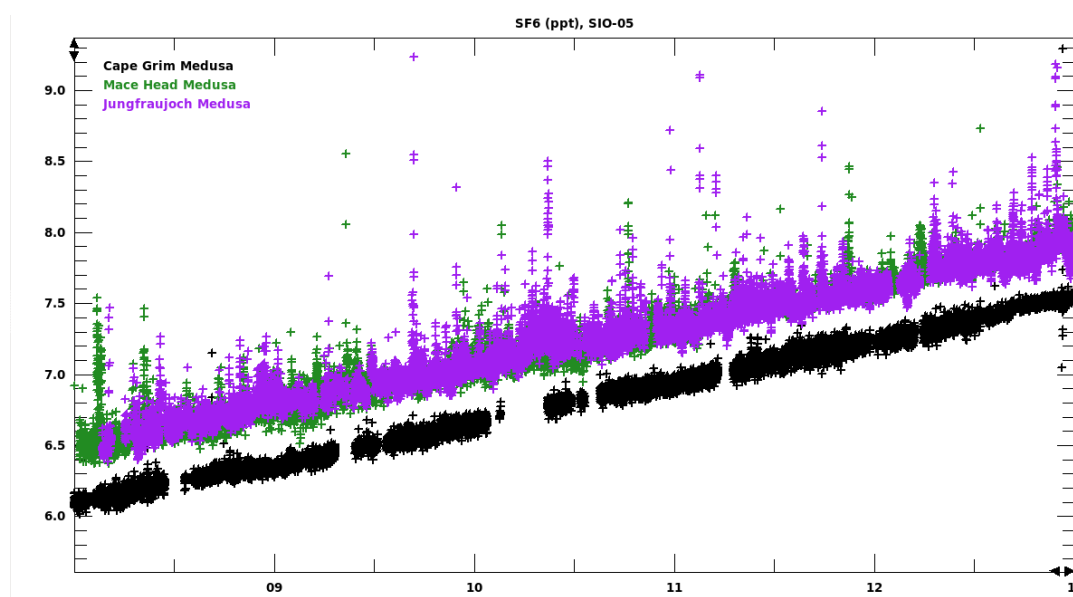


Figure 6. Same as Fig. 1 but for  $\text{SF}_6$ . The atmospheric growth rate is  $\sim 4\%/yr$ . There is a pronounced difference between the southern and the northern hemisphere, and both Jungfraujoch and Mace Head measurements show frequent regional pollution events.

Key words:

Halogenated ozone-depletion substances (ODS), greenhouse gases (GHG), perfluorinated carbons (PFCs)

Internet data bases:

<http://empa.ch/abt134>  
<http://agage.eas.gatech.edu>

Collaborating partners/networks:

Bundesamt für Umwelt (BAFU) / Federal Office for the Environment (FOEN)  
Global Atmosphere Watch (GAW), World Meteorological Organization (WMO)  
Advanced Global Atmospheric Gases Experiment (AGAGE)

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Brunner, D., S. Henne, C.A. Keller, S. Reimann, M.K. Vollmer, S. O'Doherty, M. Maione, An extended Kalman-filter for regional scale inverse emission estimation, *Atmos. Chem. Phys.*, **12**, 3455–3478, 2012.  
<http://www.atmos-chem-phys.net/12/3455/2012/acp-12-3455-2012.pdf>

Henne, S., D. Shallcross, S. Reimann, X. Ping, D. Brunner, S. O'Doherty and B. Buchmann, Future emissions and atmospheric fate of HFC-1234yf from mobile air conditioners in Europe, *Environ. Sci. Technol.*, **46**, 3, 1650–1658, doi: 10.1021/es2034608, 2012.  
<http://www.ncbi.nlm.nih.gov/pubmed/22225403>

Ruckstuhl, A.F., S. Henne, S. Reimann, M. Steinbacher, B. Buchmann, C. and Hueglin, Robust extraction of baseline signal of atmospheric trace species using local regression, *Atmos. Meas. Tech.*, **5**, 2613–2624, 2012.  
<http://www.atmos-meas-tech.net/5/2613/2012/amt-5-2613-2012.pdf>

Saikawa, E., M. Rigby, R. G. Prinn, S. A. Montzka, B. R. Miller, L. J. M. Kuijpers, P. J. B. Fraser, M. K. Vollmer, et al., Global and regional emissions estimates for HCFC-22, *Atmos. Chem. Phys.*, **12**, 10033–10050, doi: 10.5194/acp-12-10033-2012, 2012.  
<http://www.atmos-chem-phys.net/12/10033/2012/acp-12-10033-2012.pdf>

Velders, G.J.M., A.R. Ravishankara, M.K. Miller, M.J. Molina, J. Alcamo, J.S. Daniel, D.W. Fahey, S.A. Montzka, and S. Reimann, Reducing HFC influence: Preserving Montreal Protocol climate benefits, *Science*, **335**, 922–923, doi: 10.1126/science.1216414, 2012.  
<http://www.sciencemag.org>

Vollmer, M.K., S. Walter, J. Mohn, M. Steinbacher, S.W. Bond, T. Röckmann, and S. Reimann, Molecular hydrogen (H<sub>2</sub>) combustion emissions and their isotope (D/H) signatures from domestic heaters, diesel vehicle engines, waste incinerator plants, and biomass burning, *Atmos. Chem. Phys.*, 12, 6275–6289, 2012.  
<http://www.atmos-chem-phys.net/12/6275/2012/acp-12-6275-2012.pdf>

### **Conference papers**

Brunner D., Estimation of air pollutant and GHG sources using Lagrangian and Eulerian models/Chinese Academy of Sciences seminar, Beijing, China, April 27, 2012.

Brunner, D., The evolution of methyl bromide and other halocarbon emissions in Europe estimated by an extended Kalman filter/2012 ACCENT-IGAC-GEIA Conference, Toulouse, France, June 11-13, 2012.

Buchmann, B., S. Reimann, Atmospheric measurements for emission estimation: Real-world Emission Verification of Halogenated Greenhouse Gases, SBSTA Science meeting, Bonn, Germany, May 13, 2012.

Reimann, S., Global and Regional F-gas emissions, SPARC-SSC meeting, Zuerich, Switzerland, February 9, 2012.

Reimann, S., Re-evaluation of lifetime of ozone-depleting substances within SPARC/ESRL/NOAA annual meeting, Boulder, USA, May 17, 2012.

Reimann, S., VOCs in AGAGE/VOC WMO expert meeting, York, UK, September 12, 2012.

Reimann, S. Evolution of Emissions of Ozone Depleting Substances in Europe, 25th Anniversary of the Montreal Protocol, WMO, Geneva, Switzerland, November 11, 2012.

### **Data books and reports**

Reimann, S., M. K. Vollmer, D. Brunner, M. Steinbacher, M. Hill, A. Wenger, C. Keller, and B. Buchmann, Kontinuierliche Messung von halogenierten Treibhausgasen auf dem Jungfraujoch (HALCLIM-4). Empa project No 201'203, Final Report, August 2012. Available at:  
[http://www.empa.ch/plugin/template/empa/\\*/124295](http://www.empa.ch/plugin/template/empa/*/124295)

### **Radio and television**

Interview with Stefan Reimann, SRF1, «Einstein» 21. Juni 2012 / Emissionen-Schwindel in Italien  
<http://www.srf.ch/sendungen/einstein/emmissionen-schwindel-dampfer-lotti-pilzkur-fuer-himbeeren>

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Name of research institute or organization:

**Empa – Materials Science and Technology**

Title of project:

Direct and continuous measurement of NO<sub>2</sub>, NO and NO<sub>y</sub> in ambient air using quantum cascade laser absorption spectroscopy

Project leader and team:

Lukas Emmenegger, project leader  
Kerstin Zeyer  
Béla Tuzson

Project description:

Nitrogen Dioxide (NO<sub>2</sub>) is one of the most prominent air pollutants and highly relevant in atmospheric photochemical processes. However, chemiluminescence detection, the standard method for NO<sub>2</sub> measurements, requires the reduction of NO<sub>2</sub> to NO prior to analysis and is thus inherently influenced by other nitrogen containing species.

Laser absorption spectroscopy is a promising alternative approach because it is highly specific and sensitive. To demonstrate its potential, we have adapted a commercial (Aerodyne Research, USA) dual quantum cascade laser based analyzer (QCLAS) for high precision, continuous and interference free measurement of the NO and NO<sub>2</sub> in the free troposphere. In combination with an old converter, the setup also allows the detection of NO<sub>y</sub>, and thus of all oxidation states of nitrogen oxides that are routinely measured at Jungfraujoch. The instrument was installed at Jungfraujoch and operated during a three month campaign in Spring/Summer 2012 to assess its suitability for long-term monitoring of the main reactive nitrogen species under predominantly free tropospheric air conditions. A precision (1 $\sigma$ ) of 10 ppt and 3 ppt for NO and NO<sub>2</sub>, respectively, was achieved with 180 s averaging time under field conditions. The linear dynamic range of the QCLAS has been confirmed for both species from the detection limit to 45 ppbv. Excellent agreement was found in comparison with the chemiluminescence-based analyzer (Figure 1). This demonstrates the suitability of the laser spectroscopic approach for environmental applications, even at very low mixing ratios.

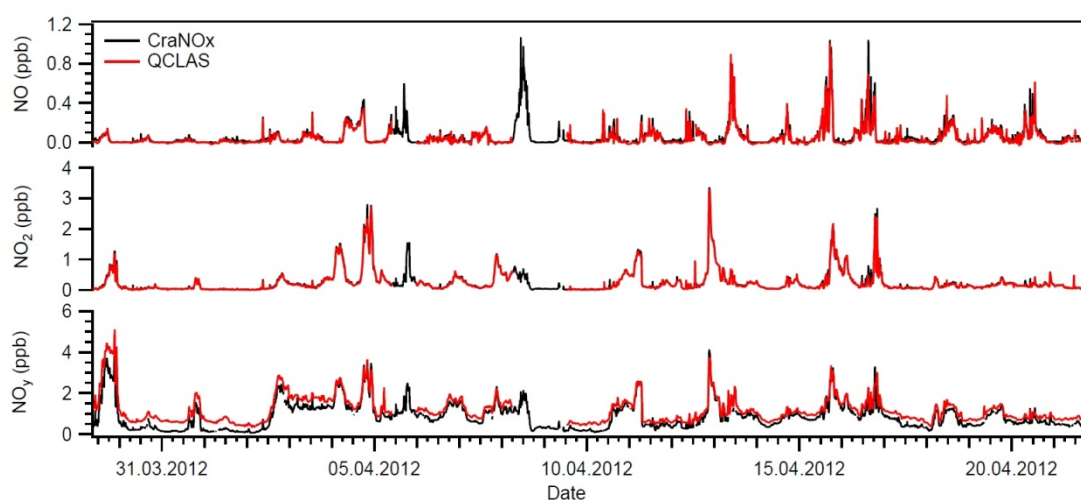


Figure 1. An exemplary sequence of NO, NO<sub>2</sub> and NO<sub>y</sub> time series measured at the Jungfraujoch with the two different methods. The gaps in the QCLAS data were caused by additional on-site works, such as calibration and converter investigation. The slight offset in the NO<sub>y</sub> data is due to differences in the Au-converter efficiencies.



Key words:

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Nitrogen oxide, nitrogen dioxide, NOy, quantum cascade laser, absorption spectroscopy

Collaborating partners/networks:

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NABEL, Switzerland

Aerodyne, USA

Scientific publications and public outreach 2012:

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**Refereed journal articles and their internet access**

Tuzson, B., K. Zeyer, M. Steinbacher, J. B. McManus, D. D. Nelson, M. S. Zahniser, and L. Emmenegger, Selective measurements of NO, NO<sub>2</sub> and NOy in the free troposphere using quantum cascade laser spectroscopy, *Atmos. Meas. Tech. Discuss.*, **5**, 1–25, doi: 10.5194/amtd-5-1-2012, 2012.

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Name of research institute or organization:

**Physikalische Chemie / FBC, Bergische Universität Wuppertal, Germany**

Title of project:

**Measurements of NO<sub>2</sub> and O<sub>3</sub> in the free troposphere by a New LOPAP Instrument (MINI)**

Project leader and team:

PD Dr. Jörg Kleffmann,  
Dipl. Chem. Sarah Peters, Dipl. Chem. Sascha Liedtke

Project description:

### **Introduction and motivation**

NO<sub>2</sub> is an important harmful trace species, which controls oxidant and acid formation in the atmosphere. Caused by its health effects, an annual average threshold limit value of ca. 20 ppb was introduced by the EU in 2010, which is typically exceeded under polluted urban conditions (EEA, 2007; Vestreng et al., 2009).

Despite its importance, standard chemiluminescence NO<sub>2</sub> instruments are known to be affected by interferences (Villena et al., 2012). Thus, a new sensitive (DL 2 ppt) NO<sub>2</sub>-LOPAP instrument was developed (Villena et al., 2011), which was recently extended for the simultaneous detection of O<sub>3</sub> (Peters et al., 2012). The instrument was successfully inter-calibrated under urban conditions and in a smog chamber (Villena et al., 2011; 2012; Peters et al., 2012), however, validation under remote conditions was still an open task.

### **Scientific objectives**

In the present study a NO<sub>2</sub>-LOPAP was intercompared with a standard chemiluminescence instrument (CLD) and a Quantum Cascade Laser Absorption Spectrometer (QCLAS) under clean atmospheric conditions at the high alpine research station “Jungfraujoch” (JFJ). In addition, the new O<sub>3</sub> channel of the LOPAP instrument was intercompared with a standard UV absorption instrument.

### **Reason for choosing the station**

In March and April 2012, EMPA had planned a CLD and QCLAS NO<sub>2</sub> intercomparison campaign at JFJ, which was thus considered as an ideal option to also intercompare our new LOPAP instrument at low pollution levels. Since JFJ is typically in the free troposphere, remote conditions are often prevailing in this easily accessible measurement station in the middle of Europe. Thus, the place and date were ideal for the scientific objectives.

### **Method and experimental set-up**

In the LOPAP instrument, O<sub>3</sub> is collected in a temperature controlled stripping coil by an effluent containing the intensively colored Indigo dye. The de-coloring of the dye is used to quantify O<sub>3</sub> in the gas phase. NO<sub>2</sub>, which almost completely passes the O<sub>3</sub> channel, is collected in a downstream stripping coil by a selective chemical reaction, converted into an azo-dye, which is sensitively measured in a liquid core wave guide. In addition, a further similar stripping coil is used to quantify losses from the NO<sub>2</sub> channel and potential interferences, which were however found to be negligible under polluted conditions. Details of the NO<sub>2</sub> and O<sub>3</sub> instruments are explained elsewhere (Villena et al., 2011; 2012; Peters et al., 2012). In contrast to these publications, modified stripping coils were used for the detection of NO<sub>2</sub>. In addition, caused by the lower pressure at JFJ and the resulting lower residence time of the gas phase in the stripping coil, a higher Indigo concentration of 40 mg/l was used in the O<sub>3</sub> channel for most days. Thus, the O<sub>3</sub> sensitivity was significantly lower (DL = 2 ppb, compared to the 0.4 ppb specified in Peters et al., 2012). In addition, caused by the lower gas flow rate (0.35 l/min), necessary for the O<sub>3</sub>-detection, and the lower used NEDA

concentration of the NO<sub>2</sub> effluent (0.3 g/l) compared to the study of Villena et al. (2011), the sensitivity and sampling efficiency for NO<sub>2</sub> were also reduced. For compensation of the reduced NO<sub>2</sub> sensitivity a longer optical path length of 5 m was used. However, an additional problem with the signal stability of the instrument was observed, which was caused by the proximity to the air conditioning of the laboratory (ca.  $\pm 6$  °C in the instrument), leading to higher periodic noise of the data. Thus, a detection limit and sampling efficiency for NO<sub>2</sub> of only 10 ppt and 91 % were obtained, whereas the short term detection limit without this periodic noise was 1-2 ppt, similar to our former results (Villena et al., 2011). For the last 2 days of the campaign, when it became evident that the NO<sub>2</sub> interference channel was not necessary at JFJ, in agreement with urban and smog chamber conditions (Villena et al., 2011, 2012), the third coil of the instrument was used to detect also NO. A commercial NO to NO<sub>2</sub> converter from a Luminol NO<sub>x</sub> instrument was used upstream the last coil. However caused by an unidentified gas leak, the measurement data of the instrument could not be used for that time period.

The instrument was installed at the Sphinx station at JFJ (3590 m) near to the other NO<sub>2</sub> instruments (CLD, QCLAS) and intercompared for 9 days of which only 7 could be used (see above). In contrast to the normal operation of the instrument, for which the external sampling unit is directly placed in the atmosphere of interest, gas samples were collected from the top of the Sphinx station by a 10 m long PFA sampling line (4 mm i.d.) similar to the other instruments. The total sampling flow rate was increased to ca. 2 l/min by the by-pass line.

## Preliminary results and conclusions

### a) General observations

During the campaign O<sub>3</sub> and NO<sub>2</sub> mixing ratios in the range 40-70 ppbv and 0.02-1.8 ppbv were measured by the LOPAP instrument, respectively (see Fig. 1), while average O<sub>3</sub> and NO<sub>2</sub> values of 59 and 0.27 ppbv were determined. Ozone mixing ratios were relatively constant, except one pollution episode on the 5.4.2012 when O<sub>3</sub> concentrations dropped sharply, while those of NO<sub>2</sub> increased (see Fig. 1), which can be explained by partial titration of O<sub>3</sub> by NO. In contrast, NO<sub>2</sub> showed stronger variability with typical higher concentrations during night-time.

A very important conclusion for the NO<sub>2</sub> detection was the absence of any significant signals in the interference channel of the instrument, except of the loss of NO<sub>2</sub> from the first channel caused by incomplete sampling. This result is in excellent agreement with urban and smog chamber measurements (Villena et al., 2011, 2012) and demonstrates that interferences in the wet chemical NO<sub>2</sub> detection used in the LOPAP instrument can be neglected for all atmospheric conditions, further simplifying this technique.

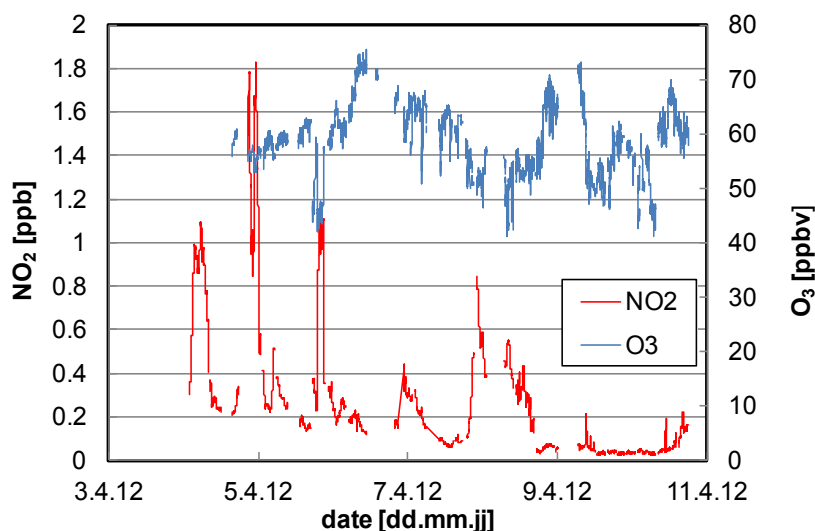


Fig. 1: O<sub>3</sub>- and NO<sub>2</sub>-LOPAP data during the intercomparison campaign at Jungfraujoch.

## b) O<sub>3</sub> intercomparison

For O<sub>3</sub> excellent agreement between the LOPAP and the data measured by a standard UV absorption instrument was obtained (see Fig. 2 and Fig. 3). From the correlation of both instruments only an average difference of 2 % was determined (see Fig. 3). In addition, also a very similar variability was obtained. Both results are in agreement with intercomparison campaigns of a O<sub>3</sub>-LOPAP instrument under urban and smog chamber conditions (Peters et al., 2012). Thus, it is concluded that potential interferences are of minor importance for the LOPAP O<sub>3</sub> data also under remote conditions.

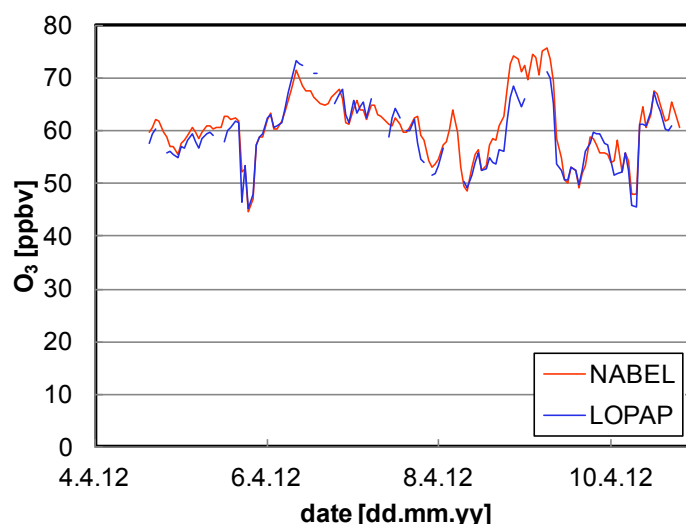


Fig. 2: Intercomparison of the 1 h averaged O<sub>3</sub> data from the LOPAP and a standard UV-absorption instrument (NABEL) at Jungfraujoch.

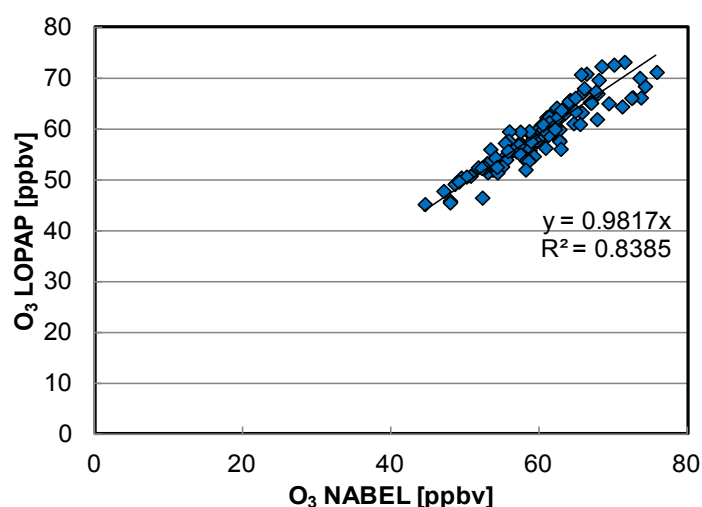


Fig. 3: Correlation of all 1 h averaged O<sub>3</sub> data from the LOPAP and a standard UV-absorption instrument (NABEL) at Jungfraujoch.

## b) NO<sub>2</sub> intercomparison

A high correlation ( $R^2 = 0.98$ ) of the NO<sub>2</sub> data by the LOPAP and the standard chemiluminescence instruments was obtained (Fig. 4 and Fig. 5). In addition, in a correlation plot of both data only a negligible intercept, lower than the precision errors, was observed, indicating a high performance of the LOPAP instrument also at very low NO<sub>2</sub> levels. However, systematically lower mixing ratios (ca. 35 %) were measured by the LOPAP instrument (see Fig 4 and Fig. 5). These observations indicate some calibration problems of one instrument. In addition, whereas concentrations (μg/m<sup>3</sup>) were specified in the NABEL data base, mixing ratios are determined by the LOPAP instrument. Thus, there may be also still some unit conversion errors (definition of the used total pressure). Since more information to the

NABEL data will be available only soon and since the QCLAS data was also yet not available, reasons for the discrepancy are still unclear.

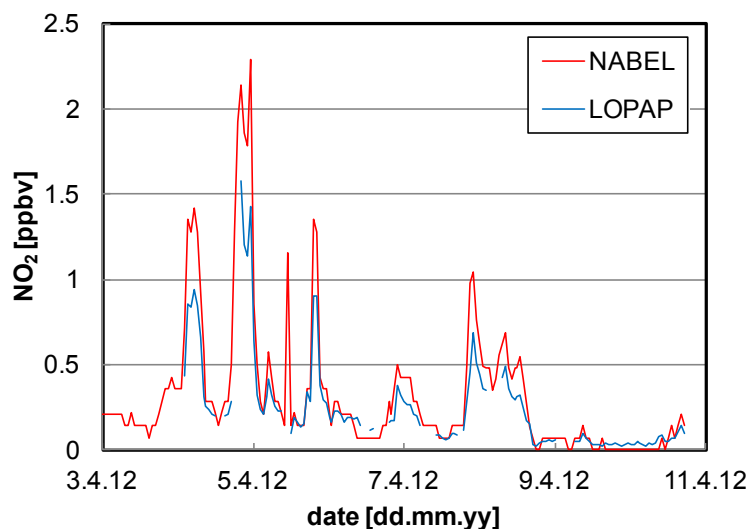


Fig. 4: Intercomparison of the 1 h averaged  $\text{NO}_2$  data from the LOPAP and a standard chemiluminescence instrument (NABEL) at Jungfraujoch.

The excellent correlation of the  $\text{NO}_2$  data indicates that interference problems of the LOPAP instrument are of minor importance for the conditions on the Jungfraujoch, in good agreement to intercomparison campaigns under urban and smog chamber conditions (Villena et al., 2012). In contrast, for potential interference problems of the LOPAP instrument, variable differences between both instruments would be expected.

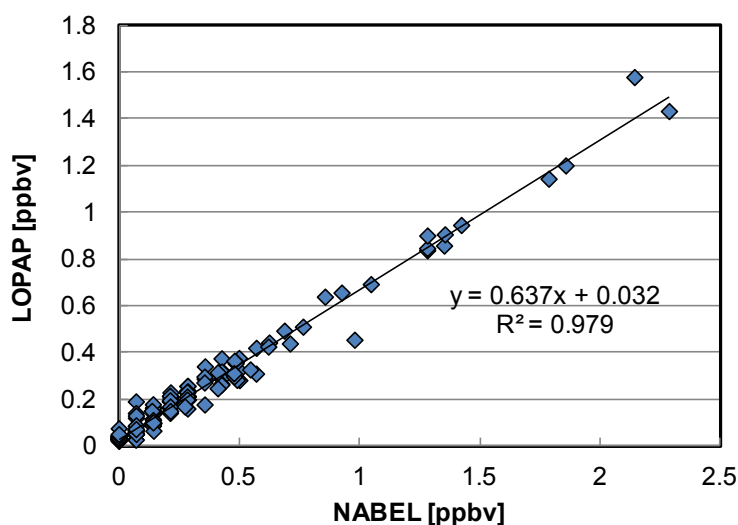


Fig. 5: Correlation of the 1 h averaged  $\text{NO}_2$  data from the LOPAP and a standard chemiluminescence instrument (NABEL) at Jungfraujoch.

### Conclusions and outlook

In the present study, a new  $\text{O}_3$ - $\text{NO}_2$ -LOPAP was intercompared at the High Alpine Research Station Jungfraujoch to standard instruments and a Quantum Cascade Laser Absorption Spectrometer (QCLAS) from EMPA. For  $\text{O}_3$  excellent absolute agreement was observed between the LOPAP and the UV absorption instrument, which routinely measures at JFJ. The good agreement demonstrates that interferences in the  $\text{O}_3$  channel of the instrument can be neglected also for low pollution levels, in agreement with urban and smog chamber results. For the  $\text{NO}_2$  channel of the instrument significantly lower concentrations compared to the standard chemiluminescence instrument were observed. Caused by the excellent correlation of the data, these results indicate some calibration problems of one instrument. In contrast,

interferences of the NO<sub>2</sub>-LOPAP instrument seem to be of minor importance, which is confirmed by the negligible signal in the interference channel of the LOPAP instrument. Since comparison to the QCLAS data is still an open task, reasons for the systematic discrepancy can be hopefully explained in the near future, when all data are available.

### Acknowledgement

The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 262254. In addition, the financial support of the German “Bundesministerium für Wirtschaft und Technologie” within the “Zentrales Innovationsprogramm Mittelstand (ZIM)” under contract number KF 2143503 WM9 and of the European Commission within the Integrated Infrastructure Initiative EUROCHAMP-2 (Grant Agreement GA228335) for the development of the instrument is gratefully acknowledged. We also like to thank the International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat (HFSJG), 3012 Bern, Switzerland, for the possibility to carry out our experiments at the Jungfraujoch. NABEL and Dr. Martin Steinbacher are acknowledged for providing preliminary NO<sub>x</sub> and O<sub>3</sub> data.

### References

- EEA Report, Air Pollution in Europe 1990-2004. European Environment Agency. Report 2/2007. ISSN 1725 9177, Copenhagen, Denmark, 2007.
- Villena, G., I. Bejan, R. Kurtenbach, P. Wiesen and J. Kleffmann, Development of a new Long Path Absorption Photometer (LOPAP) Instrument for the Sensitive Detection of NO<sub>2</sub> in the Atmosphere, *Atmos. Meas. Tech.*, **4**, 1663-1676, doi:10.5194/amt-4-1663-2011, 2011.
- Villena, G., I. Bejan, R. Kurtenbach, P. Wiesen and J. Kleffmann, Interferences of commercial NO<sub>2</sub> instruments in the urban atmosphere and in a smog-chamber, *Atmos. Meas. Tech.*, 2012, **5**, 149-159, doi:10.5194/amt-5-149-2012, 2012.
- Peters, S., I. Bejan, R. Kurtenbach, G. Villena, P. Wiesen, and J. Kleffmann, Development of a new LOPAP Instrument for the Detection of O<sub>3</sub> in the Atmosphere, *Atmos. Environ.*, **67**, 112-119, doi:10.1016/j.atmosenv.2012.10.058, 2012.
- Vestreng, V., L. Ntziachristos, A. Semb, S. Reis, I. S. A. Isaksen, and L. Tarrasón, Evolution of NO<sub>x</sub> emissions in Europe with focus on road transport control measures, *Atmos. Chem. Phys.*, **9**, 1503-1520, 2009.

### Key words:

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Nitrogen Oxides, Ozone, Intercomparison, LOPAP

### Collaborating partners/networks:

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Name of research institute or organization:

**Institute of Applied Physics, University of Bern**

Title of project:

Atmospheric Observations with STEAMR/PREMIER receiver prototypes

Project leader and team:

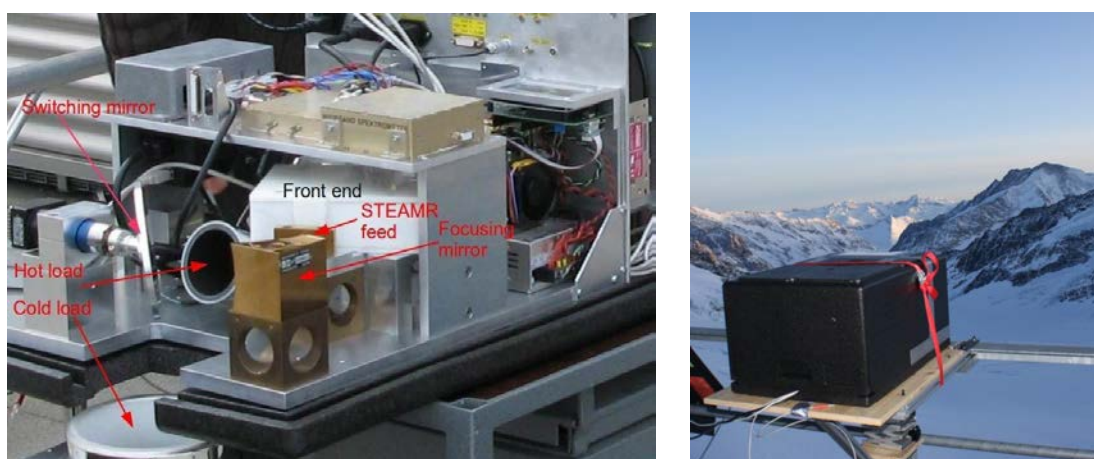
Dr. Axel Murk, project leader  
Matthias Renker, Dr. Mark Whale

Project description:

The “Stratosphere-Troposphere Exchange And climate Monitor Radiometer” (STEAMR) is a multi-beam submillimeter wave limb sounder for the next ESA Earth Explorer Mission PREMIER. The Institute of Applied Physics collaborates with Omnisys Instruments (Sweden) and the Rutherford Appleton Laboratory (UK) in the optical design and the receiver development.

The STEAMR receivers operate in a frequency band between 324 and 355 GHz and consist of either double or single sideband mixers, local oscillators, and broadband digital autocorrelation spectrometers. The radiometric performance of these receivers is of vital importance for the PREMIER mission and has been characterized by detailed laboratory tests at our institute. In order to demonstrate the observing capabilities of STEAMR and to compare the laboratory measurements against realistic spectroscopic signatures we integrated the receiver prototypes in a portable breadboard radiometer that we deployed for first light atmospheric observations at the High Altitude Research Station Jungfraujoch during February/March 2012. The high altitude of this site and the dry atmospheric conditions during winter are mandatory for ground-based observations in this frequency range.

Figure 2 gives an example of the observed spectral lines, mostly from stratospheric Ozone, in comparison with model data. The analysis of the differences between measurement and simulation provides important information about the sideband ratio, channel response and the linearity of the receiver.



*Figure 1. 340GHz radiometer breadboard with the STEAMR receiver prototype, calibration optics and thermal stabilization, installed outdoors on the Jungfraujoch Sphinx terrace.*

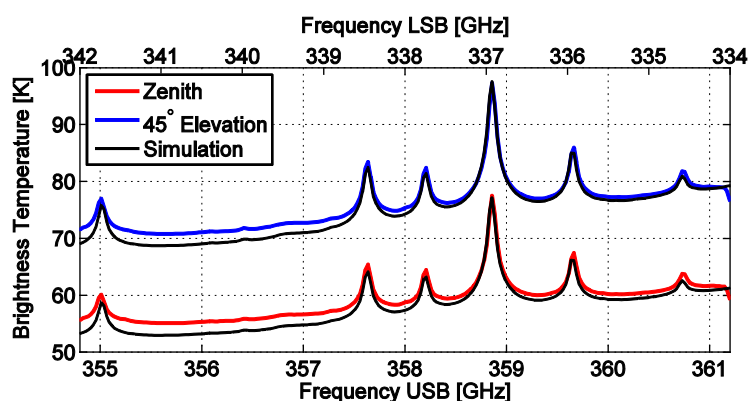


Figure 2. Observed and simulated spectral emission lines with the STEAMR double sideband receiver prototype for two different elevation angles.

The results of the Jungfraujoch observation campaign were so far reported at a conference [1] and in an internal research report [2]. Example results are also included in the ESA Assessment Report for Mission Selection [3]. Further observations and publications are planned in 2013.

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Key words:

Microwave remote sensing, submillimeter wave receiver

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Internet data bases:

[www.iapmw.unibe.ch/research/projects/STEAMR/](http://www.iapmw.unibe.ch/research/projects/STEAMR/)

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Collaborating partners/networks:

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Andres Emrich, Omnisys Instruments AB, Göteborg, Sweden ([www.omnisys.se](http://www.omnisys.se))

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Scientific publications and public outreach 2012:

**Conference papers**

[1] Rea, S. P., M. Renker, B.P. Moyna, D. Gerber, M. Whale, A. Murk, First-light atmospheric observations with a 340 GHz sideband-separating Schottky diode receiver, 37th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), doi: 10.1109/IRMMW-THz.2012.6380381, September, 2012.

**Data books and reports**

[2] Renker M., A. Murk, M. Whale, S. Rea, A. Emrich, U. Frisk, Breadboard receiver testing for STEAMR/PREMIER, IAP Research Report, No. 2012-06-MW, Institut für Angewandte Physik, Universität Bern, 2012.

[3] PREMIER: Report for Mission Selection, ESA SP-1324/3, May 2012  
[http://esamultimedia.esa.int/docs/EarthObservation/SP1324-3\\_PREMIERr.pdf](http://esamultimedia.esa.int/docs/EarthObservation/SP1324-3_PREMIERr.pdf)

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Name of research institute or organization:

**Departement Umweltwissenschaften, Universität Basel**

Title of project:

Quantifying mountain venting of boundary layer air through Rn-222 measurements

Project leader and team:

Dr. Franz Conen, project leader

Mr. Lukas Zimmermann

Dr. Alan Griffiths

Dr. Alastair Williams

Project description:

Our radon detectors at Jungfraujoch and at Bern have been operating almost continuously throughout the year, with the exception of 10 days at the beginning of December 2012, when a failed hard disk shut down operations at Bern. At Jungfraujoch we had shorter, but more frequent gaps in data coverage at times when ice formation obstructed sample flow through the air inlet. However, most of our efforts during the past year have gone into the analysis of the first two years of data (2010 and 2011) from both stations.

The conceptual framework of our analysis treats radon concentration at Jungfraujoch as a direct measure of ground influence (which means our definition of ground influence is weighted by radioactive decay of radon). Within this framework we presume that:

- Anabatic flow up the mountain has a diurnal signature with maximum concentrations in the afternoon
- Non-anabatic and local influence can happen at any time of day
- More distant ground influence is characterised by lower radon *variability*

We ranked all days by their contribution to the amplitude of the composite diurnal cycle of the full data set. According to their rank, blocks of 120 days each can be selected with the clearest anabatic, baseline and non-anabatic ground influence.

Composite diurnal plots of radon concentrations at Jungfraujoch and Bern for these three blocks of days show (Figure 1):

- Boundary-layer air at Bern is indistinguishable from the air at Jungfraujoch for a couple of hours in the afternoon on the most anabatic days
- Baseline days are characterised by the lowest radon concentrations at Jungfraujoch, but with a larger diurnal cycle at Bern than non-anabatic days (large diurnal cycle at Bern implies stronger night time stability: light winds, clear)
- Non-anabatic have an insignificant diurnal cycle at Jungfraujoch, but twice as large radon concentrations as baseline days, and the weakest diurnal cycle at Bern (i.e. less stable nights)

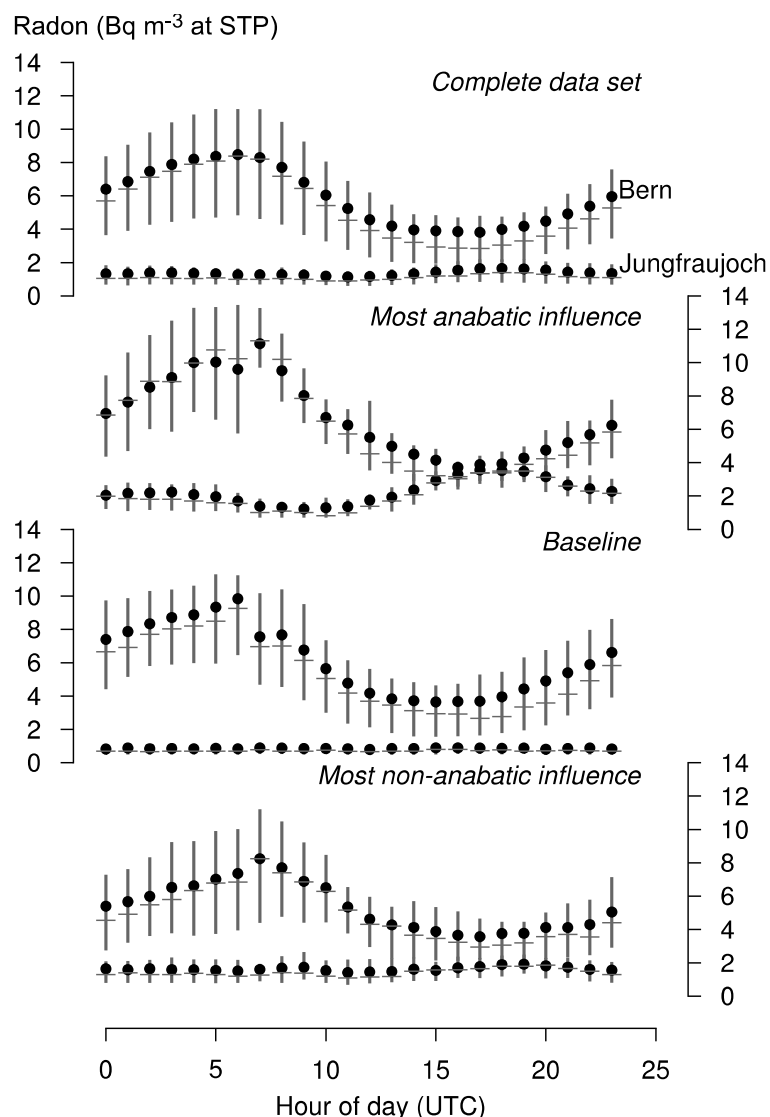


Figure 1: Jungfraujoch and Bern radon diurnal composites (note: includes only northwest winds, but including all wind directions does not change the overall picture). The mean in each bin is marked by a dot, the median by a horizontal bar and the vertical bar extends from the 25th to the 75th percentile.

An interesting feature revealed by our analysis is the apparent ‘on-off’ nature of the anabatic contribution to the daily radon loading at Jungfraujoch (Figure 2, top panel), although the radon seasonal cycle is pretty smooth (Figure 2, lower panel). Possibly, the relatively sudden change in mountain slope albedo, with the disappearance and re-appearance of snow cover in spring and autumn, respectively, and the related ability of slope surfaces to warm up during the day and drive an anabatic flow or not, may play a role in this.

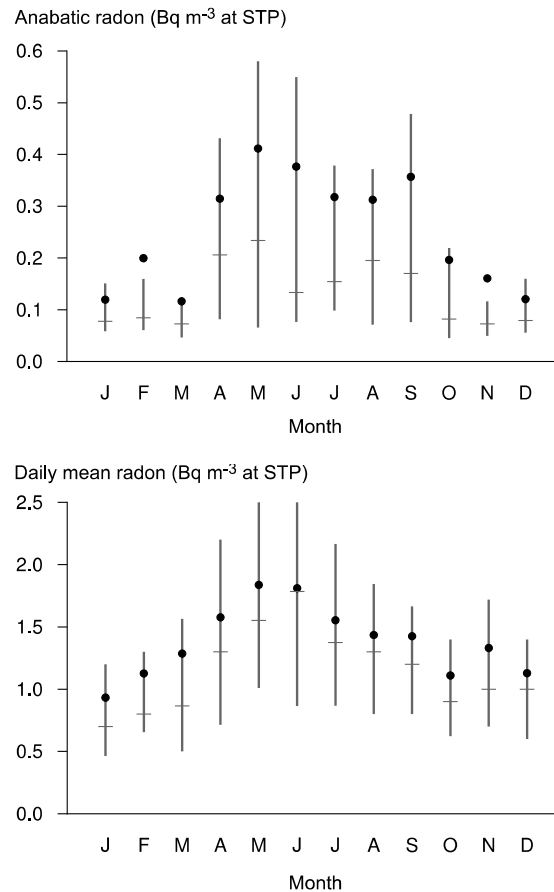


Figure 2: Anabatic contribution to the daily radon loading seasonal cycle (top) and radon seasonal cycle (bottom) at Jungfraujoch. The mean in each bin is marked by a dot, the median by a horizontal bar and the vertical bar extends from the 25th to the 75th percentile.

Key words:

Atmospheric transport and mixing, planetary boundary layer, free troposphere, radon, tracer

Internet data bases:

<http://pages.unibas.ch/environment/>

<http://radon.unibas.ch/>

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Name of research institute or organization:

**Departement Umweltwissenschaften, Universität Basel**

Title of project:

Biological ice nucleators at tropospheric cloud height

Project leader and team:

Dr. Franz Conen, project leader

Mr. Emiliano Stopelli

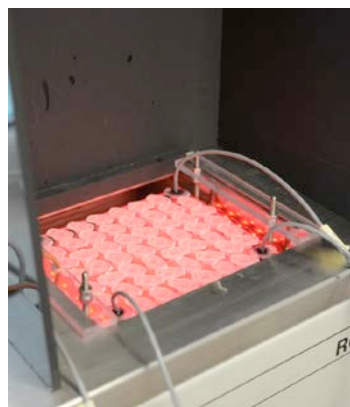
Mr. Lukas Zimmermann

Project description:

The relevance of biological ice nucleation for cloud processes, such as initiating precipitation, is ambiguous. Very little is known about abundance and nucleation spectra of biological ice nucleators (IN) at tropospheric cloud altitudes. Reasons for this are typically small number concentrations of IN active at relatively warm temperatures and related difficulties in their detection. However, this does not mean that biological IN do not play a potentially important role in clouds. At temperatures between about -3 to -8 °C a few initial ice particles can multiply in number by orders of magnitude through the process of riming and ice splintering (Hallett-Mossop process) and thereby initiate precipitation.

In 2012 we pursued two goals. First, to improve and facilitate the measurement of IN active at warm temperatures ( $> -12^{\circ}\text{C}$ ) through technical innovation. Second, to get more data on IN number concentrations in air and in precipitation (snow) at tropospheric cloud altitude, to which Jungfraujoch Station provides excellent access.

Regarding the first goal, we made some progress by developing and building an apparatus for immersion freezing assays. Its principle of operation is based on the reduction of light transmission through water upon freezing because light gets scattered by inclusions in ice, such as air bubbles and brine pockets. In immersion freezing assays the phase change from liquid to ice can therefore be detected visually when the sample changes from translucent to 'milky'. The apparatus we built around this principle consists of an array of 8 x 7 red LEDs submersed in a cold bath and pointing upwards through 0.5 ml Eppendorf tubes containing between 0.1 and 0.4 ml sample liquid (e.g. snow water). Four tubes have a Pt<sub>1000</sub> temperature sensor cast in (Figure 1). A camera in a black hood placed above the sample array looks down onto the lids of the tubes, which are illuminated from below. Images are recorded every five seconds. Light intensity in the area of each tube lid is extracted from each image and written into a file together with the temperature at the time the image was taken. This apparatus is an open hardware (and software) project and we have already made some effort to publicise it, including pictures, technical drawings and an example of an application (<http://azug.minpet.unibas.ch/~lukas/FNA/index.html>).



*Figure 1: Part of the freezing nucleation apparatus, showing sample tubes and temperature sensors mounted on top of an array of red LEDs and submerged in the cold bath, ready for analysis.*

The apparatus was already useful in analysing snow samples for IN at Jungfraujoch. Snow was collected in a Teflon®-coated tray ( $0.1 \text{ m}^2$ ) over periods of a few hours on the upper Sphinx terrace, then melted slowly, immediately transferred into Eppendorf tubes and exposed to decreasing temperatures in a cold bath, where freezing temperatures were recorded with above mentioned apparatus. Analysis of one snow sample takes less than  $\frac{1}{2}$  an hour. The nucleation spectra show generally larger number concentrations of IN at the beginning of November, when air temperatures were on average around  $-9^\circ\text{C}$ , compared to the beginning of December, when mean air temperatures were around  $-18^\circ\text{C}$  (Figure 2). However, in December onset of freezing seemed earlier. One third of the samples had a detectable number of IN already at  $-5.0^\circ\text{C}$ , whereas in November this was the case only at temperatures  $< -6.0^\circ\text{C}$ . These results are the first field data in the SNF-funded PhD project, which Emiliano Stopelli started in September 2012 and which will continue at least until 2015.

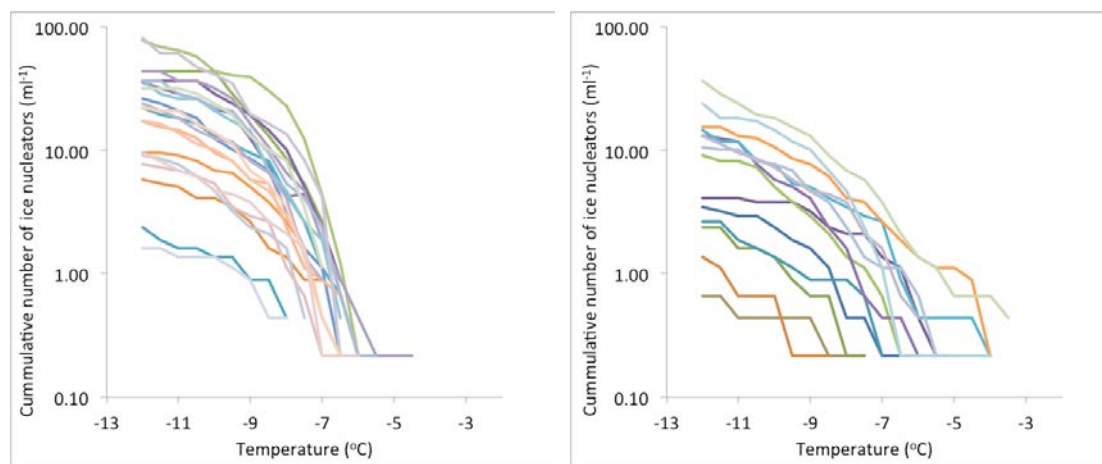


Figure 2: Ice nucleation spectra of snow water collected at Jungfraujoch (left) between 31. October and 05. November 2012 and (right) between 07. and 12. December 2012.

In 2012, four students from the University of Basel started their BSc project on the topic of IN at tropospheric cloud height at Jungfraujoch. Two have already completed their work, finding, among other things, that number concentrations of IN at Jungfraujoch ( $\text{IN m}^{-3}$ ) are well below those at urban  $\text{PM}_{10}$  monitoring stations in Switzerland, but close to, or only slightly below, those at rural monitoring stations at low altitudes. The specific IN activity of  $\text{PM}_{10}$  (number of IN per unit mass of  $\text{PM}_{10}$ ) is largest in urban environments and smallest at Jungfraujoch during Saharan dust events. However, in the absence of a Saharan dust event,  $\text{PM}_{10}$  at Jungfraujoch has a larger specific activity (at temperatures  $< -7^\circ\text{C}$ ) than  $\text{PM}_{10}$  at rural sites, possible because of a non-negligible contribution of urban  $\text{PM}_{10}$ . All filters were generously provided by Martin Steinbacher, Claudia Zellweger and Christoph Hüglin at Empa. In total, we have analysed 42 filters from Jungfraujoch. The method of analysis has been published (Conen et al., 2012). Our data so far show only a weak positive correlation ( $r^2 = 0.19$ ) between the log of IN number concentration and the log of  $\text{PM}_{10}$  mass. The lower and upper quartiles of number concentrations of  $\text{IN m}^{-3}$  active at  $-10^\circ\text{C}$  are 1.6 and 8.2, respectively (Table 1). Lower and upper quartiles for the same IN numbers per microgram  $\text{PM}_{10}$  are 0.3 and 1.4, respectively. To date, we have analysed mainly filters from the months of March to July. We plan to expand this work and link it to other measurements, such as IN analyses of snow samples.

Table 1: Number concentrations of ice nucleators found on  $PM_{10}$  filters from Jungfrauoch.

Date	$PM_{10}$ ( $\mu\text{g m}^{-3}$ )	IN at $-10^\circ\text{C}$ ( $\text{m}^{-3}$ )	IN at $-10^\circ\text{C}$ / $\mu\text{g } PM_{10}$
10.06.10	5.9	2.0	0.3
11.06.10	7.1	11.6	1.6
29.06.10	7.8	15.5	2.0
30.06.10	5.9	13.8	2.3
01.07.10	6.6	14.6	2.2
09.07.10	18.9	6.3	0.3
10.07.10	28.0	9.5	0.3
11.07.10	14.8	12.0	0.8
03.04.11	18.4	2.2	0.1
04.04.11	6.9	8.4	1.2
05.04.11	3.0	7.5	2.5
06.04.11	1.9	0.4	0.2
07.04.11	5.4	1.6	0.3
10.04.11	27.7	1.0	0.0
11.04.11	27.2	1.3	0.0
12.04.11	9.6	2.8	0.3
13.04.11	3.0	3.5	1.2
14.04.11	3.1	10.1	3.3
15.04.11	4.4	0.6	0.1
19.04.11	6.3	2.7	0.4
20.04.11	6.6	1.8	0.3
21.04.11	8.4	3.2	0.4
11.05.11	8.6	3.9	0.4
12.07.11	12.3	6.3	0.5
21.08.11	32.0	5.2	0.2
16.03.12	1.6	2.8	1.8
17.03.12	5.3	1.6	0.3
18.03.12	1.2	0.9	0.7
19.03.12	0.7	0.2	0.2
20.03.12	1.9	1.4	0.8
13.04.12	1.5	0.4	0.3
14.04.12	0.8	0.7	0.9
15.04.12	1.4	0.6	0.4
26.04.12	1.0	5.2	5.2
27.04.12	14.7	4.4	0.3
28.04.12	13.9	4.6	0.3
19.06.12	8.0	6.3	0.8
20.06.12	20.5	15.9	0.8
21.06.12	12.8	9.9	0.8
22.06.12	2.1	33.2	15.8
23.06.12	2.0	3.6	1.8
24.06.12	2.6	3.9	1.5
MIN	0.7	0.2	0.0
MAX	32.0	33.2	15.8
<b>MEDIAN</b>	<b>6.5</b>	<b>3.7</b>	<b>0.5</b>
AVERAGE	8.9	5.8	1.3
25 <sup>th</sup> percentile	2.2	1.6	0.3
75 <sup>th</sup> percentile	12.7	8.2	1.4

Key words:

Ice nucleation, biological, snow,  $PM_{10}$

Internet data bases:

<http://pages.unibas.ch/environment/>

Collaborating partners/networks:

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Group for Climate Gases, Empa, Dübendorf

NABEL, Empa, Dübendorf

Dr. Cindy Morris, Plant pathology research unit, INRA, Avignon, France

Scientific publications and public outreach 2012:

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**Refereed journal articles and their internet access**

Conen, F., S. Henne, C.E. Morris, C. Alewell, Atmospheric ice nucleators active  $\geq -12$  °C can be quantified on PM<sub>10</sub> filters, *Atmospheric Measurement Techniques*, **5**, 321-327, doi: 10.5194/amt-5-321-2012, 2012.  
<http://www.atmos-meas-tech.net/5/321/2012/amt-5-321-2012.html>

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Name of research institute or organization:

**Institute for Chemical and Bioengineering,  
Swiss Federal Institute of Technology, ETH Zurich**

Title of project:

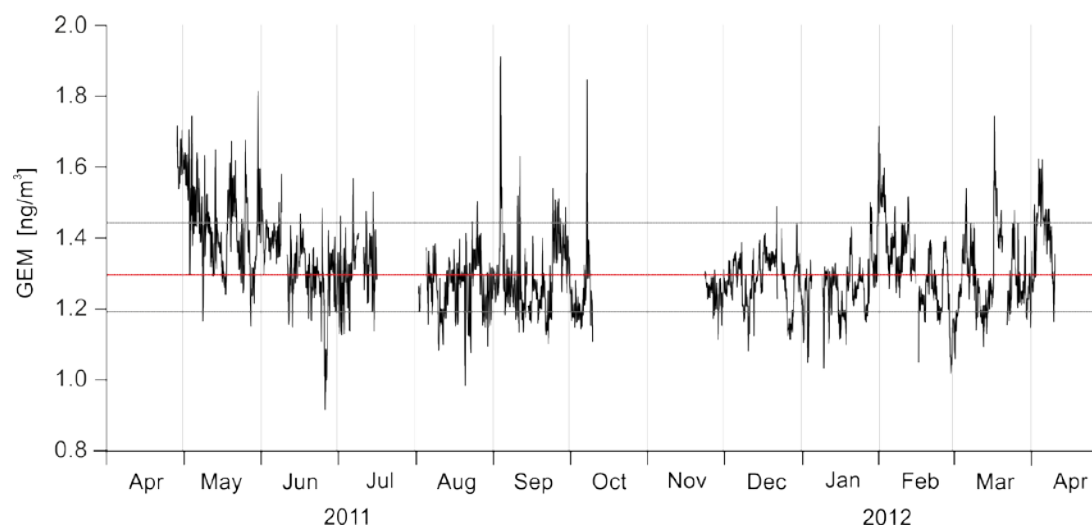
Source regions of atmospheric mercury at the High Alpine Station Jungfraujoch

Project leader and team:

Dr. Christian Bogdal, project leader  
Basil Denzler, Dr. Sandy Ubl

Project description:

Mercury is a heavy metal of particular concern due to its ability to bioaccumulate in ecosystems, and its significant negative effects on human health and the environment. Long term human exposure to small amounts of mercury has been shown to result in serious neurological impairments [1]. Due to its long residence time in the atmosphere, mercury undergoes long-range atmospheric transport [2]. Thus, mercury can occur in regions far away from its initial emission sources. For an improved understanding of the atmospheric fate and transport of gaseous elemental mercury (GEM), we measured GEM from April 2011 to April 2012 in the Sphinx Observatory at the High Altitude Research Station Jungfraujoch (3580 m a.s.l.) and applied a Lagrangian particle dispersion model (LPDM) to analyze the experimental data. Measurements were performed with cold vapor atomic fluorescence spectroscopy, calibrated with an internal GEM permeation source and providing a high sensitivity (detection limit: 0.1 ng/m<sup>3</sup>) with a high temporal resolution (measurement frequency: 5 minutes). The observed concentrations of GEM are shown in Figure 1.



*Figure 1. Gaseous elemental mercury (GEM) concentrations at Jungfraujoch averaged on a 3 hourly time scale, evolving around the median of 1.3 ng/m<sup>3</sup> (red line). The light gray lines represent the 10% lowest (lower gray line) and the 10% highest (upper gray line) concentrations.*



The GEM concentrations measured at Jungfraujoch are comparable to background levels measured worldwide [2]. The median over the whole sampling period is  $1.3 \text{ ng/m}^3$  with a standard deviation of  $0.14 \text{ ng/m}^3$ . The GEM concentrations were slightly higher in winter and spring (median:  $1.4 \text{ ng/m}^3$ ) compared to summer and autumn (median:  $1.3 \text{ ng/m}^3$ ).

To identify potential source regions of GEM measured at Jungfraujoch, we used the LPDM FLEXPART. FLEXPART was run backward in time using ECMWF IFS wind fields with a global grid spacing of  $1^\circ$  by  $1^\circ$  degree [3]. During every 3-h interval, 50'000 particles were released at the measurement point and were followed backward in time for 10 days. In backward mode, FLEXPART calculates an emission sensitivity function [ $\text{s}\cdot\text{kg/m}^3$ ]. The emission sensitivity close to the surface (0 – 100 m) is called footprint and is of particular interest because most emissions occur near the ground. The footprints thus indicate where the air has resided near the ground and could take up pollutants before arriving at the monitoring station. We summed up the footprints for times when the measured GEM concentrations were above the 90% percentile (data points above the upper gray line in Figure 1) and below the 10% percentile (data points below the lower gray line in Figure 1). These footprints were then normalized by the average footprint resulting from the whole measurement period. Values above 0.1 in Figure 2 indicate that high measured GEM concentrations are preferentially associated with transport through this region. Figure 3 shows that for the period of low GEM concentrations, no value above 0.1 could be observed over GEM emission regions.

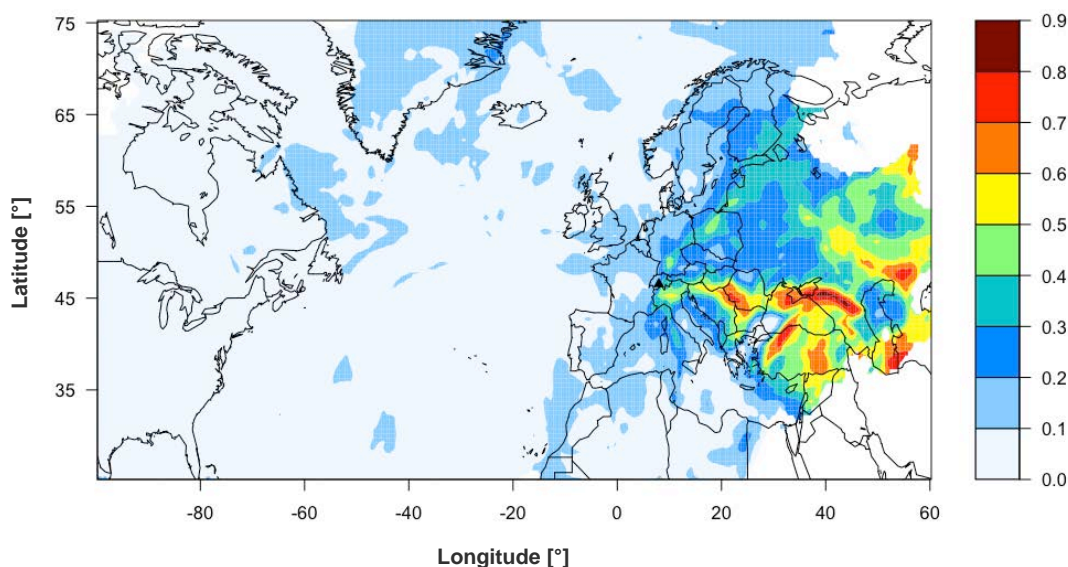


Figure 2. Potential source regions for **high GEM concentrations** at Jungfraujoch indicated by values above 0.1.

For times when the highest 10% of GEM were measured, the potential source regions were mainly located over Eastern and Central Europe. Possible anthropogenic sources of GEM from these regions are possibly the use of fossil fuel, particularly coal burning, for electrical power generation and heating, where GEM is unintentionally emitted [4]. Conversely, for periods when the lowest 10% of GEM concentrations were observed, the potential source regions were located west of Jungfraujoch.

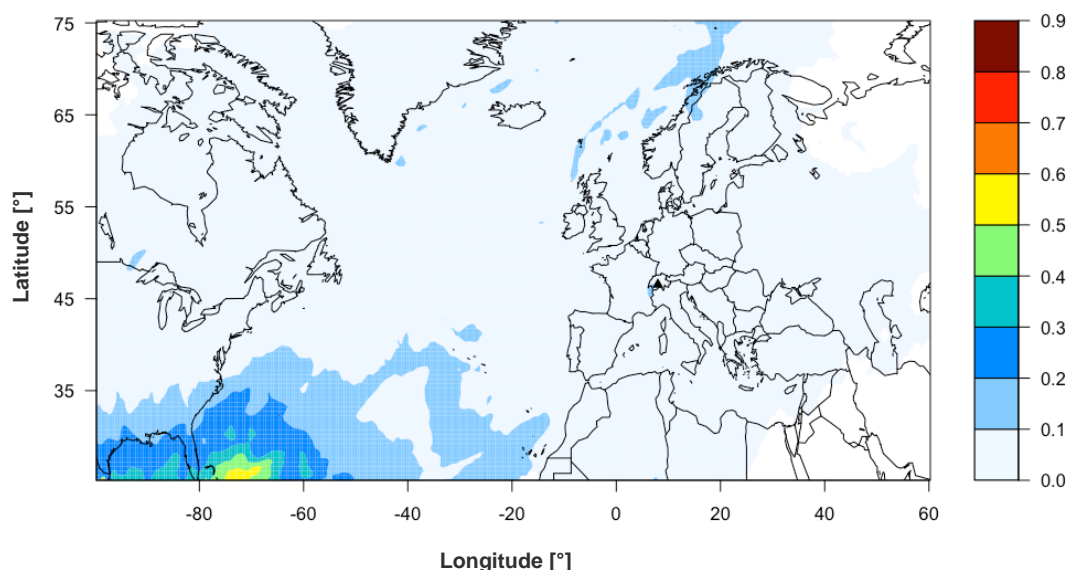


Figure 3. Potential source regions for **low GEM concentrations** at Jungfraujoch indicated by values above 0.1.

In this study, we showed that measurements of GEM at trace levels with a high temporal resolution combined with backward LPDM are an efficient tool enabling the identification of possible source regions of GEM. The observed source regions of GEM east of Jungfraujoch confirm the existing global GEM emission inventories predicting higher emissions of GEM in these countries as well [4].

The reported data set covers a period of almost one year with GEM pollution events occurring mainly in winter and spring. For a more robust identification of GEM source regions, a longer monitoring period of GEM concentrations is necessary. For more information about possible sources further east of the regions covered so far, particles in the FLEXPART model could be followed backward in time for longer than 10 days.

Our study on source apportionment of background concentrations of GEM provides an important contribution to the current process at the United Nations Environmental Programme (UNEP) to establish a global convention on mercury with the goal to reduce environmental contamination by mercury. To fulfill this goal, UNEP recommends that a global monitoring network on atmospheric mercury should be established to ensure that the required field data are available. Switzerland takes also part in the negotiations on global mercury regulations and strongly supports these international efforts.

#### Key words:

Mercury, gaseous elemental mercury, long-range transport, air monitoring, trajectory modeling, Lagrangian particle dispersion model

#### Collaborating partners/networks:

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LPDM modeling: Dr. Stephan Henne, EMPA, Dübendorf, Switzerland

#### Scientific publications and public outreach 2012:

##### Refereed journal articles and their internet access

[1] Clarkson, T.W., L. Magos, The toxicology of mercury and its chemical compounds. Crit. Rev. Toxicol. **36**, 609-662 (2006).

- [2] Sprovieri, F., N. Pirrone, R. Ebinghaus, H. Kock, A. Dommergue, A review of worldwide atmospheric mercury measurements, *Atmos. Chem. Phys.*, **10**, 8245-8265, 2010.
- [3] Uhl, S., M. Scheringer, A. Stohl, J.F. Burkhardt, K. Hungerbühler, Primary source regions of polychlorinated biphenyls (PCBs) measured in the Arctic, *Atmos. Environ.*, **62**, 391-399, 2012.
- [4] Pacyna, E.G., J.M. Pacyna, K. Sundseth, J. Munthe, K. Kindbom, S. Wilson, F. Steenhuisen, P. Maxson, Global emission of mercury to the atmosphere from anthropogenic sources in 2005 and projections to 2020, *Atmos. Environ.*, **44**, 2487-2499, 2010.

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**Institut für Veterinär Bakteriologie, Universität Bern  
Freie Universität Berlin**

Title of project:

Transport and survival of desert soil- and rock surface inhabiting micro-organisms in atmospheric mineral dust.

Project leader and team:

Prof. Joachim Frey, Institute of Veterinary Bacteriology, University of Bern  
Prof. Dr. Anna Gorbushina, Freie Universität Berlin

Project description:

The part of the project at Jungfrauoch targets samplings of dust from the air after Sahara storm. For this purpose, 2 different sampling systems are prepared to be mounted temporarily at Jungfrauoch, i) a filter sampler that collects air on sterilized filters and ii) a Coriolis sampler taking liquid samples of sand storm thus having the advantage of including also electrically charged particles that might be lost by the filter sampler. Both devices are designed so that they can be easily installed and withdrawn after use.

**As in 2012 no Sahara storm was forecasted, no activities at the Jungfrauoch facilities were implemented.**

Key words:

Microbiology, Sahara Storm, Wind Transmission, Aeolian, Firmicutes, Actinobacteria, Geodermatophilaceae, Nocardiodaceae, Solirubrobacteraceae, Proteobacteria, Oxalobacteraceae, Rhizobiales, Sphingomonadaceae, Bacteroidetes, Cytophagaceae, Ascomycota

Collaborating partners/networks:

Freie Universität Berlin, Fachbereich Biologie, Chemie und Pharmazie & Geowissenschaften, Berlin, Germany, Prof. Anna Gorbushina, Prof. W. Broughton  
Université de Genève, Département de Biologie, végétale, Dr. Joceline Favet  
Bundesanstalt für Material-forschung, und -prüfung, Berlin, Germany, Prof. Anna Gorbushina

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Favet J., A. Lapanje, A. Giongo, S. Kennedy, Y.Y. Aung, A. Cattaneo, A.G. Davis-Richardson, C.T. Brown, R. Kort, H.J. Brumsack, B. Schnetger, A. Chapell, J. Kroijenga, A. Beck, K. Schwibbert, A.H. Mohamed, T. Kirchner, P.D. de Quadros, E.W. Triplett, W.J. Broughton, A.A. Gorbushina, Microbial hitchhikers on intercontinental dust: catching a lift in Chad, The ISME Journal, doi:10.1038/ismej.2012.152., 2012.  
<http://www.nature.com/ismej/journal/vaop/ncurrent/full/ismej2012152a.html>

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Name of research institute or organization:

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**Peter E. Zingg**

Title of project:

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Activity and migration of bats at Jungfrauoch

Project leader and team:

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Dr. Peter E. Zingg, project leader  
Martin Fischer, custodian

Project description:

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It is known that certain populations of specific European bat species migrate seasonally in SW (autumn) and NE (spring) direction. So far, studies about bat migration in the European Alps took place at altitudes below 3000 m.a.s.l. In an initial exploratory study we collected information about bat activity at the Jungfrauoch. Additionally, we got first hints about which species do cross the Jungfrauoch in which season, under which meteorological conditions and around what night-time.

Flying bats use an echolocation system to orientate themselves, to catch food and for communication. These calls are predominantly in the ultrasound range. To detect flying bats at Jungfrauoch, we exposed an ultrasound datalogger on the glacier passage at Jungfrauoch at 3480 m.a.s.l. in nights with an evening air temperature above 0°C (due to the limited energy budgets of bats, we assumed that the probability to encounter flying bats is greater at higher air temperatures and at an obstacle free passage). The about 4300 files with recorded ultrasound were transferred to a well-structured database and scanned for bat calls, mainly manually. In spring 4% and in autumn 2% of the files contained bat calls; the rest were files with wind and other noise. In further steps of the workflow, criteria for the taxonomic assignments have to be fixed, so that the bat calls can later be classified to an appropriate level (species, species-complex or genus). Identification of bat species by their calls is difficult and in many cases calls can only be assigned to a species-complex or to a genus.

In 33% of the study nights in spring (n=15) and 32% of the study nights in autumn (n=22) we recorded bat calls. The analyses not finished to this day yet, we identified three to four different bat species in springtime and seven to eight bat species in autumn.

Various facts are remarkable such as the “climbing” of bats to 3480 m.a.s.l. at the Jungfrauoch, the high number of different species that cross over this altitude, at least in autumn, and that the bats have to cover a distance of approximately 22 kilometers in the south of the Jungfrauoch, an area only covered with rocks and glaciers (along the great Aletsch glacier or the Lötschental).

Key words:

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Bats, chiroptera, migration, high altitude

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Name of research institute or organization:

**Cardiovascular Prevention & Rehabilitation, Swiss Cardiovascular Centre Bern, University Hospital (Inselspital), 3010 Bern**

Title of project:

Effect of high altitude exposure on hemodynamic response to exercise in patients with mild congenital heart disease

Project leader and team:

Ass. Prof. Jean-Paul Schmid, project leader

Dr. Andreia Schmidt, Dr. Mladen Pavlovic, Lukas Minder, Thomas Radtke, Dr. Matthias Wilhelm, Prof. Hugo Saner

Project description:

***Clinical Background:***

Spending time at high altitude for recreational activities such as skiing or ski touring, hiking or going snowshoeing is common practice in Switzerland. Being unable to participate with their peers in at least some of the less strenuous activities at high altitude poses a severe impact on the quality of life for the persons concerned. This is actually the case for a big number of adolescents with congenital heart disease.

Adolescents with congenital heart disease suffer from a reduced exercise tolerance compared to healthy subjects of the same age. The most obvious reason for this may be an altered hemodynamic response to exercise due to the underlying heart disease. However, it is known that central hemodynamic factors are not the main determinants of exercise capacity. Instead, training status and the condition of the peripheral muscles are much more important. The reason for the physical deconditioning often found in these patients may also originate from an overprotection of these children by their parents or carers during their childhood years, leading sometimes to almost complete exercise abstinence. Insecure parents often rely on clinicians to advise them on sports activities that their children can perform safely. Unfortunately, at this stage, there are no scientific grounds to base their recommendations on.

Based on our previous studies on patients with coronary artery disease and patients with stable heart failure we assume that the risk of serious adverse events with high altitude exposure in these patients is low. Nevertheless, for this first study of high altitude exposure of patients with congenital heart disease we selected patients with minor congenital heart disease in New York Heart Association (NYHA) functional class I or II. None of these patients are known for having significantly impaired cardiovascular circulation at low land, significant intracardiac shunts, elevated pulmonary artery pressure at rest, or decreased oxygen saturation. However, a rise in pulmonary artery pressure and a consecutive deterioration of right ventricular function with decrease of cardiac output during exercise at high altitude cannot be excluded in these patients.

Few studies have addressed the hemodynamic effects of altitude exposure in patients with congenital heart disease. Although we consider the risk of a cardiac incident as low, an abnormal adaptation of right ventricular function or a disproportionate rise in pulmonary or systemic arterial pressure with an impaired adaptation of cardiac output would discourage us from recommending high altitude activities. The aim of this study was therefore to measure the hemodynamic response of acute high altitude exposure during exercise in adolescents with congenital heart disease and to compare it to a healthy control group.

**Trial population:**

We included 16 adolescents with congenital heart disease (56% male, mean age 14.6 years) recruited at the Swiss Cardiovascular Centre Bern, University Hospital Bern, and 21 healthy age-matched adolescents (62% male, mean age 14.8 years) from a local school.

**Research aim and hypothesis:**

The aims of the study were to test the hemodynamic response (cardiac output) of a steady state exercise at high altitude (3454 m) in adolescents with congenital heart disease and to measure the influence of high altitude on single components of cardio-pulmonary response during a maximal exercise stress test.

We hypothesized that high altitude exposure of adolescents with congenital heart disease may be associated with a deterioration of right ventricular function during exercise and hence a decrease of cardiac output compared with healthy controls.



*Fig. 1: Technical equipment at the Jungfrauoch: from left to right: echocardiography equipment, ergometer with set-up for inert gas rebreathing measurement (balloon mounted to the mouth piece) and cart with gas analyser (Innocor<sup>®</sup>) and monitor.*

**Trial design:**

Baseline testing was performed at the Cardiovascular Prevention and Rehabilitation Centre at the University Hospital in Bern (altitude 540 m), and included echocardiography, cardiopulmonary exercise stress testing on a cycle ergometer, pulmonary function testing, measure of cardiac output during a submaximal steady state exercise test by the non-invasive inert gas rebreathing method (Innocor<sup>®</sup>) and a 24h ECG recording. Within a time period of ten weeks the same tests were performed on the Jungfrauoch (altitude 3454 m) in groups of three to five adolescents on a single day. Testing required approximately 2-3 hours and the subjects had an additional two hours for their own recreation on the Jungfrauoch.

**Results:**

Table 1 shows the hemodynamic response during a symptom limited exercise stress test at 540 m above sea level and at high altitude (3454m) among grown-up congenital heart disease (GUCH) patients in comparison with the healthy control group. Although the heart disease of the GUCH patients was only minor, their exercise capacity was significantly lower. This was also reflected by a lower heart rate and lower ventilation during maximal exercise at low land. However at high altitude, these differences were not significant anymore, indicating the good tolerance of hypoxia in this patient population.



	Bern (540m)			Jungfrauoch (3454m)		
Exercise parameters	Healthy	GUCH	P-value	Healthy	GUCH	P-value
Systolic BP, mmHg	109.6±7.6	113.1±16.1	.514	113.2±7.6	116.8±15.6	.254
Diastolic BP, mmHg	56.3±5.4	58.0±5.9	.338	60.3±6.3	60.5±8.3	.964
Heart rate at rest, 1/min.	67.5±9.3	64.6±7.9	.369	79.0±15.4	80.2±8.8	.293
Exercise capacity, Watt	199.7±39.3	164.1±52.2	.009	157.9±40.4	144.1±41.8	.752
Max. heart rate, 1/min.	188.8±10.4	179.4±13.1	.039	189.6±8.8	185.3±11.2	.198
O <sub>2</sub> saturation at rest, %	97.0±1.0	96.9±1.0	.883	91.6±1.5	90.8±0.9	.213
O <sub>2</sub> saturation at max. exercise, %	95.6±0.8	94.8±1.3	.044	83.9±2.5	82.7±2.0	.345
Peak O <sub>2</sub> uptake, ml/kg/min.	43.7±7.5	40.2±9.2	.262	35.4±6.7	35.9±6.7	.538
O <sub>2</sub> uptake at VT	21.9±5.2	21.8±8.9	.459	18.2±7.7	17.8±7.8	1.0
Max. ventilation, l/min.	92.8±22.9	75.4±18.7	.018	89.4±27.3	82.9±15.3	.702
VE/VCO <sub>2</sub> slope	28.0±3.5	28.7±3.0	.440	36.6±4.9	36.2±4.3	1.0

Table 1: Cardiopulmonary exercise parameters of a symptom limited exercise stress test on a bicycle ergometer at low land (540m) and at the Jungfrauoch (3454m). P-value indicates differences between the groups.

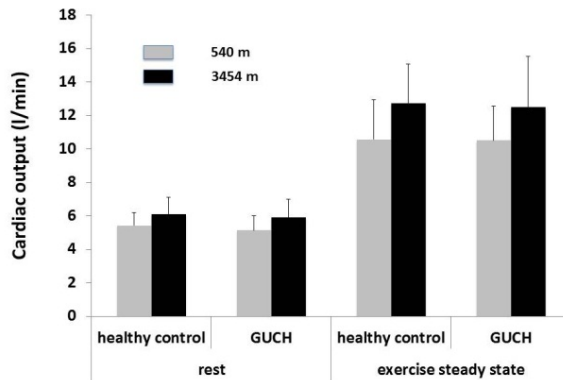
BP: blood pressure; GUCH: grown-up congenital heart disease; VE/VCO<sub>2</sub> slope: ventilatory efficiency; VT: ventilatory (1<sup>st</sup> lactate) threshold.



Fig. 2: Patient during a steady state exercise test for cardiac output measurement by inert gas rebreathing technique. The upper screen shows heart rate and rhythm, the lower screen depicts O<sub>2</sub>-uptake and CO<sub>2</sub> production (blue and red trace respectively).

The hemodynamic response to a submaximal steady state exercise showed a 22.7% and 16.6% increase in cardiac output for the healthy subjects and GUCH patients respectively (c.f. Figure 3). The difference between the groups was not statistically significant (p=0.666).





*Fig. 3: Cardiac output measurements at rest and during steady state exercise at low land (540m) and high altitude (3454m).*

*No differences were noted between the healthy subjects and the GUCH patients.*

### Conclusions:

Adolescents with mild congenital heart disease reveal a reduced exercise capacity at low land when compared with age-matched healthy subjects. However, hemodynamic adaptation to exercise at high altitude is normal in terms of the rise of cardiac output as a compensatory mechanism for hypoxemia. Whether these results can be extended to patients with more severe congenital heart disease has to be explored further.

### Key words:

Grown-up congenital heart disease, high altitude, cardiac output, exercise capacity

### Scientific publications and public outreach 2012:

#### **Refereed journal articles and their internet access**

Cattadori G., J.P. Schmid, P. Agostoni, Noninvasive measurement of cardiac output during exercise by inert gas rebreathing technique. *Heart Fail Clin.*, **2**, 209-215, doi: 10.1016/j.hfc.2008.11.004, 2009.

Schmid J.P., M. Noveanu, R. Gaillat, G. Hellige, A. Wahl, H. Saner, Safety and exercise tolerance of acute high altitude exposure (3454 m) among patients with coronary artery disease, *Heart*, **7**, 921-925, 2006.

#### **Radio and television**

“Wie viel Höhenluft ertragen kranke Herzen?”, Television report about the study “Effect of high altitude exposure on hemodynamic response to exercise in patients with mild congenital heart disease, SRF, “Puls”, June 4, 2012. <http://www.srf.ch/gesundheit/forschung/wie-viel-hoehenluft-ertragen-krank-herzen>

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URL: <http://www.kardrehab.insel.ch/>

Name of research institute or organization:

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**Institute of Physiology, University of Zürich**

Title of project:

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Human adaptation to high altitude

Project leader and team:

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Prof. Carsten Lundby  
Dr. Mikael Sander  
Dr. Peter Rasmussen  
Dr Christoph Siebenmann  
Dr Anne-Kristine Meinild  
Dr. Robert Jacobs  
Prof.Dr.Med Marco Maggiorini  
Dr.Med Matthias Hilty  
Stefanie Keiser  
Mike Hug  
Mario Widmer  
Daniela Flück

Project description:

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The study aim was to find answers to the following questions:

- A. Is four weeks of altitude exposure sufficient to increase red cell blood volume?
- B. Is the reduction in stroke volume at rest and during exercise related to a reduced plasma volume?
- C. Does chronic hypoxic exposure cause substantial sensitisation of the chemoreflex, which at least partially explains the sympathoexcitation of high altitude?
- D. Does mitochondrial function change with hypoxic exposure?
- E. Do changes in sympathetic activity alter cerebral auto regulation?
- F. Do 4 weeks of altitude exposure cause continuous increase in ventilatory sensitivity to CO<sub>2</sub> during NREM sleep and are 4 weeks of altitude exposure associated with increasing instability of ventilatory control during sleep?
- G. Is exposure to hypobaric hypoxia at 3450 m associated with impairment of cognitive and psychomotor function and if so is there an improvement of these skills over the course of the 4 weeks acclimatization period?
- H. Does sleep quality have an influence on red cell mass (question A) and measures of autonomic cardiovascular control (question C and E)?
- I. How do high altitude related changes of the autonomous nervous system activity influence pulmonary hemodynamics?

The data have thus far only been analyzed in its complete for aim D. Here we show that the human mitochondrion adapts to high altitude exposure by optimizing its pathways. This finding has been published.

Key words:

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Human physiology

Collaborating partners/networks:

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University Hospital Zürich

University Hospital Copenhagen

Scientific publications and public outreach 2012:

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**Refereed journal articles and their internet access**

Jacobs R.A., C. Siebenmann, M. Hug, A.K. Meinild, C. Lundby, 28 days at 3,454 m diminishes respiratory capacity but enhances efficiency in human skeletal muscle mitochondria, *FASEB J.*, **26**, 12, 5192-5200, doi: 10.1096/fj.12-218206, 2012.

<http://www.fasebj.org/content/26/12/5192.abstract>

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Name of research institute or organization:

**Pneumology, High Altitude Research Group, University of Munich,  
Germany**

Title of project:

Influence of gender on high altitude adaptation: Comparison of ACE2-levels in plasma between women and men

Project leader and team:

PD Dr. med. Rainald Fischer, Dr. Iris Pircher

Project description:

ACE2 levels might be involved in regulation of plasma fluid in patients with acute mountain sickness. However, it is unclear, whether ACE2 levels are different between men and women during high altitude exposure. We therefore plan a study to evaluate ACE2-levels after short and medium term exposure to an altitude of 3454 m (Jungfrauojoch).

In preparation of this study, we tested the blood draw system, the transport of the blood and the feasibility of capillary blood gases during a small pilot study with four men and one woman.

During this pilot study, we were able to draw blood gases during several occasions with the expected values of PaO<sub>2</sub> and PaCO<sub>2</sub>. The used system (EPOC, Alere Inc., Ontario, Canada) showed to be a reliable system with a broad range of environmental conditions to be used. We were even able to draw blood gases during an outdoor trip to the Mönchsjoehut, with outside temperatures below 0° C.

In contrast, the results obtained by the blood sampling were not reliable and showed apparently wrong data. Therefore, it is necessary to use a cooled centrifuge directly after blood sampling and to maintain an environment with temperatures below 20°C for the whole transport to the final lab.

Key words:

ACE2, blood gases, blood sampling

Scientific publications and public outreach 2012:

For 2013, an abstract was submitted to the German Pneumology Society regarding blood gas sampling in the field. The abstract was accepted as poster presentation on March, 22, 2013.

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Name of research institute or organization:

**Department of Medicine, Unit of Anatomy, University of Fribourg**

Title of project:

Effects of physical exercise and Vascular Endothelial Growth Factor on the neurogliovascular adaption to hypoxia

Project leader and team:

Dr. Enrike G. Argandoña, project leader

Project description:

Microvascular environment plays a fundamental role in the adaptive response to increases in activity, involving an increase in energy demand. To punctual increases in demand, the response is effected by changes in local flow, but if demand remains high, angiogenic process is triggered through the formation of new capillaries from preexisting vessels. The trigger factor of angiogenesis is local neuronal hypoxia as result of increased activity, mediated by angioglioneurins whose main exponent is VEGF. There are situations in which hypoxia is not from an increased activity, but from a decrease in available oxygen, as occurs in the altitude exposure. Our goal is to study the changes underlying microvascular acute adaptation to moderate altitude and the possible effects of physical exercise and environmental enrichment and the behavioural effects of acute altitude hypoxia on spatial and visual memory.

## **MATERIAL AND METHODS**

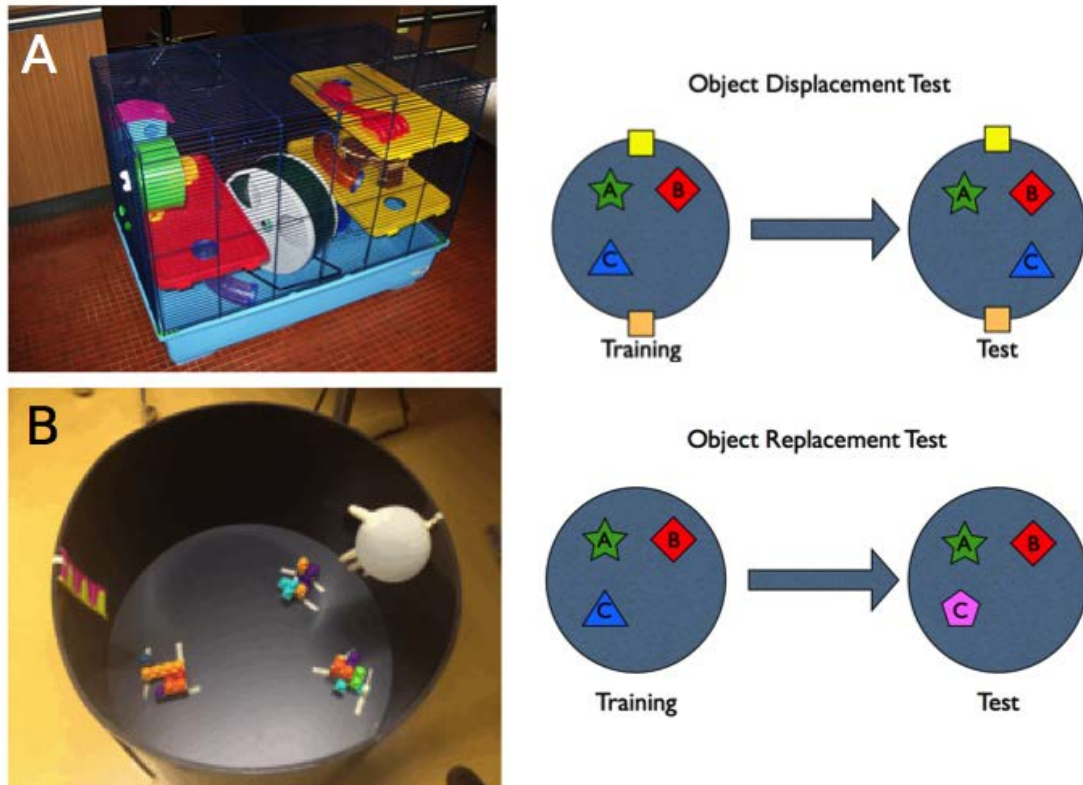
Long Evans Rats were bred at 600 m (P45) and transported to the Jungfrauoch High Altitude Research Station (3450m) in a trip of 150 minutes. We used the following cohorts of 5 rats each: a group was housed indoors in standard laboratory conditions, another group was housed in an enriched environment including free access to running wheel. Behavioural tests were performed from P49 to P56 after a 3 days adaptation to the arena. The environment used for the tasks consists of a black circular open field (diameter 1 m; height 0.5 m) in a dimly-lit room. The objects which have been subjected to exploration of rats are constructed from toy bricks and are fixed to the floor of the open field, 15 cm from the walls. A spatial cue is fixed to the wall. Spatial memory was measured by the Object Displacement Test (ODT), visual memory was measured by the Object Replacement Test (ORT).

### **a) Object Displacement Test (ODT)**

For the training phase of the OD task, three objects are positioned in the open field with spatial cues. For training, each rat is allowed to explore the objects for 3 x 5 minute trials with an inter-trial rest period of 5 minutes. For the testing phase, object C is moved from its original position and rats are reintroduced to the open field 24 hours post-training, for a single 5 minutes trial for each series of experiments. The time spent exploring object C is expressed as a percentage of the total exploration time.

### **b) Object Replacement Test (ORT)**

For the training phase of the OS task, three new objects are positioned in the open field without spatial cues. Training is same as OST with 2 days lap. For the testing phase, 24 hours later, object C is replaced with the novel object in the same position. Each rat is reintroduced to the open field for a single 5 minutes trial. The time spent exploring the familiar objects and the novel object is recorded and expressed as a percentage of the total exploration time.



*Fig. 1a: Pictures of the cage used for Environmental Enrichment (A) and for the arena used for Behavioural tests (B). Picture (B) shows the set for the Object Displacement Test with the three objects and the spatial cues. Fig. 1b: Schema of the Tasks for Object Displacement (ODT) and Object Replacement (ORT). First reflects Spatial Learning and Memory, second Visual Learning and Memory. After a training session composed by 3x5' exposure, the following day a unique session of 5 min. is done by changing the position of one of the objects (ODT) or by changing one of the objects in the same position (ORT).*

## RESULTS

Behavioural experiments show a trend towards a higher exploration activity in environmentally enriched rats, as well as a better performance in visual and spatial learning and memory, as transportation to altitude produced a significant deficit in spatial and non-spatial learning and memory.

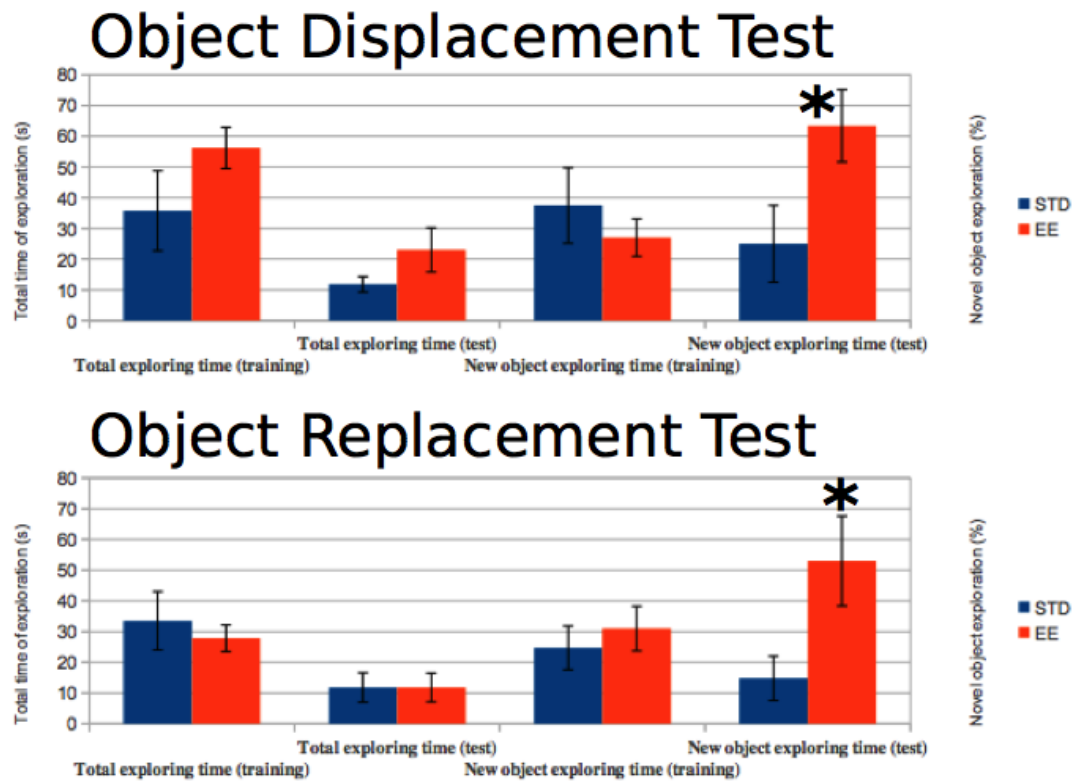


Fig. 2: The graph shows the total exploration time for behavioural tests (in seconds) and the percentage of time exploring the Displaced object (ODT) or the Replaced one (ORT). \* shows significance between standard environment (std) and Environmental Enrichment (EE).

The acute adaptation to moderate altitude is an increasingly relevant issue given the increase in displacements at moderate or high altitudes, with serious consequences such as acute mountain sickness, which in its most severe degree leads to brain edema. Our results show that exercise can play a protective role through adaptive angiogenesis. On the other hand, although exploration time did not differ significantly, altitude seems to have effects on both spatial and visual memory, which are compensated by rearing in a complex environment. More research on the role of angiogenesis in adaptive mechanisms should be performed.

#### Key words:

Angioglioneurins, neuroglivascular unit, environmental enrichment, altitude hypoxia, learning and memory

#### Collaborating partners/networks:

I have made a collaboration with the Institute of Veterinary Physiology, University of Zürich, Switzerland, and eventually we will try to finish the project all together. Also I started a collaboration with Dr. Juan Carlos López Ramos, División de Neurociencias, Universidad Pablo de Olavide, Sevilla, for a future collaboration on the same field of adaptation to altitude in rodents. Therefore a way to allow research from Spain has to be explored.

**Scientific publications and public outreach 2012:**

By now all scientific publications are in progress, and they are due for 2013, nevertheless, the advances have been presented at some conferences and can be accessed online. A paper with preliminary results on the same field, (but not at the HFSJG) can be consulted to understand the basis of the project.

**Refereed journal articles and their internet access**

Argandoña E.G., H. Bengoetxea, S. Bulnes, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Vascular Endothelial Growth Factor: Adaptive changes in the neuroglialvascular unit, *Current Neurovascular Research*, **9**, 1, 72-81, doi: 10.2174/156720212799297119, 2012.

<http://www.eurekaselect.com/76454/article>

**Conference papers**

Argandoña, E.G., H. Bengoetxea, S. Bulnes, R. Ledezma, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Environmental enrichment reverts the cognitive effects of altitude hypoxia inducing changes at the neuroglialvascular unit, 74th Annual Meeting of the Swiss Society for Anatomy, Histology, and Embryology 2012, F1000 Posters 2012, 3: 1302, Zurich, Switzerland, September 7, 2012.

<http://f1000.com/posters/browse/summary/1092456>

Argandoña, E.G., H. Bengoetxea, S. Bulnes, R. Ledezma, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Physical exercise mediates neuroprotective responses to the effects of altitude hypoxia at the neuroglialvascular unit, 8th FENS Forum of Neuroscience 2012, F1000 Posters 2012, 3: 1043, Barcelona, Spain, July 14-18, 2012.

<http://f1000.com/posters/browse/summary/1092145>

Argandoña, E.G., H. Bengoetxea, S. Bulnes, R. Ledezma, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Environmental enrichment reverts the cognitive effects of altitude hypoxia inducing changes at the neuroglialvascular unit, 2013 Annual Meeting of the Swiss Society of Neuroscience, Geneva, Switzerland, February 2, 2013.

**Radio and television**

Arratoiengaren 3.500 metrora (Investigating rat brains at 3500 m), Interview with neuroscientist Enrike G. Argandoña, University of Fribourg, Euskadi Irratia, "Mezularia" April 10, 2012.

<http://www.eitb.com/eu/audioak/osoak/865531/arratoiengaren-3500-metrora--mezularia/> (Basque)

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Name of research institute or organization:

**Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW),  
ETH Zürich**

Title of project:

Glaciological investigations on the Grosser Aletschgletscher

Project leader and team:

Dr. Andreas Bauder, project leader

Dr. Daniel Farinotti, Nina Zoller and Hermann Bösch

Project description:

Long-term glacier observations have been carried out to document glacier variations of Grosser Aletschgletscher and include annual length change measurements since 1880, accumulation and mass balance measurements starting in 1918, repeated map or arial photograph surveys, complemented by stream runoff in the Massa river since 1922 by **BAFU**, respectively.

In an ongoing project the length, area, volume, and mass changes are continuously observed applying modern remote sensing techniques as well as direct field measurements. The research activities are focused on long term trends and seasonal fluctuations. Net volume changes of the entire glacier are calculated by comparison of digital elevation models. Mass balance components with firm accumulation and ablation are measured in detail at Jungfraufirn.

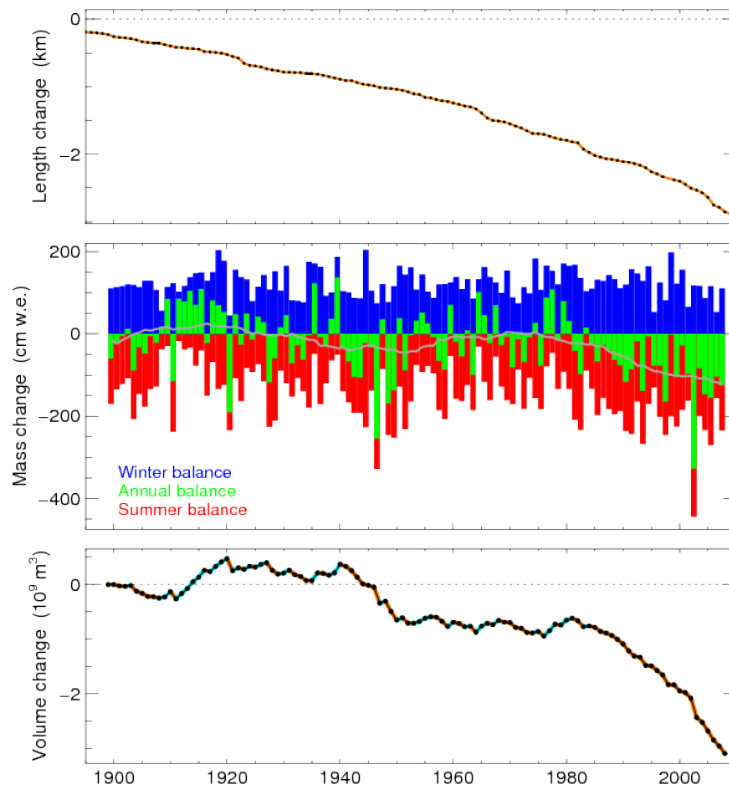


Figure: Frontal variation (top), mass balance (center) and volume change (bottom) of Grosser Aletschgletscher since 1900.

The photogrammetrical evaluation of recent arial photographs taken in fall 2009 allowed a periodic update of the volume change and mass balance for Grosser Aletschgletscher since the last detailed survey of the glaciers in the Aletsch area of 1999. A further significant volume loss over the last decade was observed. The rate of loss increased in comparison with the two previous decades 1980-99. Strong negative mass balances occurred and not a single positive or nearly balanced year was present. As a result of the ongoing mass losses the glacier front further retreated.

Key words:

Glacier measurements, firn accumulation, ice melt, volume change, mass balance

Internet data bases:

[http://www.vaw.ethz.ch/people/gz/abauder/projects/data/gz\\_141\\_variations\\_gr\\_aletschgretscher](http://www.vaw.ethz.ch/people/gz/abauder/projects/data/gz_141_variations_gr_aletschgretscher)

Collaborating partners/networks:

Swiss Glacier Monitoring Network  
Federal Office for the Environment (BAFU)

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Farinotti, D., S. Usselman, M. Huss, A. Bauder and M. Funk, Runoff evolution in the Swiss Alps: projections for selected high-alpine catchments based on ENSEMBLES scenarios, *Hydrological Processes*, **26**, 13, 1909-1924, doi: 10.1002/hyp.8276, 2012. <http://dx.doi.org/10.1002/hyp.8276>

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URL: <http://www.vaw.ethz.ch/divisions/gz/>

Name of research institute or organization:

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**Laboratory of Radiochemistry and Environmental Chemistry,  
Paul Scherrer Institut**

Title of project:

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Determining winter snow accumulation with shallow firn cores

Project leader and team:

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Prof. Margit Schwikowski, project leader  
Dr. Anja Eichler, Johannes Schindler, Pierre-Alain Herren  
Dieter Stampfli, Felix Stampfli (FS INVENTOR)  
Prof. Susan Kaspari, Central Washington University, Ellensburg, USA

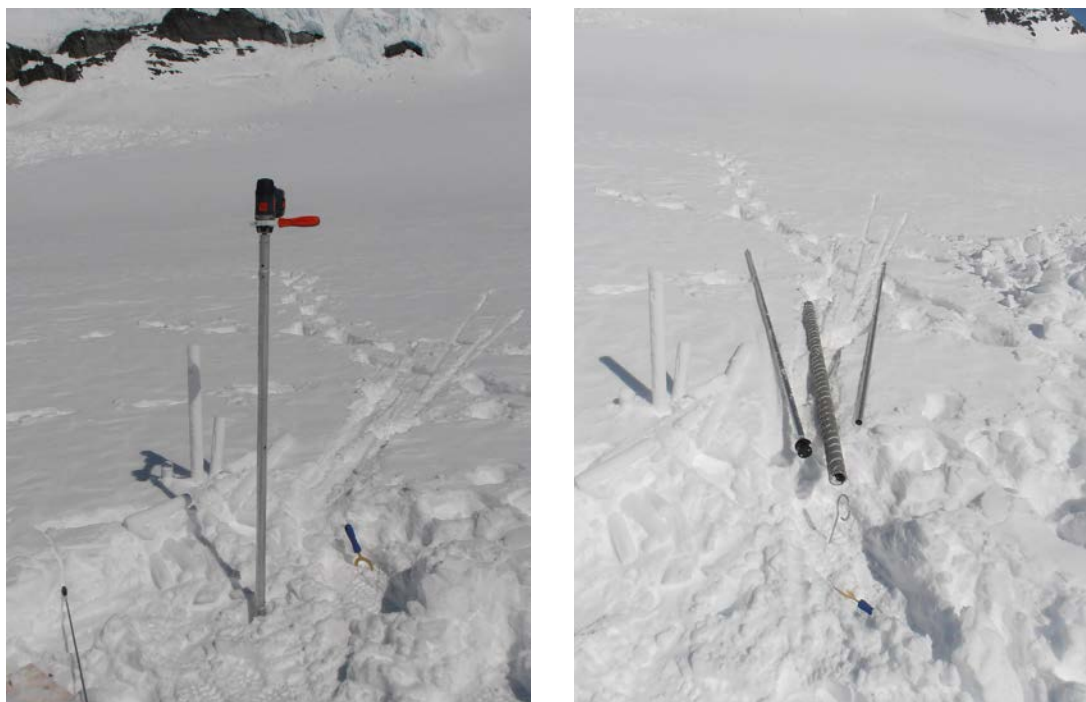
Project description:

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In the frame of a new SNF project „Helicopter-borne GPR for mapping snow accumulation distribution“, snow accumulation, its spatial distribution and its water equivalent are investigated. The development of the winter snow accumulation has a strong impact on the future management of water resources and tourism in the Alps, but also directly affects important cryospheric processes, such as snow avalanche hazards, glacier mass balance and permafrost degradation. In high-alpine terrain snow depth can vary by one order of magnitude over distances of a few meters. Measurements are laborious and only possible with direct surveys in the field. No easily applicable models for the spatial snow accumulation distribution are available to date. Therefore, tools to identify the spatial distribution of snow are an urgent need and would contribute to a much better understanding of the highly variable spatial distribution of snow.

In this collaborative effort, involving scientists from the Université de Fribourg and PSI, a new technology for monitoring and determining the spatial distribution of snow in high-alpine terrain by the application of innovative helicopter-borne GPR techniques is applied and further developed. This technology is used to accurately map the pattern of spatial variability in the snow cover in high-alpine terrain. The helicopter-borne GPR soundings are performed in combination with extensive ground based measurements (snow probing, snow/firn coring, ground-based GPR reference measurements, pits, etc.) to assess the uncertainties. The team from PSI is responsible for in-situ determination of snow accumulation from shallow snow/firn cores. With the firn cores snow/firn layer density and physical properties will be determined.

For collecting 10 m shallow firn cores an optimized version of the small Fast Electromechanical Lightweight Ice Coring System (FELICS small) was tested at the Jungfraufirn near the research station in April 2012. FELICS small is composed of a 90 cm long core barrel (60 mm inner diameter), chip barrel and drive unit attached to a 20 m long electric cable connected to a control box and the battery pack. No winch is used; the drill system is manually lifted out of the borehole by pulling on the electric cable. The optimized version uses aluminum extension rods with a simple coupling system instead of the electrical cable and a commercial cordless electric drill as drive unit (Fig. 1). The system worked well and allows a better guidance of the core barrel. After successful testing at the Jungfraujoch, the drill was employed to collect three 10 m firn cores on the Findelen glacier in May 2012 in the frame of the SNF project.



*Fig. 1: Test of the shallow firn drill FELICS small at the Jungfraufirn. Left: Aluminum extension rod with commercial cordless electric drill. Right: Extension rod with coupling and core barrel.*

Key words:

Winter snow accumulation, firn cores

Internet data bases:

<http://www.psi.ch/lch/analytical-chemistry>  
<http://p3.snf.ch/Project-134768>

Collaborating partners/networks:

Prof. Martin Hölzle, Département des Géosciences Université de Fribourg  
Dr. Matthias Huss, Département des Géosciences Université de Fribourg

Scientific publications and public outreach 2012:

**Refereed journal articles and their internet access**

Bukowiecki, N., P. Zieger, E. Weingartner, Z. Juranyi, M. Gysel, B. Neining, B. Schneider, C. Hueglin, A. Ulrich, A. Wichser, S. Henne, D. Brunner, R. Kaegi, M. Schwikowski, L. Tobler, F.G. Wienhold, I. Engel, B. Buchmann, T. Peter, U. Baltensperger, Ground-based and airborne in-situ measurements of the Eyjafjallajökull volcanic aerosol plume in Switzerland in spring 2010, *Atmos. Chem. Phys.*, **11**, 10011–10030, 2011.  
<http://www.atmos-chem-phys.net/11/10011/2011/acp-11-10011-2011.pdf>.

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<http://www.psi.ch/lch/analytical-chemistry>

Name of research institute or organization:

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**WSL Institute for Snow and Avalanche Research SLF**

Title of project:

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Snow on permafrost rock walls

Project leader and team:

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Dr. Marcia Phillips (Project leader, permafrost researcher)

Anna Haberkorn (PhD Student)

Hansueli Rhyner (Mountain guide)

Robert Kenner (Surveyor)

Martin Hiller (Electronics engineer)

Project description:

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Permafrost rock walls and ridges tend to react very rapidly to temperature change as they generally lack an insulating snow cover - a heterogeneously distributed, thin layer of snow is nevertheless very often present. Changes in rock or ice temperature or modifications in ice or water content can lead to rock wall instability and the role of the snow is probably of central importance. SLF has started a new SNF DACH project entitled 'Influences of snow on permafrost rock walls' in collaboration with the Universities of Bonn, Fribourg, Zurich - and a parallel partnership with the ETH Zurich. The project aims to investigate the role of snow on the thermal regime and mechanical stability of steep rock walls. The research sites include the Sphinx North and South walls, which were equipped with various temperature and deformation logging devices by ETH and the University of Zurich in the context of the PermaSense project ([www.permasense.ch](http://www.permasense.ch)). The data obtained has kindly been made available by these institutions. Additional in-situ investigations of the snow cover on both sides of the Sphinx ridge (Fig. 1) contribute to obtaining a better understanding of the role of the snow on the thermal regime of the rock.

Data from the Jungfrau Ostgrat permafrost borehole is also used in the context of this project. The sub-horizontal borehole is located at 3590 m in the North oriented wall of the Jungfrau Ostgrat. It is 20 m long and equipped with 9 thermistors and a data logger. Rock temperatures vary between -4 and -8°C. The main form of heat transfer is conduction (Fig. 2). The high elevation of the borehole and the fact that it is located in a steep, exposed rocky ridge make the data particularly valuable.



Fig. 1. Highly variable snow cover distribution in the North rock wall of Sphinx (Photograph M. Phillips, 21. November 2012).

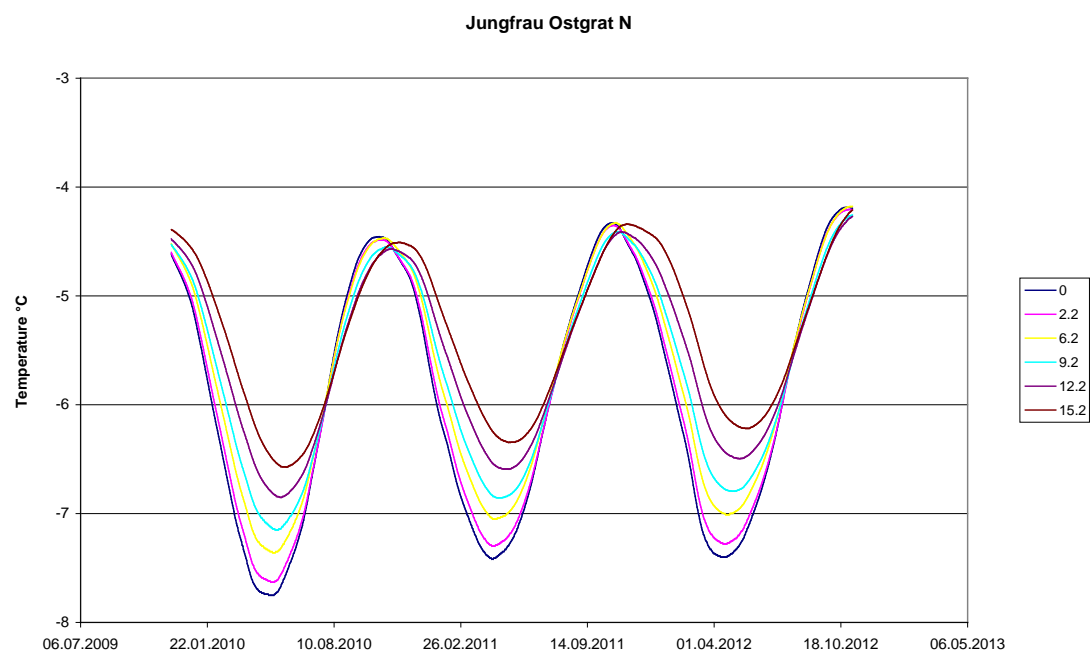


Fig. 2. Borehole temperatures in the Jungfrau Ostgrat borehole (North) between 2009 and 2012.

Key words:

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Mountain permafrost, thermal regime, active layer, rock walls, snow cover distribution

Internet data bases:

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[www.permos.ch](http://www.permos.ch)  
[www.permasense.ch](http://www.permasense.ch)

Collaborating partners/networks:

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Universities of Bonn, Fribourg and Zurich, ETHZ.  
PERMOS Network: [www.permos.ch](http://www.permos.ch) (the Jungfrau Ostgrat borehole is a candidate for PERMOS)  
PermaSense

Address:

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Name of research institute or organization:

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**Department of Geography, University of Zurich**

Title of project:

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Permasense

Project leader and team:

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Dr. Stephan Gruber, UZH, project leader

Dr. Lucas Girard, UZH

Dr. Jan Beutel, ETH Zurich

Roman Lim, ETH Zurich

Project description:

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Topic: Understanding freezing induced rock damage in-situ.

The progressive damage and fracture of porous media exposed to freezing is a fundamental problem for both scientists and engineers, as it can affect natural rock slopes, landscape development through physical weathering of bedrock and debris production, as well as concrete structures. In steep terrain, this process may be crucial for the slow preconditioning of rock fall from warming permafrost areas. As frost cracking operates slowly in the field, it has been mostly approached by laboratory experiments and theoretical studies. Such studies have documented empirical relationships between frost sensitivity of rocks and environmental controls (temperature, moisture, rock properties). They have also demonstrated that frost weathering can result from the operation of two different mechanisms, (i) the 9% volumetric expansion of freezing water and (ii) ice segregation, a mechanism comparable to frost heave in soils, yielding slow growth of ice inside rock under sustained freezing conditions. While these phenomena are now understood rather well for the controlled and idealized conditions of laboratory experiments, transferring these insights to field conditions remains a difficult task.

The goal of our research is to fill the gap between laboratory/theoretical insights on frost weathering and field conditions. In order to achieve this we carry out in-situ observations of freezing-induced rock damage, along with simultaneous monitoring of relevant environmental parameters. Through a first pilot experiment carried out at Jungfraujoch in 2010, we have demonstrated the possibility of using acoustic emission (AE) monitoring to capture freezing-induced rock fracture under natural conditions (Amitrano et al. 2012). AE monitoring consists in detecting transient elastic waves that are generated by the rapid release of energy within a material, through crack formation or friction between solid surfaces. This pilot study demonstrated that AE generated by freezing-induced stresses can indeed be detected and that the statistical properties of AEs correspond to that of micro-fracturing. However, the short duration of the experiment did not allow to detail the sensitivity to different controls of environmental parameters (rock temperature, moisture content) on the frost cracking activity.

In order to extend these first results, we have deployed, during summer-fall 2011, two continuous measurement systems on a rock wall close to the Jungfraujoch research station (Figure 1). Each measurement system is composed of a custom-built AE acquisition system, detecting AE at 10 and 50cm depth in the rock, a 1m-long temperature probe, as well as a capacitance probe intended to estimate variation in rock liquid water content (Girard et al. 2012).





Figure 1 - Field deployment at Jungfrauoch, close-up of the measurement site, and detail of measurement system M2.

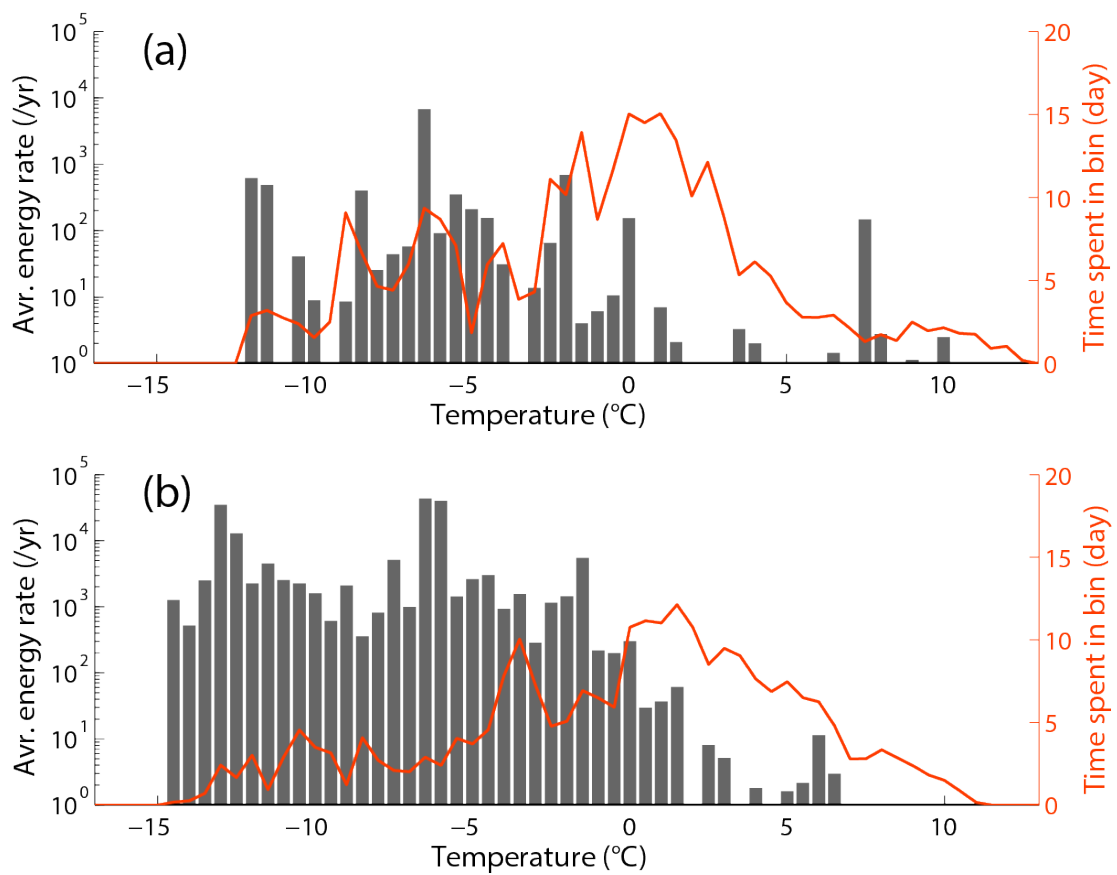


Figure 2 – Average rates of AE energy detected at both measurement sites, at 50cm depth, as a function of the rock temperature.

Throughout the year 2012, these two monitoring systems have operated almost uninterruptedly, yielding an unprecedented data set which allows us to revisit the characteristics and controls of field frost weathering. These important results will be the focus of a new publication currently in preparation. In brief, the measurements highlight:

- The strong sensitivity of frost cracking to rock liquid water content, as suggested by laboratory experiments.
- The fact that periods of sustained freezing yield stronger frost weathering activity than freeze-thaw cycling.
- The operation of frost weathering on a wide range of sub-zero temperatures, down to the lowest temperature detected ( $-15^{\circ}\text{C}$ ) (Figure 2).

These new insights allow us to revisit an important and controversial question of frost weathering studies: through which mechanism does frost weathering operate in the field. Our results suggest that both candidate mechanisms debated in literature operate in the field, although ice segregation may be seen as the prevailing mechanism. A striking aspect of our results is that the range of temperatures over which frost cracking was detected goes beyond what was expected in earlier studies that attempted to transfer laboratory/theoretical knowledge to real natural conditions.

Finally, the year 2012 has also seen the beginning of a new collaboration with a group of researchers from SLF, Davos, led by Dr. Marcia Phillips. This collaboration takes place within the scope of the PhD thesis of Anna Haberkorn, dealing with properties of snow in steep rock walls. As part of this work, a first measurement campaign was carried out together with the PermaSense team in November 2012. Further planned research steps include analyses based on the 4-year timeseries of rock temperature acquired near the Jungfraujoch research station as part of the PermaSense project.

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**Key words:**

Rock mechanics, acoustic emission, weathering, permafrost

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**Internet data bases:**

[www.permasense.ch](http://www.permasense.ch)

[www.data.permasense.ch](http://www.data.permasense.ch)

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**Collaborating partners/networks:**

Dr. David Amitrano, ISTERre, CNRS / Université J. Fourier, Grenoble, France

Dr. Marcia Phillips, SLF Davos, Switzerland

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**Scientific publications and public outreach 2012:**

**Refereed journal articles and their internet access**

Girard, L., J. Beutel, S. Gruber, J. Hunziker, R. Lim, S. Weber, A custom acoustic emission monitoring system for harsh environments: application to freezing-induced damage in alpine rock walls, *Geosci. Instrum. Method. Data Syst.*, **1**, 155–167, doi: 10.5194/gi-1-155-2012, 2012.  
<http://dx.doi.org/10.5194/gi-1-155-2012>

Amitrano, D., S. Gruber, L. Girard, Evidence of frost-cracking inferred from acoustic emissions in a high-alpine rock-wall, *Earth and Planetary Science Letters*, **341**, 86–93, doi: 10.1016/j.epsl.2012.06.014, 2012.  
<http://dx.doi.org/10.1016/j.epsl.2012.06.014>

**Book sections**

Weber, S., S. Gruber, L. Girard, Design of a Measurement Assembly to Study In-Situ Rock Damage Driven by Freezing, in *Proceedings of the tenth international conference on Permafrost*, Russia, June 2012.

**Conference papers**

Amitrano, D., S. Gruber, L. Girard, Cryo-induced cracking in high-alpine rock-wall, evidences from acoustic emissions monitoring, *European Geophysical Union, General Assembly*, Vienna, Austria, 2012.

Girard, L., S. Gruber, S. Weber, J. Beutel, Continuous monitoring of near-surface damage in a freezing rock-wall, 10<sup>th</sup> Swiss Geoscience Meeting, Bern, Switzerland, 2012.

Gruber, S., L. Girard, D. Amitrano, J. Beutel, S. Weber, Can improved understanding of frost cracking help anticipating focal zones for rockfall from degrading permafrost? The Geological Society of America, Annual meeting, Charlotte, North Carolina, USA, 2012.

Weber, S., S. Gruber, L. Girard, J. Beutel, Acoustic emission measurement system to investigate rock damage driven by freezing, 10th Int. Conference on Permafrost, Salekhard, Russia, 2012.

Weber, S., S. Gruber, L. Girard, J. Beutel, Let rock crack, let crack rocks, AK Permafrost meeting, Potsdam, Germany, 2012.

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Name of research institute or organization:

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**Department of Geography, University of Zurich**

Title of project:

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PERMOS

Project leader and team:

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Dr. Stephan Gruber, project leader  
Dr. Jeannette Noetzli, lead PERMOS  
Dr. Christin Hilbich, postdoc  
Lorenz Boeckli, PhD student

Project description:

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The Swiss Permafrost Monitoring PERMOS operates a number of measurement sites around Jungfrauoch that are serviced once or twice per year.

The aim of the Swiss Permafrost Monitoring Network (PERMOS) is the systematic long-term documentation of state and changes of mountain permafrost in the Swiss Alps. The observation strategy of the PERMOS network has been established based on the experiences of its first ten years of operation, during which it transformed from a loose network of sites from research projects to an operational monitoring service. Based on the strategy and experiences, measurement sites, key variables and observation techniques were selected and are continuously evaluated.

The distribution and the thermal conditions of mountain permafrost are spatially highly variable and mainly influenced by topography as well as surface and subsurface characteristics of different landforms. PERMOS includes three types of observations which are taken at sites on different landforms in varying topographic settings: (1) ground temperatures measured in boreholes and at the surface (in the case of Jungfrauoch and surroundings) near to the drill site, (2) changes in subsurface ice and unfrozen water content at the drill sites by geo-electrical surveys, and (3) velocities of permafrost creep determined by geodetic surveys and photogrammetry. In addition, fast mass movements from permafrost areas (e.g., rock fall) are documented in an inventory.

Key words:

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Permafrost monitoring

Internet data bases:

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[www.permos.ch](http://www.permos.ch)

Scientific publications and public outreach 2012:

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**Data books and reports**

PERMOS, Permafrost in Switzerland 2008/2009 and 2009/2010, Noetzli J. (ed.), Glaciological Report (Permafrost) No. 10/11 of the Cryospheric Commission of the Swiss Academy of Sciences (in prep., for publication in 2012).

**Magazines and Newspapers articles**

Schnee, Gletscher und Permafrost 2010/2011 (Snow, Glaciers and Permafrost 2010/2011), Die Alpen/Les Alpes, 8/2012.

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Name of research institute or organization:

**Bundesamt für Landestopografie / Swiss Federal Office of Topography  
(swisstopo)**

Title of project:

Automated GNSS Network Switzerland (AGNES)

Project leader and team:

Dr. Elmar Brockmann,  
Dominique Andrey, Daniel Ineichen, Leïla Kislig, Christian Misslin, Dr. Stefan Schaer,  
Dr. Urs Wild

Project description:

The station is part of the Automated GNSS Network of Switzerland (AGNES) consisting of 31 sites, partly equipped with GPS and GPS-GLONASS (the Russian equivalent of GPS) combined receivers and antennas. Due to the extreme weather conditions a special antenna is installed at Jungfrauoch. This antenna is unfortunately not capable to receive the Russian GLONASS satellite data.

AGNES is a multipurpose network which serves as reference for surveying, real-time positioning (positioning service swipos GIS/GEO) and for scientific applications (geotectonics and GNSS-meteorology). The GPS station JUJO is mainly contributing to scientific applications. Important results from the swisstopo processing of the GPS data of JUJO, the troposphere path delays, are provided to MeteoSwiss on an hourly basis. Furthermore, the data are sent to the European meteo community EUMETNET, where the data are available for all meteo agencies for numerical weather predictions. At the moment, UK METO, MeteoFrance, DMI, and KNMI are using the GNSS-derived troposphere models routinely in the weather forecasts. This activity is coordinated by the EGVAP project. The results are also sent to the Institute of Applied Physics (IAP) of the University of Berne where the data contribute to the STARTWAVE database.

In 2012, the complete data flow of the raw GNSS data for all AGNES stations was re-organized. In April 2012, all users of the swisstopo positioning service were moved to a new computer central facility operated by the private hoster BEGASOFT and not any longer operated in the federal infrastructure. Beside new redundant processing queues, also a test infrastructure was built according to Fig. 1. Due to the high altitude, JUJO data are not used for the commercial positioning system.

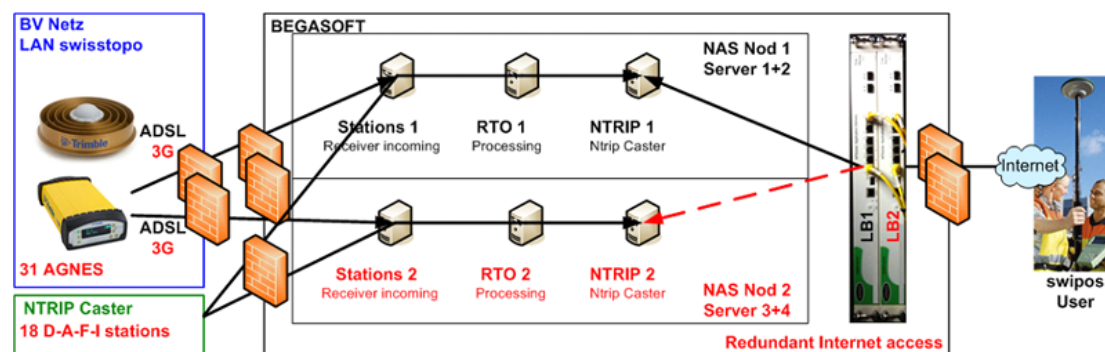


Figure 1. New swipos infrastructure of the computer center (in place since April 2012).

Furthermore, the data flow of the raw files was completely modified starting end of October 2012. Instead of a direct data download of the archive RINEX files every hour and every day to swisstopo pnac computers, the data are transferred every hour in a binary mode to the above mentioned new computer center. Here, all AGNES data are converted to RINEX files and are finally submitted to the swisstopo data archive, from where the data are used for the data processing (hourly and daily) and for generating the above mentioned results. Fig. 2 gives an idea of the new data flow.

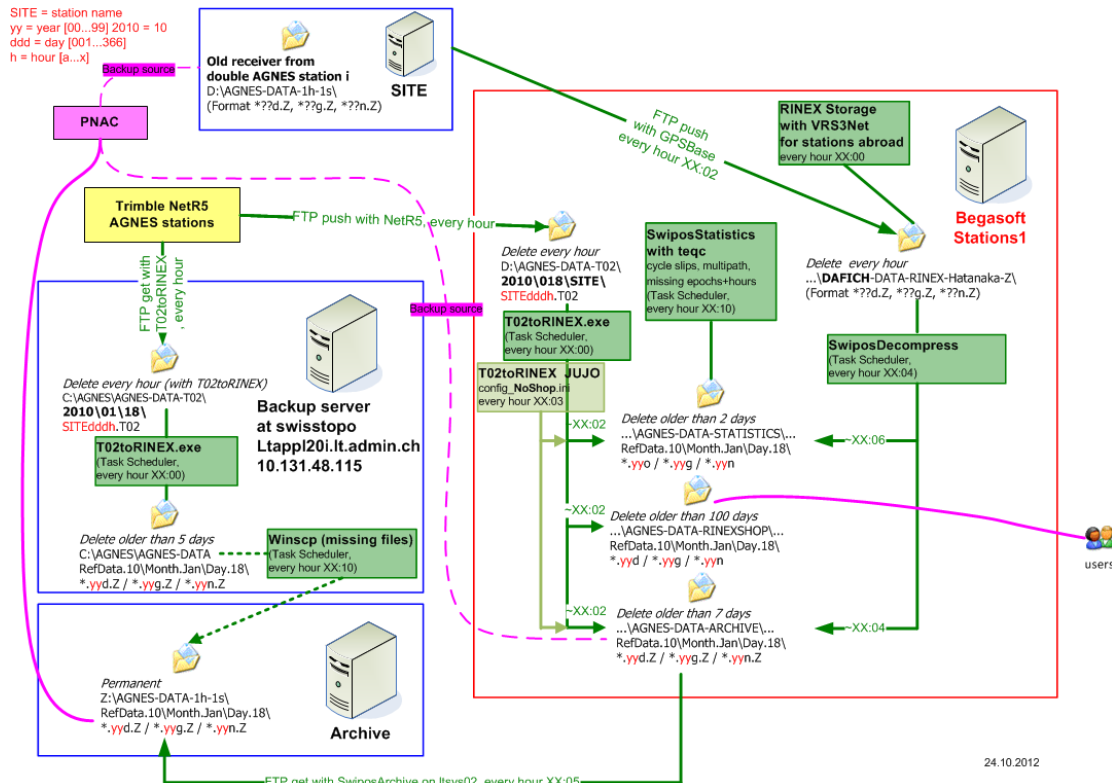


Figure 2. New data flow of raw data (in place October 2012).

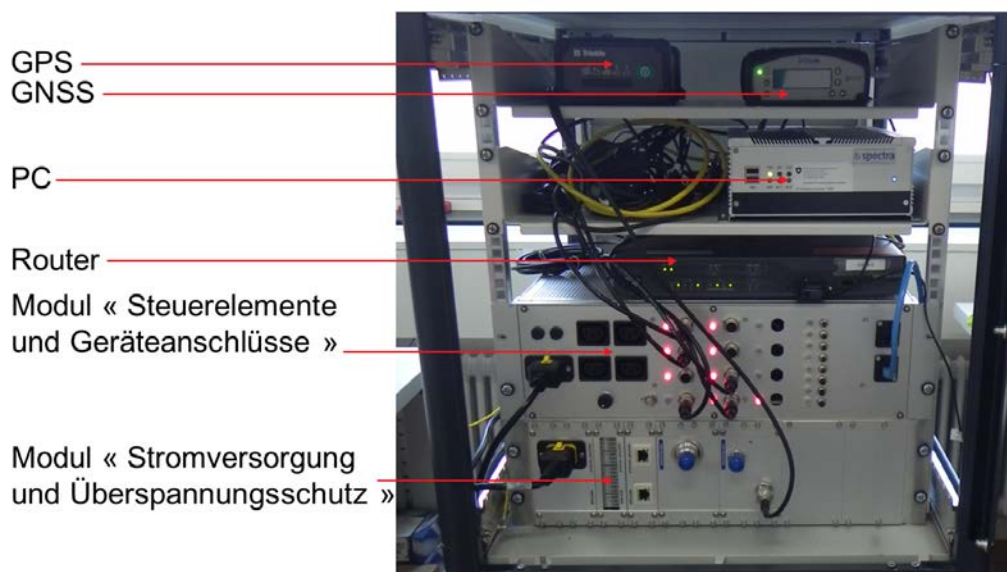


Figure 3. New station design (without a PC on single stations)- here an example for a double station (with a PC, a GPS and a GNSS receiver).

Finally, the station setup on-site was modified for almost all AGNES stations till end of 2012. For JUJO, the installation is scheduled for the beginning of 2013. Fig. 3 gives an overview of the new station concept, where a PC is only necessary on double stations (the single station JUJO therefore does no longer need a station PC).

In 2013, it is planned that all GPS data of JUJO back to 1998 are consistently reprocessed. The EU-COST project GNSS4SWEC will be launched at the beginning of 2013 to analyse the long-term results of the troposphere parameters and to derive possible statements concerning climate change.

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**Key words:**

GPS, GLONASS, GNSS, Meteorology, Positioning, Integrated Water Vapor, Zenith Path Delay, GPS Tomography, Geotectonic

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**Internet data bases:**

<http://www.swisstopo.ch/pnac> ; <http://egvap.dmi.dk/> ;  
<http://www.iapmw.unibe.ch/research/projects/STARTWAVE/>

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**Collaborating partners/networks:**

Astronomical Institute (AIUB), University of Berne  
MeteoSwiss, Zurich and Payerne  
Institute of Applied Physics (IAP), University of Berne  
Institute of Geodesy and Photogrammetry, ETH Zürich  
E-GVAP II (EUMETNET GPS Water Vapor Programme)

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**Scientific publications and public outreach 2012:**

**Conference papers**

Brockmann E. et al., EUREF'12: Paper contributions to the EUREF-Symposium in Paris, June 6-8, 2012:  
«National Report of Switzerland» and «Geodetic control surveys at the Geostation Zimmerwald», swisstopo-report 12-07  
<http://www.swisstopo.admin.ch/internet/swisstopo/de/home/docu/pub/geodesy/report.parsys.70206.downloadList.45836.DownloadFile.tmp/report1207.pdf>

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Name of research institute or organization:

**Surface Meteorological Networks, MeteoSwiss, Payerne**

Title of project:

Operation of a meteorological station at high altitude in the Alps

Project leader and team:

Dr. Christian Félix, head of surface networks, MeteoSwiss  
Gilles Durieux, Bertrand Equey and the surface networks team

Project description:

MeteoSwiss operates an automatic meteorological station at the Jungfraujoch Observatory and services the instrumentation for the Global Atmosphere Watch Radiation Measurements Project.

Very few interventions were necessary in 2012, which demonstrates again the very high reliability of this equipment despite demanding meteorological conditions.

In December 2012 a new instrument (a SPN1 from DeltaT) that measures the global and diffuse short wave radiation as well as the sunshine duration, was installed on the radiation bridge.



*Figure 1: New instrument (SPN1 by DeltaT) installed on the radiation bridge.*

The support from the custodians for various tasks (cleaning radiation instruments, resetting the acquisition electronics, resetting the electric power ...) is gratefully acknowledged.

Key words:

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Wind, temperature, sunshine duration, solar radiation, pressure, relative humidity

Internet data bases:

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[http://www.meteoschweiz.admin.ch/web/en/meteoswiss/international\\_affairs/GAW/GAW\\_CH.html](http://www.meteoschweiz.admin.ch/web/en/meteoswiss/international_affairs/GAW/GAW_CH.html)

[http://www.meteoschweiz.admin.ch/web/en/weather/current\\_weather.par0001.html?region=8&station=JUN](http://www.meteoschweiz.admin.ch/web/en/weather/current_weather.par0001.html?region=8&station=JUN)

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Name of research institute or organization:

**Federal Office of Meteorology and Climatology MeteoSwiss**

Title of project:

The weather in 2012

Report by:

Stephan Bader

### **Report for the International Foundation HFSJG**

In 2012 the annual mean temperature in Switzerland was about one degree Celsius above the norm value 1961-1990. Annual precipitation amounted to a surplus of five percent compared to the norm. The year started in very wintery fashion with above-average snow in the mountains and an intensely cold spell in February. The spring was extremely warm, very sunny and rather dry. The summer however developed rather slowly and only August brought real high summer weather including a heat wave. Some snowfall down to medium altitudes in early autumn produced a first hint of winter while October was characterized by a glorious Indian Summer followed by an abrupt change with snow down to the lowlands. The snow theme remained in the foreground with an episode of severe wintery weather at the end of November on the southern slopes of the Alps, in the Valais and Jura and with intensive snowfall all over Switzerland down to low altitudes in the first half of December.

As can be seen in Table 1 below, the year 2012 was too warm compared to the long-term average 1961-1990 (reference period), with a temperature surplus of slightly over one degree both in the lowland regions north of the Alps and in the high Alpine regions. Precipitation totals reached about 120 percent of the normal values in the Jungfrau region and 110 percent in the lowland regions north of the Alps.

*Table 1: Annual values 2012 referring to the parameters temperature and precipitation as well as to the deviations from the reference period 1961-1990 for the stations Jungfraujoch and Bern. As precipitation is not measured on Jungfraujoch the values pertaining to the Kleine Scheidegg are used here.*

	<i>Jungfraujoch</i>	<i>Berne</i>
Average temperature	-6.7 °C	9.2 °C
Deviation	+1.2 °C	+1.3 °C
Precipitation	1874 mm	1128 mm
Deviation	119 %	110 %

### **Masses of snow in the mountains at the start of the year**

As the year 2011 came to its close there was already an above-average amount of snow in many parts of the Swiss Alps. A strong north-westerly front in the first days of 2012 brought again large amounts of snow at high altitudes, increasing the danger of avalanches. In Andermatt in the Central Alps slightly over 2 m of snow were recorded, the third-highest January snow cover since observations started in 1966. In the Swiss lowlands, however, temperatures remained mild and there was scarcely any snow.

### **Intensively cold in February**

After a period with sunny and mild winter weather Switzerland was seized by the most powerful cold spell in 27 years from the beginning of February on. In lower regions of Eastern Switzerland, cold air from Siberia caused the daily mid-temperatures to fall as low as -9 to -10°C from 1 to 14 February. In Western Switzerland the values were slightly higher, in Southern Switzerland considerably higher with -2 to -8°C. On the plain north of the Alps minimum temperatures fell locally below -20°C, in the high Alpine valley of the Engadin below -30°C. In the second week of February smaller lakes on the Swiss Plateau froze. Access to the frozen „Pfäffikersee“ was possible and the ice cover on the „Greifensee“ was also open to the public for a short while. In the upper part of Lake Zurich a lot of ice skaters enjoyed themselves on the frozen bay of Rapperswil, and there were extended ice sheets along many shore areas.

During the cold spell some snow fell occasionally north of the Alps, causing permanent snow cover in many low-altitude areas as well. However, snow depths were generally moderate in these places.

### **Extreme cold followed by extreme warmth**

In the second half of February temperatures turned out exceptionally mild, starting south of the Alps. On 25 February 2012 the temperature in Locarno-Monti rose to 23.3°C, breaking the February record since observations started in 1935. The former February record of 1948 was more than 1°C below this mark.

The exceptional warmth finally extended to all Swiss regions and lasted up to the first days of April. Overall, it was the second warmest March in Switzerland, south of the Alps even the warmest since observations began in 1864. North of the Alps sunshine duration reached record values while in the Alps values were on a par with former records.

### **Summer temperatures in spring**

After the period of record-breaking warmth the weather continued unsettled and cool until mid-April. A “Föhn” storm in the last April days, however, generated summery conditions. On 28 April the highest April temperatures were recorded by some weather stations since observations began, e.g. in Berne 28.2°C (since observations started in 1864) or in Lucerne 29.1°C (since 1886). In the Alps, too, it was extremely mild. In Davos (1600 m a.s.l.) the thermometer rose to 19.4°C. This was the same temperature as measured on 25 April 2007 and a record for April since observations started in 1877. A short while later high summer temperatures set in. On 11 May there was plenty of sunshine and widespread temperatures of 27 to 29°C, in isolated sites a very hot day (above 30°C) was recorded, a rare event so early in May in the lowlands of the German-speaking part of Switzerland. The zero degree level was as high as 4140 m a.s.l., an altitude which had not been reached before in the past 40 years in the first part of May.

### **A wet and grey start to the summer**

Only a day after the summer heat Switzerland came again under the influence of a polar cold front. With heavy rainfalls temperatures on the Plateau reached little over 10°C. In mid-May it snowed down to an altitude of 600 m a.s.l. Further strong precipitation followed in the last third of May. The first half of June was grey and wet in the entire country: sunshine duration north of the Alps amounted to only 10 to 20% of the long-term average values. In the Valais and south of the Alps these values were higher, but with about 30% clearly below the expected sunshine duration. The first three weeks in July were also dominated by unsettled weather episodes and the repeated influx of cool air masses. At the end of this period, which can hardly be described as summery, a splendid waterspout was observed in the lower part of Lake Zurich on 21 July in changeable and cool west-wind weather.

### **Hot summer weather only in August**

From the beginning of summer hot weather spells were limited in many areas to short periods in the last thirds of June and July while in the Ticino summer weather prevailed throughout July. Only August brought persistent warm summer conditions to all of Switzerland. After the middle of the month the entire country was seized by an intense heat wave. Temperatures of above 30°C were recorded up to altitudes of over 500 m a.s.l., and at some higher-altitude stations record values for the month of August were observed. On the Jungfrauoch, temperatures rose to a new, absolute maximum of 12.8°C. With 36.9°C the weather station in Sion reported the highest temperature. This was the highest temperature registered by MeteoSwiss in our country since the record heat of the summer of 2003. However, the values registered then were substantially higher.

### **First harbingers of winter**

A powerful polar front on the threshold of August to September put paid to the summer heat of 2012. There was a lot of precipitation on the northern slopes of the Alps and some Alpine passes had to be closed due to snowfall. After a period of summery high pressure weather a new strong influx of cold air on 11 to 12 September again brought snow as far down as medium altitudes. As cold air from the North arrived, several waterspouts could be seen on Lake Constance on 13 September. A few days later the same scenario was repeated: mild late summer weather followed by a cold spell with snow in the mountains.

In the last September days a pronounced „Föhn“ situation established itself, bringing abundant precipitation to some southern regions of the Alps. The large amount of rain made the waters of the Maggia river rise dangerously on 26 and 27 September. After the subsequent quick changes between sunny/mild and wet/grey days a further powerful cold front followed in mid-October with heavy precipitation. Along the eastern slopes of the Alps an uninterrupted snow cover appeared above 800 m a.s.l. and in the Canton of Graubünden there were 10 to 20 cm of fresh snow above 1000 m a.s.l. On the Swiss Plateau temperatures remained under 10°C in the daytime.

### **Beautiful Indian Summer**

After this wintery episode Switzerland enjoyed a splendid Indian Summer from 17 to 25 October. Even in medium altitudes temperatures rose partly above 20°C in sunny weather conditions, which is exceptionally mild for this season. As a consequence some weather stations in alpine locations reported new temperature records for the second half of October. From 23 October regions below 1000 to 1400 m a.s.l. north of the Alps disappeared under a dense blanket of fog.

### **Winter down to the lowlands in October**

A massive influx of polar air masses in the last days of October spread a wintery cover over most parts of Switzerland. On 28 October there were overall 1 to 10 cm of fresh snow in the German-speaking parts, 10 to 20 cm in slightly higher altitudes, locally even more. The persistent snowfall down to low altitudes brought a new October snow record to St. Gallen: 33 cm, exceeding by far the former record of 18 cm (30./31.10.1974, according to the measurement series starting in 1959). At the Langnau im Emmental station 30 cm of snow were measured, the former record amounting to 27 cm (30.10.2008; measurement series starting in 1958). At lower altitudes lower values were registered. There were 19 cm of snow in Zurich on the morning of 29 October. The October record so far dates back to 30.10.2008 with 20 cm (measurement series starting in 1931). The two events are therefore on a similar scale. Towards the Alps snow levels were not as spectacular compared to former October events. There was no snow in the area of Lake Geneva, in low-altitude sites of the principal valley of the Canton of Valais, of the Ticino and in the valleys of the rivers Aare, Reuss and Rhine.

### **Mild and sunny late autumn in mid-November**

From 12 November a stable autumnal high pressure situation with sunny mountain weather established itself. The zero degree level rose to above 3000 m a.s.l. in the daytime, pushing the maximum temperature on the Jungfrauoch (3580 m a.s.l.) up to +3°C. In the lowlands north of the Alps typical November fog developed while the Ticino enjoyed a lot of sunshine.

### **Heavy snowfall**

In the last days of November heavy precipitation started in the west and above all south of the Alps. In the Jura, in the northern Ticino and in the Simplon area the snow line sank to about 800 m a.s.l. There were 80 to 120 cm of fresh snow along the southern slopes of the Alps, from Monte Rosa to Simplon, Ticino and to the Valle Mesolcina while 30 to 50 cm were measured on the main ridge of the Alps and in the Upper Valais; 40 to 60 cm in the Jura above 1500 m a.s.l. The centre of this heavy precipitation event was located in the area of Valle Maggia – Locarnese.

On 29 November cold air masses from the north brought some fresh snow also to the lowlands north of the Alps. Along the pre-Alps from 700 to 900 m a.s.l. there were 40 cm of snow while lesser amounts of fresh snow were registered toward the Alps.

### **Lots of snow at the beginning of winter**

The influx of cold air generated the first “ice day” with temperatures below zero during the whole day in many regions north of the Alps exactly at the beginning of the meteorological winter (1.12.). Marking the arrival of winter even further, an active snow front crossed the entire area north of the Alps on the following day. Dense snow flurries wrapped the lowlands into a blanket of powdery fresh snow on that first Sunday in December, with snow heights of 2 to 10 cm, locally even to 20 cm.

From 3 to 4 December the Valais was snowed in. In Sion 30 cm of fresh snow fell, Brig got 50 cm and at Ulrichen in the Upper Valais the snow cover was as deep as 80 cm.

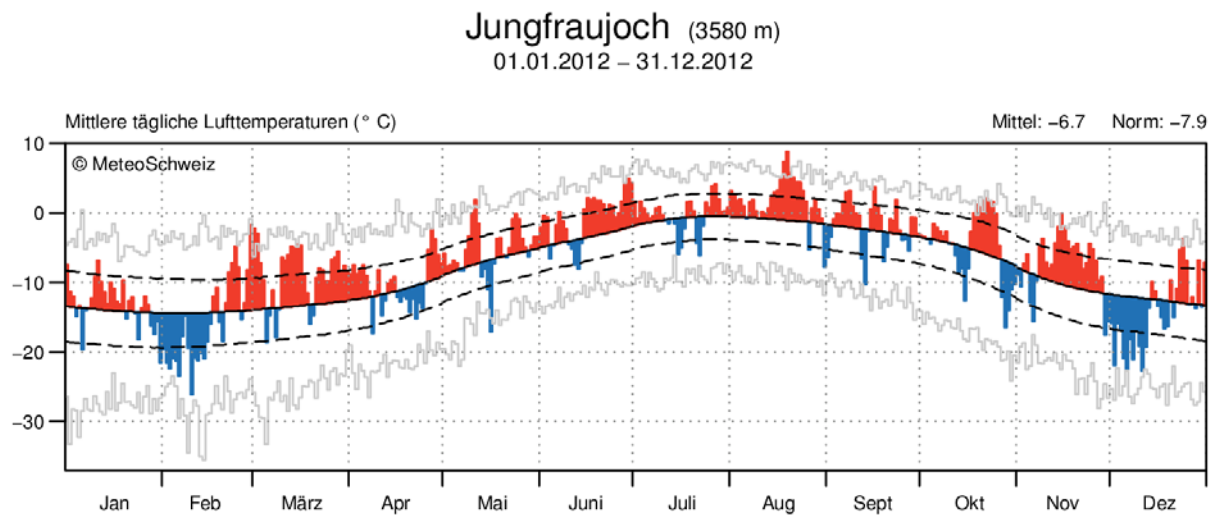
The second December weekend was also very wintery. After a substantial snowfall in the night Switzerland presented itself mostly in white on Saturday morning (8.12.2012). From Lake Geneva to Lake Constance the Swiss Plateau was under a snow cover of 5 to 35 cm and in certain regions of the northern slopes of the Alps 50 to 65 cm. Even Locarno-Monti (367 m a.s.l.) in the Ticino reported 1 cm of snow. In low altitudes north of the Alps the snow cover remained for about a week before it disappeared on the third December weekend, which brought rain and mild temperatures. South of the Alps however it snowed heavily on that weekend and as a result there were 10 to almost 20 cm of snow in the low regions of the Ticino.

### **Annual balance**

Averaging the total of Swiss measurements, the year 2012 was about 1°C too warm in comparison with the norm value 1961-1990. In the Ticino the temperature surplus amounted to +1.6°C regionally, in the Valais up to +1.8°C, in lower areas north of the Alps however only from +0.6 to +0.8°C.

Precipitation was significantly above average in northern Switzerland and regionally on the north-eastern slopes of the Alps, resulting in 120 to 130 percent of the norm value. The valleys south of the Alps in parts received 110 to 120 percent of the norm value 1961-1990. In other parts of the country values amounted to 100 to 115 percent of the norm.

Sunshine duration reached 110 to 120 percent of the norm 1961-1990 on the Swiss Plateau from Lake Geneva to Lake Constance. In most other areas values were around 100 to 110 percent.



*Figure 1: Development of the 24-hour mean temperatures 2012 at the station Jungfrauoch, in relation to the long-term mean value 1961-1990 (unbroken line) and the long-term mean fluctuation (broken line, standard deviation). The two grey curves show the highest and the lowest 24-hour mean temperatures since observations started.*

Address:

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Krähbühlstrasse 58  
CH-8044 Zürich  
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URL: <http://www.meteoschweiz.ch>

Name of research institute or organization:

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**PV-Labor der Berner Fachhochschule Technik und Informatik BFH-TI**

Title of project:

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PV production in high alpine sites

Project leader and team:

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Prof. Urs Muntwyler, project leader

Project description:

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The production on the high alpine site Jungfrauoch continued in 2012. The installation was serviced in June 2012.

In 2012 the comparison with other high alpine sites as Birg and other sites in the alps has started. The question is, if high alpine PV-sites could replace the solar production in Northern Africa and Southern Europe. Due to the fast progress in the PV-technology and the strong decline of the production prices this seems more and more realistic.

The study of new sites with existing infrastructure, as for example cable cars, dams, avalanche barriers etc., has started. A new site on an avalanche barrier in Bellwald will be installed with measurement equipment in 2013.

First reflections for a new PV-plant on the Jungfrauoch with new high efficiency solar cells and a high efficiency inverter have started.

Key words:

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PV production on high alpine sites, stability of PV-production on high alpine sites

Internet data bases:

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<http://pvtest.ch>

Collaborating partners/networks:

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Studiengesellschaft Mont Soleil/ Brenet/ SUPSI/ University of Bern/ KWO

Scientific publications and public outreach 2012:

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Diskussionspapier mit energie-cluster.ch/ Bau+Energie-Messe (55 Seiten)/ November 2012: Die Photovoltaik ist marktreif für die Schweiz – Der Massenmarkt ist jetzt zu erschliessen! [www.energie-cluster.ch](http://www.energie-cluster.ch)

### **Refereed journal articles and their internet access**

Häberlin H., Wie mit PV-Strom durch den Winter?, *Elektrotechnik*, **1**, 44-49, 2012.

<http://www.pvtest.ch/index.php?id=393>

### **Conference papers**

Muntwyler U., Designaspekte von weitgehend Energie-autonomen Häusern in den Hoch-Alpen am Beispiel der „Neuen Monte-Rosa Hütte SAC“, Photovoltaic Conference, Staffelstein, Germany, March, 2012.

### **Edited books**

Häberlin H., Photovoltaik - Strom aus Sonnenlicht für Verbundnetz und Inselanlagen, Electrosuisse-Verlag, ISBN 978-3-905214-62-8, 2012.

Häberlin H., Photovoltaics - System Design and Practice, John Wiley&Sons Ltd., ISBN 978-1-119-99285-1, 2012.

### **Magazine and Newspapers articles**

“Professor fordert Alpine Solaranlagen“, *Berner Zeitung*, October, 2012.



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Name of research institute or organization:

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**Institut des Sciences de l'Environnement, Université de Genève**

Title of project:

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Assessing Climate Change Impacts on the Quality and Quantity of Water (ACQWA)

Project leader and team:

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Prof. Martin Beniston, project coordinator

PD Dr. Markus Stoffel, project director

Project description:

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The overall goal of ACQWA is to maintain and extend European pre-eminence in the provision of policy-relevant information on climate and climate change impacts on the quality and quantity of water and its interactions with society. ACQWA will achieve this through: (i) the use of advanced modelling techniques to quantify the influence of climatic change on the major determinants of river discharge at various time and space scales; (ii) the analysis of the impact of climatic change and changes in water quality and quantity on society and economy while taking feedback mechanisms into account.

The focus will be on continuous transient scenarios from the 1960s up to 2050. In comparison to many existing studies, limiting the modelling horizon to the mid-21<sup>st</sup> century allows for the development of more realistic assessments of progressive impacts on social, economic and political systems, which we expect to evolve, typically, in an adaptive mode on time scales shorter than the centennial, eventually shifting to new equilibria when forced abruptly.

The project draws on the involvement and expertise of a large number of institutes (currently 30 partners – and 37 independent research groups from 7 European countries, and in addition 3 non-European partners in Argentina, Chile and Kyrgyzstan. The list of contractors is given at the end of this Executive Summary.

ACQWA aims at providing detailed predictions of climate change, and its impacts on the quality and quantity of water, using a suite of modeling tools. The development of systematic approaches to the quantification of changes in water availability is expected to provide a significant and original contribution to worldwide research into climate change impact prediction. Regional climate model outputs shall provide the essential information on shifting precipitation and temperature patterns, and snow, ice, and biosphere models will feed into a hydrological model in order to assess the changes in basin hydrology, seasonality, amount, and incidence of extreme events. This output is intended as input for developing, evaluating and applying a range of impact models. The multi-model system itself will be used for transient regional climate change scenarios. Both datasets should be of particular interest for regional stakeholders.

The largest progress during the past year concerned the completion of the climate scenarios simulations, including those characterized by high spatial resolution and obtained through dynamical downscaling, the consolidation of the downscaling procedures, and the advancement of the research on modeling the complex response of snow, glaciers (incl. the Aletsch glacier) and consequently river basins to climate change, both at the small and the large scale. The methodologies developed on snow, ice and runoff are currently being used to address environmental and socio-economic responses to changes in hydrological regimes in terms of hazards, hydropower, tourism, agriculture, aquatic ecosystems, and health implications of changing water quality. These results will feed into a quantitative model of water use incorporating supply and demand. The resulting integrated model will permit the construction of scenarios and allow evaluation of various policy options for adaptation and mitigation, which will be of particular interest to policy makers and various stakeholders.

Key words:

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Snow, ice, glaciers, runoff, impacts, climate change, Rhone catchment, Aletsch glacier

Internet data bases:

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<http://www.acqwa.ch>

Collaborating partners/networks:

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37 partner institutions from Europe, Central Asia and South America

Address:

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Name of research institute or organization:

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**Société Astronomique de Liège (SAL)**

Title of project:

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Observing the sky and describing the objects

Project leader and team:

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Benoît Lempereur

Project description:

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The project consists of observing the sky in better conditions (less light pollution and thinner atmosphere at Jungfraujoch) and describing different objects in the sky. These observations will produce a description of what is seen through amateur telescopes. This data will be presented during observation evenings to schools, but also to a wider public audience to allow them to discover the beauty of the sky at night.

Key words:

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Observing, describing

Address:

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Name of research institute or organization:

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**Walter Bersinger, amateur filmmaker**

Title of project:

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«In the Brightness of the Night» (In der Helle der Nacht)

Project leader and team:

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Walter Bersinger, amateur filmmaker

Heinz Rauch, assistant and documentation photography

Project description:

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*Introduction*

Inspired by the cinema film *Baraka* (1992) I pursued plans to make a private film featuring shots like Ron Fricke's magnificent nightly views of the starry night sky moving over American National Park scenery. I was absolutely stunned by Fricke's time-lapse shots of ancient cultural monuments and archaeological sites such as Angkor Wat in Cambodia and Luxor in Egypt with the play of light and shadow cast by the shine of the moon and with the stars and clouds dashing across the night sky.

*The first project in the 1990s*

Since my early youth I have been a keen amateur filmer. After seeing *Baraka* I planned a private amateur film project entitled *In the Brightness of the Night* («*In der Helle der Nacht*»). I decided to modify my Beaulieu R16 movie camera so it could take time exposures. For that purpose I diverted the sound synchronization connector from its intended use. I attached a self-made crank to this mechanical interface and removed the camera's power supply. Upon pressing the camera trigger, the mechanism was released and could be operated manually via the crank, frame by frame. Each single frame had to be exposed in manual camera mode by turning the crank once every 30 seconds, making for an exposure time of about 29 seconds (30 seconds minus about 1 second for the transport of the film to the next frame). Lacking the skills to design and build programmable electronic and mechanical devices, I was restricted to manual operation of the camera, which involved looking at my wrist watch and turning the crank by hand every half minute!

During the years 1995 to 2001 I thus exposed about 18'000 single frames (about 70 scenes). Barely 11'000 of the frames were eventually used in the final seven-minute work. The film contains shots of moonlit landscapes, polar lights, the comets Hyakutake 1996 and Hale-Bopp 1997, the total lunar eclipse of 27 September 1996, lightning, and all kinds of other nightly light phenomena.

Because I saw now bright future for the chemical film imaging, I sold my 16-mm camera equipment in 2001 and hurriedly and somewhat half-heartedly finished the film. Realizing that digital imaging improved in quality rapidly and became more affordable over the years I planned a remake of the same project at a later stage. No sound track was ever added to the 7-minute film.

*The digital era dawns*

In 2005 I bought my first digital reflex photo camera, a Canon EOS 350D, and gained experience with it. Four years later I purchased a second camera (EOS 40D) and, in April 2009, began working on the remake of a film entitled, as its predecessor described above, *In the Brightness of the Night*. Thanks to the comfortable serial exposure mode of these modern cameras the number of scenes intended to be used for the new film accumulated much faster than with the 16-mm camera during the 1990s. Within only three and a half years to date I gathered more than four times the number of single frames than for the earlier film and far more spectacular ones, too!

I intend to make the new version in the full HD format 16:9 (1920x1080px). In most cases the single frames are exposed for 25 to 30 seconds. The closing and re-opening of the shutter takes about one to two seconds, making for intervals between 26 to 32 seconds. The time lapse factor resulting from these intervals is about 650 to 800. The final film will feature the *Suite Française* for flute and harp by Swiss composer Marguerite Roesgen-Champion.

Until August 2012 more than 200 video clips have piled up on my hard disk. No astronomical highlights such as the spectacular comets of the 1990s worthy or suited for time lapse filming occurred during the past few years or they were obstructed by clouds. Most of the shots taken so far cover alpine scenery by moonlight, the milky way moving over the mountain skylines, the starry night sky mirrored in an idyllic mountain lake, impressive cloud formations lit by the moon, seas of fog that look like rapid rivers, lightning, moonrises and moonsets, airport landings and takeoffs and a great deal more. The most intriguing effects are produced by the shadows in mountainous scenery cast by the full or nearly full moon. Especially moonsets create shadows lengthening at increasing speed, plunge the nightly scenery in yellowish and orange hues and eventually reveal an abundance of stars. Moonrises create the same effects in the reverse order.

### *Jungfrauoch*

In secret I have long dreamed of taking shots from the Jungfrauoch and the magnificent views of the alpine scenery and the Aletsch Glacier. However, knowing that there are no lodging facilities available for the public, I had to give up this idea. Luck turned my way when I visited Jungfrauoch with friends in September 2011 and enjoyed a guided tour of the High Altitude Research Station. Upon my inquiry about spending two or three nights in the living quarters of the research station, the custodians referred me to the foundation which generously granted me permission.

In the two nights of 27th and 28th August 2012 my dream came true. My friend and assistant, Heinz Rauch, and myself set up the two digital reflex cameras Canon EOS 350D and 40D on the Sphinx terrace. With only scattered clouds gracefully embellishing my planned time-lapse shots the weather proved perfect for our purpose.





We mounted the 40D on an old astronomical tracking device Vixen SP6 on a photo tripod. The custodian couple Joan and Martin Fischer showed to be very helpful. As Joan expressed concerns about gusty winds, we fixed the tripod with three lead blocks. The camera with the 10-mm wide-angle lens attached to it was intended to capture the Moench with the Sphinx dome in the foreground and to slowly pan over to the Trugberg and Aletsch Glacier (see collage next page a-d). The settings applied were ISO speed 400, aperture at the zoom lens' maximum F/3.5, the maximum exposure time the camera could handle on a self-controlled basis of 30 seconds and white balance preset 'daylight'. The second camera, the EOS 350D, was mounted on a sturdy camera clamp and fixed to the railing of the terrace. With the 28-mm fix focus lens I aimed it at the Aletsch Glacier, the Dreieckhorn and the Aletschhorn. As the moon descended towards the western horizon, the shadows of the mountain range west of the glacier lengthened and crept up the slopes of the mountains in the East of the glacier. Settings applied to the EOS 350D: ISO speed 200, aperture F/2.5, 30 seconds and white balance preset 'daylight'. We triggered both cameras around 2200 hrs or shortly afterwards and then simply enjoyed the majestic scenery gleaming mysteriously in the shine of the nearly full moon. We deemed it a unique privilege to have the whole Sphinx all to ourselves and felt overwhelmed by the beauty of the views and the complete silence up here!

While the cameras were clicking we returned to the living quarters around 2300 hrs and took a late evening snack. Shortly after midnight we went up to the terrace again to check if the cameras were working alright. Heinz proved an invaluable help when I had to change



the accumulators of the panning camera EOS 40D. In order to keep the time leap in the image sequence to a minimum, the power supply change had to be performed very quickly. I then stopped the EOS 350D, removed the camera and fixed it to the railings in the north. I

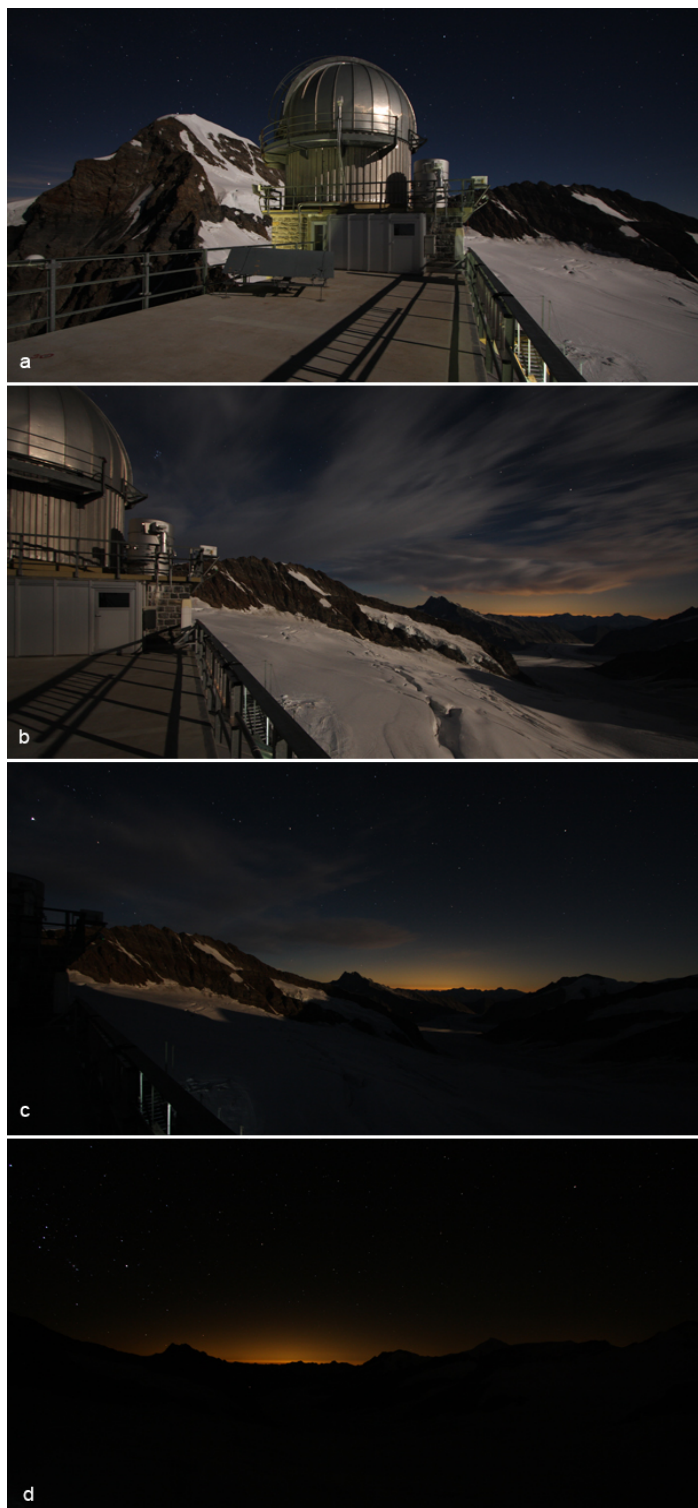


pointed it to the Moench on the slope of which was already clearly visible the shadow of the double peak of the Jungfrau (including that of the Wengen Jungfrau) slowly rising as the moon got ready to set below the western horizon. At 0118 hrs I triggered the camera and we went to sleep for about three hours. By 4 o'clock when we returned to the Sphinx terrace, the moon had long set (0306 hrs) and the absence of its shine revealed an absolutely breathtaking starry night sky with the milky way. Only the deplorable light pollution of the city of Milan and the Po plain in 150 km distance loomed over the south-eastern horizon. We stopped both cameras and went to sleep again.

The next morning I copied the frames to my notebook and converted them to video clips. We were very delighted about all three of the scenes and satisfied that all worked well technically.

The next day clouds increased and at times it even snowed during the day! Different weather services provided rather contradictory forecasts for the second night. When we stepped onto the Sphinx terrace at 2130 hrs our head lights cast a light cone into thick fog! At first we said to each other: «That was it»! Reluctant to give in, though, we hung on for a while, put off our lights and, indeed, after a couple of minutes we believed to spot a somewhat darker area above our heads. Before long, a tiny speck of the Aletsch Glacier became visible and Arcturus shone through a gap in the fog. Instantly, I came up with the flash idea of taking time-lapse shots of the likely process of the fog lifting and revealing the grand scenery later on. Although I lost no time to install my cameras, the fog lifted faster than desired! I fixed the EOS 40D with the 10-mm Sigma fisheye lens on the camera clamp to the railing in the south-western corner and placed it in a presumed position that would frame the Aletsch Glacier on the left and the Jungfrau on the right, at this time both still enshrouded in thick fog. Camera settings:

ISO 160, F/2.8, 30 sec. At 2150 hrs I triggered this camera with high hopes and then turned





my attention to the second camera. To the North large patches of clear skies had meanwhile become visible including the seas of light of the cities of Thun, Bern and Interlaken. I mounted the EOS 350D with the 10-mm zoom lens on the tripod and aimed it to the NNW to frame these city lights and the slope of the Moench. Camera settings: ISO 200, F/3.5, 30 sec. At 2200 hrs I set the camera to work and Heinz and I retreated to the heated lab rooms of the research station. Every now and then we went out to check the weather situation and the cameras and discovered that the fog lifted and returned in rapid succession. Wafts of mist curled in air currents above the Jungfrau Firn in wild up and down movements and made us fear that the video scenes would turn out very hectic in appearance. Indeed, the fog enshrouded the Sphinx once or twice again and around midnight we decided to stop the cameras.

When we converted the single frames to a video the next day, the clips did not convince us. As expected, the movements of the fog appeared very fast and almost hurt one's eye. Extremely satisfied with the results of the first night, though, we drew a very positive balance of this excursion.

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Key words:

Art, astronomy, photography, time-lapse film

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Internet data bases:

*Jungfrauojoch trailer*

It is recommended to click full screen and to select the highest quality (1080p) for a sharp image and to bring out the most intense colours:

<http://www.youtube.com/watch?v=jfORumzm9Vk>

*Progress on the project can be followed on my website:*

<http://homepage.bluewin.ch/wabers/IdHdN.html>

The latest pictures are always added on the bottom of the page. There are mostly still images. However, there are a few sample videos that can be viewed on YouTube. Next to some of the still photos you will find yellow links entitled «Sample Video on YouTube».

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Scientific publications and public outreach 2012:

In the Brightness of the Night («In der Helle der Nacht») is a private non-commercial, non-scientific film project and yet to be finalized. The film of an expected running time of about 13 to 15 minutes is planned to be screened within the scope of club events such as for astronomical societies and similar.

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## **Research statistics for 2012**

### **High Altitude Research Station Gornergrat**

#### **Solar Neutron Telescope SONTEL and Foundation HFSJG**

<b>Institute</b>	<b>Country</b>	<b>Person-working days</b>
Physikalisches Institut, Universität Bern	Switzerland	<b>3</b>

#### **University of Bern**

<b>Institute</b>	<b>Country</b>	<b>Person-working days</b>
Centre for Space and Habitability	Switzerland	<b>17</b>

#### **Field campaigns**

<b>Institute</b>	<b>Country</b>	<b>Person-working days</b>
VAW ETH Zürich	Switzerland	<b>8</b>

Name of research institute or organization:

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**Physikalisches Institut, Universität Bern**

Title of project:

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SONTEL - Solar Neutron Telescope for the identification and the study of high-energy neutrons produced in energetic eruptions at the Sun

Project leader and team:

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Dr. Rolf Bütikofer

Project description:

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The solar neutron telescope (SONTEL) at Gornergrat, Switzerland, has been in continuous operation since 1998 as the European cornerstone of a worldwide network for the study of high-energy neutrons produced in energetic processes at the Sun (Flückiger et al., 1998). The network consists of seven solar neutron telescopes that are located at high altitudes and at low to mid-latitudes (short path through atmosphere) as well as at different longitudes (24 hour readiness to observe): Mt. Norikura (Japan), Yanbajing (Tibet), Mt. Aragats (Armenia), Gornergrat (Switzerland), Mt. Chacaltaya (Bolivia), Sierra Negra (Mexico) and Mauna Kea (USA).

SONTEL Gornergrat was in continuous operation during 2012, with only some short data gaps caused by electrical power outages. Some rivets, which fix aluminium plates at the lab container, have been broken by the wind over the years and as a consequence the aluminium plates broke off, see Figure 1. This damage had no effect on the measurements of SONTEL. In September 2012 new plates were fixed by the workshop of the Physikalisches Institut, University of Bern.

Four years after the beginning of solar spot cycle 24 the activity of the Sun was still low. On 17 May 2012 a solar cosmic ray event was observed by the worldwide network of neutron monitors (see the activity report of the neutron monitors at Jungfraujoch in this volume). The onset of the count rate increase of the neutron monitors was at about 0150 UT, i.e. at night-time in Europe. As the neutrons travel on a straight line like the photons from the Sun to the Earth, it would not have been possible to observe solar neutrons at Gornergrat during this event. The solar neutron telescope at Mt. Norikura (36.1°N, 137.5°E) was the station that had the most suitable position to observe solar neutrons during this event. However, the solar neutron telescope at Mt. Norikura did not show an increase in the counting rate that could be attributed to solar neutrons.

In 2012 the radioactivity measurement with a GammaTracer device inside the detector housing of SONTEL was continued.



*Figure 1: Defective roof of SONTEL lab container.*

Key words:

Astrophysics, cosmic rays, solar neutrons

Internet data bases:

<http://cosray.unibe.ch>

<http://www.stelab.nagoya-u.ac.jp/ste-www1/div3/CR/Neutron/index.html>

Collaborating partners/networks:

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Prof. Y Muraki, Konan University, Nada-ku, Kobe 657-0000, Japan

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Name of research institute or organization:

**Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW)**

Title of project:

Determination of englacial temperature in Gornergletscher

Project leader and team:

Dr. Martin Lüthi

Claudia Ryser

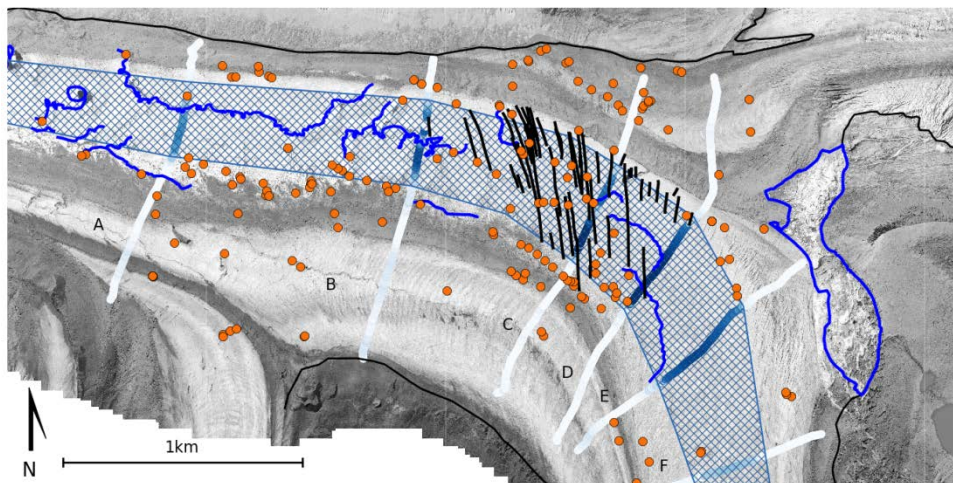
Project description:

The thermal structure of Gornergletscher was investigated with a helicopter-borne 30 MHz ice radar and in-situ temperature measurements in 15 boreholes through the glacier.

Cold ice is advected from the high-elevation accumulation zone (Colle Gnifetti 4500 m a.s.l.) and reaches the glacier tongue. There it occupies a flowband of 400 m width and reaches depths up to  $\frac{3}{4}$  of the total ice thickness.

Cold ice within a polythermal ice body controls its flow dynamics through the temperature dependence of the ice viscosity, and affects glacier hydrology by blocking water flow paths. Lakes at the surface, linked by persistent, deeply incised melt-water streams, are hallmark features of cold ice in the ablation zone of Gornergletscher.

In the following figure (Figure 1), the extent of cold ice on the tongue of Gornergletscher is marked with the blue hatched area.



*Figure 1: the extent of cold ice on the tongue of Gornergletscher.*

The cold ice extent was delineated by radar-profiles (labeled A to F) which indicate temperate ice in white and cold ice in blue. The thin blue lines indicate deep melt-water streams and the outline of Gornersee. Moulins (orange dots) are common in the temperate part but nearly absent in the cold ice, except for the highly crevassed zone (marked by black strokes).

Key words:

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Polythermal ice, ice radar, englacial temperature

Internet data bases:

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[http://www.vaw.ethz.ch/divisions/gz/projects\\_DE](http://www.vaw.ethz.ch/divisions/gz/projects_DE)

Collaborating partners/networks:

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Universität Münster, Institut für Geophysik  
Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover

Scientific publications and public outreach 2012:

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**Refereed journal articles and their internet access**

Ryser C., M. Lüthi, N. Blindow, S. Suckro, M. Funk and A. Bauder, Cold ice in the ablation zone: its relation to glacier hydrology and ice water content, J. Geophys. Res., in press.

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URL: <http://www.glaciology.ch>

Name of research institute or organization:

**Center for Space and Habitability, Universität Bern**

Title of project:

Stellarium Gornergrat

Project leader and team:

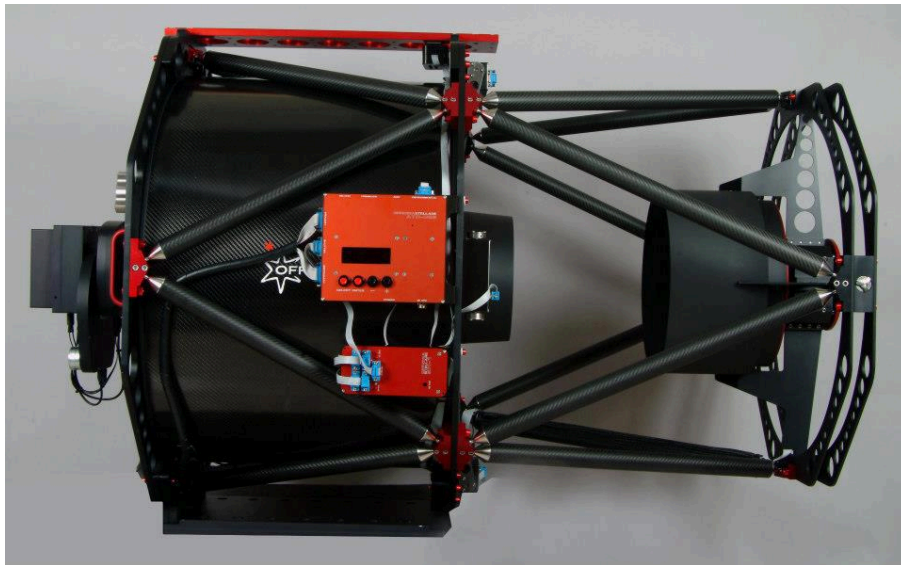
Prof. Kathrin Altwegg, University of Bern

Michael Affolter, University of Bern

Prof. Didier Queloz, University of Geneva

Project description:

The center for Space and Habitability, University of Bern and the Institute for Astronomy, University of Geneva are establishing an astronomical observation facility for schools on the Gornergrat. The goal of this project is to make available several telescopes, the largest having 60cm diameter, to be used by Swiss schools for astronomical observations by remote control. While the hardware on the Gornergrat was paid for by the Burgergemeinde Zermatt, the installation of all necessary equipment as well as of the hardware related remote control is the responsibility of the University of Bern. The University of Geneva is responsible for the “astronomical” part including pedagogical modules for teachers. Currently the dome has been prepared to accommodate the telescopes and has been upgraded to accommodate also visitors on the Gornergrat for guided astronomical tours. The telescopes are being tested with the mount and the software at the University of Bern. It is planned to install all hardware on the Gornergrat during April 2013. The first modules should be ready by summer 2013 and test classes can then start using these modules and the telescopes. The full operation is planned to start by summer 2014.



*RiLA 600 (Riccardi large Astrograph 600mm F/3.7)!*

Key words:

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Telescope

Astronomy for schools

Internet data bases:

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<http://www.facebook.com/stellariumgornergrat>

Collaborating partners/networks:

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University of Geneva

Bürgergemeinde Zermatt

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## **The International Foundation HFSJG in the News**

- 40 Print media
- 2 Radio
- 6 Television
- 1 Internet

“Wie mit PV-Strom durch den Winter?”, ET Elektrotechnik, January 26, 2012.

“Himmliche Schneemengen”, Berner Oberländer, February 1, 2012.

“Wenn ich ins Tal gehe, friere ich manchmal mehr”, Der Bund, February 6, 2012.

“Wegen der Klimaerwärmung werden die Bergwinter kühler”, Tages-Anzeiger / Zürcher Oberland / Zürcher Unterland / Zürichsee linkes Ufer / Zürichsee rechtes Ufer / Gesamt, Der Bund, February 7, 2012.

“6 Geschichten aus der Eiszeit”, SonntagsBlick, February 12, 2012.

“Bilder aus diversen Perspektiven”, Berner Oberländer, February 17, 2012.

“Bilder unter extremen Bedingungen”, Der Brienzer, Der Oberhasler, Echo von Grindelwald, Jungfrau-Zeitung, February 21, 2012.

“Oberland, voyage au centre de l'Eiger”, Chroniques d'en Haut, France 3 télévisions, March 17, 2012.

“Wunschkind aus dem Reagenzglas haben ein erhöhtes Herz-Kreislauf-Risiko”, Radio BeO, April 4, 2012.

“Arratoi garuna ikertzen 3.500 metrora (Investigating rat brains at 3500 m)”, Interview with neuroscientist Enrike G. Argandoña, University of Fribourg, Euskadi Irratia, “Mezularia”, April 10, 2012.  
<http://www.eitb.com/eu/audioak/oso/865531/arratoi-garuna-ikertzen-3500-metrora--mezularia/> (Basque)

“FCKW-Ersatzstoffe: Gut für die Ozonschicht, schlecht für das Klima”, SVG-Journal, April 20, 2012.

“Feinstaub: Lungenschäden und Regenfälle”, SDA / Schweizerische Depeschagentur, May 4, 2012.

“Auf 3500 Metern den Puls der Atmosphäre messen”, SDA / Schweizerische Depeschagentur, May 4, 2012.

“Den Puls der Atmosphäre messen”, Walliser Bote, May 5, 2012.

“Der Atmosphäre wird der Puls gemessen”, Die Südostschweiz am Sonntag / Glarus / Gaster und See / Graubünden, May 6, 2012.

“Der Puls der Atmosphäre”, Wiler Zeitung / Der Volksfreund Wil-Uzwil-Flawil / Der Volksfreund Hinterthurgau, Toggenburger Tagblatt, Thurgauer Zeitung, St. Galler Tagblatt / St. Gallen + Gossau / Rorschach, Der Rheintaler, Appenzeller Zeitung, May 7, 2012.

“Jungfraujoch: prendre le pouls de l'atmosphère à 3500 mètres”, ATS / Agence Télégraphique Suisse, May 7, 2012.

“Le Sphinx mesure l'air depuis 75 ans à la Jungfraujoch”, Tribune de Genève, May 7, 2012.

“Jungfraujoch: L'observatoire du Sphinx à 75 ans”, Le Nouvelliste, La Côte, May 8, 2012.

“Lungenschäden und Regenfälle”, Engadiner Post / Posta Ladina, May 8, 2012.

“75 ans d'observations au sommet”, Le Temps, May 11, 2012.

“La station du Jungfraujoch, <un honneur pour la Suisse>”, Le Temps, May 11, 2012.

- “Recherche au sommet”, *Le Temps*, May 11, 2012.
- “The Big Bang Theory”, 60 Minutes, Nine Network Australia, May 13, 2012.
- “Asien-Hochzeit mit Böniger Schülern”, *Berner Oberländer*, May 30, 2012.
- “75 Jahre Sphinx-Observatorium”, *Tec 21*, June 1, 2012.
- “Zum Hundertsten so beliebt wie nie”, *Die Südostschweiz am Sonntag / Glarus / Graubünden / Gaster und See*, June 3, 2012.
- “Zum Hundertsten so beliebt wie nie”, *Sarganserländer*, June 4, 2012.
- “Höhenexposition”, *Sendung Puls*, Schweizer Fernsehen SF1, June 4, 2012.
- “Hausherr der höchsten Forschungsstation Europas”, *Tages-Anzeiger*, *Der Bund*, June 11, 2012.
- “Hochalpine Top-Wissenschaft”, *Neue Zürcher Zeitung*, June 12, 2012.
- “Emissionen-Schwindel in Italien”, *Sendung Einstein*, Schweizer Fernsehen SF1, June 21, 2012.
- “Presseschau: Hochalpine Top-Wissenschaft”, *Echo von Grindelwald*, *Jungfrau-Zeitung*, June 19, 2012.
- “Spitzenforschung für die Industrie”, *CH-D Wirtschaft*, June 23, 2012.
- “Mit Hundert auf Kurs”, *Unternehmer Zeitung*, July 10, 2012.
- “Des labos de pointe sur le toit de l’Europe”, *Migros Magazine*, July 23, 2012.
- “Fünf Astronauten ganz hoch oben”, *Berner Oberländer*, July 28, 2012.
- “Gletscherwunder Jungfraubahn”, *Sendung Eisenbahn-Romantik*, SWR, July 29, 2012.
- “Illustrer Besuch”, *Der Brienzer*, *Der Oberhasler*, *Echo von Grindelwald*, *Jungfrau-Zeitung*, July 31, 2012.
- “Astronauten landen auf dem Jungfraujoch”, *Der Brienzer*, *Der Oberhasler*, *Echo von Grindelwald*, *Jungfrau-Zeitung*, July 31, 2012.
- “Moderationen”, *Sendung Abenteuer Alpen*, 3sat/SRF, August 1, 2012.
- “Die Mikrophysik der Wolken”, *Neue Zürcher Zeitung*, August 8, 2012.
- “Sorgen-Gletscher verhalten sich ruhig”, *Jungfrau-Zeitung*, August 31, 2012.
- “Ein Besuch unter dem Himmelszelt”, *Pestalozzi Schüleragenda 2012/13*, 2012.
- “Climate: to find warming’s speed, scientists must see through clouds”, *Greenwire*, November 13, 2012. <http://www.eenews.net/public/Greenwire/2012/11/13/1>.
- “Autant en emporte le vent”, *Environnement*, November 26, 2012.
- “Messen, was der Wind bringt”, *Umwelt*, November 26, 2012.
- “Luftfremdstoffen auf der Spur”, *Der PVB*, December 6, 2012.
- “Gestresster Embryo”, *Neue Zürcher Zeitung*, December 12, 2012.

## Publication list

- 32 Refereed publications
- 2 Master (1) and secondary school (1) theses
- 48 Conference presentations / posters
- 5 Books / edited books
- 3 Popular publications and presentations
- 8 Data books and reports

### Refereed publications

Amitrano, D., S. Gruber, L. Girard, Evidence of frost-cracking inferred from acoustic emissions in a high-alpine rock-wall, *Earth and Planetary Science Letters*, **341**, 86–93, doi: 10.1016/j.epsl.2012.06.014, 2012.  
<http://dx.doi.org/10.1016/j.epsl.2012.06.014>

Argandoña E.G., H. Bengoetxea, S. Bulnes, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Vascular Endothelial Growth Factor: Adaptive changes in the neuroglialvascular unit, *Current Neurovascular Research*, **9**, 1, 72-81, doi: 10.2174/156720212799297119, 2012.  
<http://www.eurekaselect.com/76454/article>

Brunner, D., S. Henne, C.A. Keller, S. Reimann, M.K. Vollmer, S. O'Doherty, M. Maione, An extended Kalman-filter for regional scale inverse emission estimation, *Atmos. Chem. Phys.*, **12**, 7, 3455-3478, doi: 10.5194/acp-12-3455-2012, 2012.  
<http://www.atmos-chem-phys.net/12/3455/2012/acp-12-3455-2012.html>

Buchmann, B., Research at Jungfraujoch supports policy, Public Service Review: European Science & Technology 2012, **14**, 190-191, 2012.  
[http://www.publicservice.co.uk/article.asp?publication=European%20Science%20and%20Technology&id=554&content\\_name=Environment%20and%20Energy&article=18998](http://www.publicservice.co.uk/article.asp?publication=European%20Science%20and%20Technology&id=554&content_name=Environment%20and%20Energy&article=18998)

Conen, F., S. Henne, C.E. Morris, C. Alewell, Atmospheric ice nucleators active  $\geq -12$  degrees C can be quantified on PM<sub>10</sub> filters, *Atmos. Meas. Tech.*, **5**, 2, 321-327, doi: 10.5194/amt-5-321-2012, 2012.  
<http://www.atmos-meas-tech.net/5/321/2012/amt-5-321-2012.html>

Deolal, S.P., D. Brunner, M. Steinbacher, U. Weers, J. Staehelin, Long-term in situ measurements of NO<sub>x</sub> and NO<sub>y</sub> at Jungfraujoch 1998-2009: time series analysis and evaluation, *Atmos. Chem. Phys.*, **12**, 5, 2551-2566, doi: 10.5194/acp-12-2551-2012, 2012.  
<http://www.atmos-chem-phys.net/12/2551/2012/acp-12-2551-2012.html>

Duflot, V., D. Hurtmans, L. Clarisse, Y. R'honi, C. Vigouroux, M. De Mazière, E. Mahieu, C. Servais, C. Clerbaux, and P.-F. Coheur, Measurements of hydrogen cyanide (HCN) and acetylene (C<sub>2</sub>H<sub>2</sub>) from the Infrared Atmospheric Sounding Interferometer (IASI), *Atmos. Meas. Tech. Discuss.*, **5**, 7567-7586, 2012.  
<http://www.atmos-meas-tech-discuss.net/5/7567/2012/amtd-5-7567-2012.html>

Farinotti, D., St. Usselman, M. Huss, A. Bauder, M. Funk, Runoff evolution in the Swiss Alps: projections for selected high-alpine catchments on ENSEMBLES scenarios, *Hydrological Processes*, **26**, 13, 1909-1924, doi: 10.1002/hyp.8276, 2012.  
<http://dx.doi.org/10.1002/hyp.8276>

Girard, L., J. Beutel, S. Gruber, J. Hunziker, R. Lim, S. Weber, A custom acoustic emission monitoring system for harsh environments: application to freezing-induced damage in alpine rock walls, *Geosci. Instrum. Method. Data Syst.*, **1**, 155–167, doi: 10.5194/gi-1-155-2012, 2012.  
<http://dx.doi.org/10.5194/gi-1-155-2012>

Hendrick, F., E. Mahieu, G.E. Bodeker, K.F. Boersma, M.P. Chipperfield, M. De Mazière, I. De Smedt, P. Demoulin, C. Fayt, C. Hermans, K. Kreher, B. Lejeune, G. Pinardi, C. Servais, R. Stuebi, R. van der A, J.P. Vernier, M. Van Roozendaal, Analysis of stratospheric NO<sub>2</sub> trends above Jungfraujoch using ground-based UV-visible, FTIR, and satellite nadir observations, *Atmospheric Chemistry and Physics*, **12**, 18, 8851-8864, doi: 10.5194/acp-12-8851-2012, 2012.  
<http://www.atmos-chem-phys.net/12/issue18.html>

Jacobs R.A., C. Siebenmann, M. Hug, A.K. Meinild, C. Lundby, 28 days at 3,454 m diminishes respiratory capacity but enhances efficiency in human skeletal muscle mitochondria, *FASEB J.*, **26**, 12, 5192-5200, doi: 10.1096/fj.12-218206, 2012.  
<http://www.fasebj.org/content/26/12/5192.abstract>

Keller, C.A., M. Hill, M.K. Vollmer, S. Henne, D. Brunner, S. Reimann, S. O'Doherty, J. Arduini, M. Maione, Z. Ferenczi, L. Haszpra, A.J. Manning, T. Peter, European Emissions of Halogenated Greenhouse Gases Inferred from Atmospheric Measurements, *Environmental Science & Technology*, **46**, 1, 217-225, doi: 10.1021/es202453j, 2012.  
<http://pubs.acs.org/doi/full/10.1021/es202453j>

- Kerzenmacher, T., B. Dils, N. Kumps, T. Blumenstock, C. Clerbaux, P.-F. Coheur, P. Demoulin, O. García, M. George, D.W.T. Griffith, F. Hase, J. Hadji-Lazaro, D. Hurtmans, N. Jones, E. Mahieu, J. Notholt, C. Paton-Walsh, U. Raffalski, T. Ridder, M. Schneider, C. Servais, and M. De Mazière, Validation of IASI FORLI carbon monoxide retrievals using FTIR data from NDACC, *Atmos. Meas. Tech.*, **5**, 2751-2761, 2012.  
<http://orbi.ulg.ac.be/handle/2268/124179>
- Kohlhepp, R., R. Ruhnke, M.P. Chipperfield, M. De Mazière, J. Notholt, S. Barthlott, R.L. Batchelor, R.D. Blatherwick, Th. Blumenstock, M.T. Coffey, P. Demoulin, H. Fast, W. Feng, A. Goldman, D.W.T. Griffith, K. Hamann, J.W. Hannigan, F. Hase, N.B. Jones, A. Kagawa, I. Kaiser, Y. Kasai, O. Kirner, W. Kouker, R. Lindenmaier, E. Mahieu, R.L. Mittermeier, B. Monge-Sanz, I. Morino, I. Murata, H. Nakajima, M. Palm, C. Paton-Walsh, U. Raffalski, Th. Reddmann, M. Rettinger, C.P. Rinsland, E. Rozanov, M. Schneider, C. Senten, C. Servais, B.-M. Sinnhuber, D. Smale, K. Strong, R. Sussmann, J.R. Taylor, G. Vanhaelewyn, T. Warneke, C. Whaley, M. Wiehle, and S.W. Wood, Observed and simulated time evolution of HCl, ClONO<sub>2</sub>, and HF total column abundances, *Atmos. Chem. Phys.*, **12**, 3527-3556, 2012.  
<http://hdl.handle.net/2268/117940>
- Kristiansen, N. I., A. Stohl, A.J. Prata, N. Bukowiecki, H. Dacre, D. Eckhardt, S. Henne, M.C. Hort, B.T. Johnson, F. Marengo, B. Neininger, O. Reitebuch, P. Seibert, D.J. Thomson, H.N. Webster and B. Weinzierl, Performance assessment of a volcanic ash transport model mini-ensemble used for inverse modeling of the 2010 Eyjafjallajökull eruption, *Journal of Geophysical Research*, **117**, D00U11, doi: 10.1029/2011JD016844, 2012.  
<http://dx.doi.org/10.1029/2011JD016844>
- Logan, J.A., J. Staehelin, I.A. Megretskaia, J.P. Cammas, V. Thouret, H. Claude, H. De Backer, M. Steinbacher, H.E. Scheel, R. Stuebi, M. Froehlich, R. Derwent, Changes in ozone over Europe: Analysis of ozone measurements from sondes, regular aircraft (MOZAIC) and alpine surface sites, *Journal of Geophysical Research-Atmospheres*, **117**, 1-23, doi: 10.1029/2011jd016952, 2012.  
<http://www.agu.org/pubs/crossref/2012/2011JD016952.shtml>
- Nyeki, S., C.H. Halios, W. Baum, K. Eleftheriadis, H. Flentje, J. Groebner, L. Vuilleumier, C. Wehrli, Ground-based aerosol optical depth trends at three high-altitude sites in Switzerland and southern Germany from 1995 to 2010, *Journal of Geophysical Research-Atmospheres*, **117**, doi: 10.1029/2012jd017493, 2012.  
<http://www.agu.org/pubs/crossref/2012/2012JD017493.shtml>
- Parrish, D. D., K.S. Law, J. Staehelin, R. Derwent, O.R. Cooper, H. Tanimoto, A. Volz-Thomas, S. Gilge, H.-E. Scheel, M. Steinbacher, E. Chan, Long-term changes in lower tropospheric baseline ozone concentrations at northern mid-latitudes, *Atmospheric Chemistry and Physics*, **12**, 11485-11504, doi:10.5194/acp-12-11485-2012, 2012.  
<http://www.atmos-chem-phys.net/12/11485/2012/acp-12-11485-2012.html>
- Piters, A.J.M., K. F. Boersma, M. Kroon, J. C. Hains, M. Van Roozendaal, F. Wittrock, N. Abuhassan, C. Adams, M. Akrami, M. Allaart, I. Alonso Calvo, A. Apituley, H.B. Bergwerff, A.J.C. Berkhout, D. Brunner, A. Cede, J. Chong, K. Clémer, C. Fayt, U. Frieß, L.F.L. Gast, M. Gil Ojeda, F. Goutail, R. Graves, A. Griesfeller, K. Großmann, G. Hemerijckx, F. Hendrick, B. Henzing, J. Herman, C. Hermans, M. Hoexum, G.H. van der Hoff, H. Irie, P.V. Johnston, Y. Kanaya, M.P. Keuken, Y.J. Kim, H. Klein-Baltink, K. Kreher, G. de Leeuw, R. Leigh, A. Merlaud, M.M. Moerman, P. Monks, G.H. Mount, M. Navarro-Comas, H. Ötjen, A. Pazmino, E. Peters, A. du Piesanie, G. Pinardi, O. Puertedura, A. Richter, H.K. Roscoe, A. Schönhardt, B. Schwarzenbach, R. Shaiganfar, W. Sluis, E. Spinei, A.P. Stolk, K. Strong, D. Swart, H. Takashima, T. Vlemmix, M. Vrekoussis, T. Wagner, C. Whyte, K. Wilson, M. Yela, S. Yilmaz, P. Zieger, Y. Zhou, The Cabauw Intercomparison campaign for Nitrogen Dioxide Measuring Instruments (CINDI): Design, Execution, and First Results, *Atmos. Meas. Tech.*, **5**, 457-485, 2012.  
<http://www.atmos-meas-tech.net/5/457/2012/amt-5-457-2012.html>
- Popp, C., D. Brunner, A. Damm, C. Fayt, M. Van Roozendaal, and B. Buchmann, High resolution NO<sub>2</sub> remote sensing from the Airborne Prism EXperiment (APEX) imaging spectrometer, *Atmos. Meas. Tech.*, **5**, 2211-2225, 2012.  
<http://www.atmos-meas-tech.net/5/2211/2012/amt-5-2211-2012.html>
- Riepl, R. L., R. Fischer, H. Hautmann, G. Hartmann, T. D. Muller, M. Tschop, M. Toepfer, B. Otto, Influence of acute exposure to high altitude on Basal and postprandial plasma levels of gastroenteropancreatic peptides, *PloS one*, **7**, 9, e44445-e44445, doi: 10.1371/journal.pone.0044445, 2012.  
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3435278/>
- Rinsland, C.P., E. Mahieu, P. Demoulin, R. Zander, Ch. Servais, J.M. Hartmann, Decrease of the carbon tetrachloride (CCl<sub>4</sub>) loading above Jungfraujoch, based on high resolution infrared solar spectra recorded between 1999 and 2011, *Journal of Quantitative Spectroscopy & Radiative Transfer*, **113**, 1322-1329, doi: 10.1016/j.jqsrt.2012.02.016, 2012.  
<http://www.sciencedirect.com/science/article/pii/S0022407312000763>
- Risi, C., D. Noone, J. Worden, C. Frankenberg, G. Stiller, M. Kiefer, B. Funke, K. Walker, P. Bernath, M. Schneider, D. Wunch, V. Sherlock, N. Deutscher, D. Griffith, P.O. Wennberg, K. Strong, D. Smale, E. Mahieu, S. Barthlott, F. Hase, O. García, J. Notholt, T. Warneke, G.C. Toon, D. Sayres, S. Bony, J. Lee, D. Brown, R. Uemura, and C. Sturm, Process-evaluation of tropospheric humidity simulated by general circulation models using water vapor isotopologues: 1. Comparison between models and observations, *J. Geophys. Res.*, **117**, D05303, doi: 10.1029/2011JD016621, 2012. <http://hdl.handle.net/2268/123815>

- Ruckstuhl, A. F., S. Henne, S. Reimann, M. Steinbacher, M.K. Vollmer, S. O'Doherty, B. Buchmann, C. Hueglin, Robust extraction of baseline signal of atmospheric trace species using local regression, *Atmospheric Measurement Techniques*, **5**, 11, 2613-2624, 2012.  
<http://www.atmos-meas-tech.net/5/2613/2012/amt-5-2613-2012.html>
- Saikawa, E., M. Rigby, R. G. Prinn, S. A. Montzka, B. R. Miller, L. J. M. Kuijpers, P. J. B. Fraser, M. K. Vollmer, et al., Global and regional emissions estimates for HCFC-22, *Atmos. Chem. Phys.*, **12**, 10033-10050, doi: 10.5194/acp-12-10033-2012, 2012.  
<http://www.atmos-chem-phys.net/12/10033/2012/acp-12-10033-2012.pdf>
- Schneider, M., S. Barthlott, F. Hase, Y. González, K. Yoshimura, O.E. García, E. Sepúlveda, A. Gomez-Pelaez, M. Gisi, R. Kohlepp, S. Dohe, T. Blumenstock, K. Strong, D. Weaver, M. Palm, N.M. Deutscher, T. Warneke, J. Notholt, B. Lejeune, P. Demoulin, N. Jones, D.W.T. Griffith, D. Smale, and J. Robinson, Ground-based remote sensing of tropospheric water vapor isotopologues within the project MUSICA, *Atmos. Meas. Tech.*, **5**, 3007-3027, doi: 10.5194/amt-5-3007-2012, 2012.  
<http://hdl.handle.net/2268/135828>
- Spiegel, J.K., P. Zieger, N. Bukowiecki, E. Hammer, E. Weingartner, W. Eugster, Evaluating the capabilities and uncertainties of droplet measurements for the fog droplet spectrometer (FM-100), *Atmospheric Measurement Techniques*, **5**, 9, 2237-2260, doi: 10.5194/amt-5-2237-2012, 2012.  
<http://www.atmos-meas-tech-discuss.net/5/3333/2012/amtd-5-3333-2012.html>
- Thevenon, F., M. Chiaradia, T. Adatte, Ch. Hueglin, J. Pote, Characterization of Modern and Fossil Mineral Dust transported to High Altitude in the Western Alps: Saharan Sources and Transport Patterns, *Advances in Meteorology*, 1-14, doi: 10.1155/2012/674385, 2012.  
<http://www.hindawi.com/journals/amet/2012/674385/>
- 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 CO<sub>2</sub>,  $\delta(\text{O}_2/\text{N}_2)$  and  $\delta^{13}\text{CO}_2$  measurements at Jungfraujoch, Switzerland: results from a flask sampling intercomparison program, *Atmos. Meas. Tech. Discuss.*, **5**, 7293-7322, doi: 10.5194/amtd-5-7293-2012, 2012.  
<http://www.atmos-meas-tech-discuss.net/5/7293/2012/>
- Wiedensohler, A., W. Birmili, A. Nowak, A. Sonntag, K. Weinhold, M. Merkel, B. Wehner, T. Tuch, S. Pfeifer, M. Fiebig, A.M. Fjåraa, E. Asmi, K. Sellegri, R. Depuy, H. Venzac, P. Villani, P. Laj, P. Aalto, J.A. Ogren, E. Swietlicki, P. Williams, P. Roldin, P. Quincey, C. Hüglin, R. Fierz-Schmidhauser, M. Gysel, E. Weingartner, F. Riccobono, S. Santos, C. Grüning, K. Faloon, D. Beddows, R. Harrison, C. Monahan, S.G. Jennings, C.D. O'Dowd, A. Marinoni, H.-G. Horn, L. Keck, J. Jiang, J. Scheckman, P.H. McMurry, Z. Deng, C.S. Zhao, M. Moerman, B. Henzing, G. de Leeuw, G. Löschau and S. Bastian, Mobility particle size spectrometers: harmonization of technical standards and data structure to facilitate high quality long-term observations of atmospheric particle number size distributions, *Atmos. Meas. Tech.*, **5**, 657-685, doi: 10.5194/amt-5-657-2012, 2012.  
<http://dx.doi.org/10.5194/amt-5-657-2012>
- Zieger, P., E. Kienast-Sjoegren, M. Starace, J. von Bismarck, N. Bukowiecki, U. Baltensberger, F.G. Wienhold, T. Peter, T. Ruhtz, M.C. Coen, L. Vuilleumier, O. Maier, E. Emili, C. Popp, E. Weingartner, Spatial variation of aerosol optical properties around the high-alpine site Jungfraujoch (3580 m a.s.l.), *Journal of Atmospheric Chemistry and Physics*, **12**, 15, 7231-7249, doi: 10.5194/acp-12-7231-2012, 2012.  
<http://www.atmos-chem-phys.net/12/7231/2012/acp-12-7231-2012.html>
- Wilson, R. C., Z.L. Fleming, P.S. Monks, G. Clain, S. Henne, I.B. Kononov, S. Szopa, L. Menut, Have primary emission reduction measures reduced ozone across Europe? An analysis of European rural background ozone trends 1996–2005, *Atmospheric Chemistry and Physics*, **12**, 1, 437-454, 2012.  
<http://www.atmos-chem-phys.net/12/437/2012/acp-12-437-2012.html>

## **Theses**

Palumbo Adrien, Étude de faisabilité d'une caméra IP destinée au contrôle d'expérience en haute altitude et basée sur un système embarqué dans un FGPA, Travail de fin d'étude présenté en vue de l'obtention du grade de bachelier en informatique et systèmes finalité réseaux et télécommunications, Haute Ecole de la Province de Liège, Seraing, Année académique 2011-2012.

Van Laeken Lionel and Boileau Quentin, La station de recherche du Jungfraujoch. Étude de la composition chimique de l'atmosphère terrestre par la spectroscopie infrarouge à transformée de Fourier, Mémoire de fin d'études secondaires, Ecole Sainte-Marie, Huy, January 2012.

### Conference presentations / Posters

Amitrano, D., S. Gruber, L. Girard, Cryo-induced cracking in high-alpine rock-wall, evidences from acoustic emissions monitoring, European Geophysical Union, General Assembly, Vienna, Austria, 2012.

Argandoña, E.G., H. Bengoetxea, S. Bulnes, R. Ledezma, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Environmental enrichment reverts the cognitive effects of altitude hypoxia inducing changes at the neuroglivascular unit, 74th Annual Meeting of the Swiss Society for Anatomy, Histology, and Embryology 2012, F1000 Posters 2012, 3: 1302, Zurich, Switzerland, September 7, 2012.  
<http://f1000.com/posters/browse/summary/1092456>

Argandoña, E.G., H. Bengoetxea, S. Bulnes, R. Ledezma, N. Ortuzar, I. Rico-Barrio, J.V. Lafuente, Physical exercise mediates neuroprotective responses to the effects of altitude hypoxia at the neuroglivascular unit, 8th FENS Forum of Neuroscience 2012, F1000 Posters 2012, 3: 1043, Barcelona, Spain, July 14-18, 2012.  
<http://f1000.com/posters/browse/summary/1092145>

Bader, W., E. Mahieu, B. Bovy, B. Lejeune, P. Demoulin, and C. Servais, First retrievals of methanol (CH<sub>3</sub>OH) above Jungfraujoch (46.5°N): Optimization of the retrieval strategy and information content, poster presentation at the "Journée des doctorants UNITER", Université Libre de Bruxelles, Belgique, December 10, 2012.  
<http://hdl.handle.net/2268/135878>

Bader, W., A. Perrin, D. Jacquemart, J.J. Harrison, G.C. Toon, K. Sudo, O.A. Søvde, P. Demoulin, C. Servais, and E. Mahieu, Retrievals of ethane from ground-based high-resolution FTIR solar observations with updated line parameters: determination of the optimum strategy for the Jungfraujoch station, poster presentation at the "11th Atmospheric Spectroscopy Applications" meeting (ASA 2012), united with the "12th HITRAN Conference", Reims, France, August 29-31, 2012.  
<http://hdl.handle.net/2268/129289>

Bader, W., A. Perrin, D. Jacquemart, K. Sudo, H. Yashiro, M. Gauss, P. Demoulin, C. Servais, and E. Mahieu, Retrievals of ethane from ground-based high-resolution FTIR solar observations with updated line parameters: determination of the optimum strategy for the Jungfraujoch station, poster presentation at the "EGU 2012 General Assembly", Vienna, Austria, April 22-27, 2012 and at the 4th Symposium on METEOrology and CLIMatology for PhD students - MeteoClim2012, 2012.  
<http://hdl.handle.net/2268/117067>

Bader, W., A. Perrin, D. Jacquemart, K. Sudo, H. Yashiro, O.E. Søvde, P. Demoulin, C. Servais, and E. Mahieu, Retrievals of ethane from ground-based high-resolution FTIR solar observations with updated line parameters: determination of the optimum strategy for the Jungfraujoch station, poster presentation at the "NDACC-IRWG Annual Meeting", Wengen, Switzerland, June 11-15, 2012.  
<http://hdl.handle.net/2268/124230>

Brockmann E. et al., National Report of Switzerland and Geodetic control surveys at the Geostation Zimmerwald, swisstopo-report 12-07, EUREF'12: Paper contributions to the EUREF-Symposium in Paris, France, June 6-8, 2012.  
<http://www.swisstopo.admin.ch/internet/swisstopo/de/home/docu/pub/geodesy/report.parsys.70206.downloadList.45836.DownloadFile.tmp/report1207.pdf>

Brunner D., Estimation of air pollutant and GHG sources using Lagrangian and Eulerian models, Chinese Academy of Sciences seminar, Beijing, China, April 27, 2012.

Brunner, D., The evolution of methyl bromide and other halocarbon emissions in Europe estimated by an extended Kalman filter, 2012 ACCENT-IGAC-GEIA Conference, Toulouse, France, June 11-13, 2012.

Buchmann, B., S. Reimann, Atmospheric measurements for emission estimation: Real-world Emission Verification of Halogenated Greenhouse Gases, SBSTA Science meeting, Bonn, Germany, May 13, 2012.

Bütikofer, R. and E.O. Flückiger, Differences in published characteristics of GLE60 and their consequences on computed radiation dose rates along selected flight paths, 23rd European Cosmic Ray Symposium, Moscow, Russia, Conference Proceedings, 2012.

Cubison M., R. Fröhlich, J. Slowik, A. Prévôt, U. Baltensperger, U. Rohner, M. Gonin, J. Kimmel, D. Worsnop and J. Jayne, *A novel compact aerosol mass spectrometer - the ToF-ACSM: Instrument performance and first field deployment*, AAAR 31<sup>st</sup> Annual Conference, Minneapolis, Minnesota, USA, October 08-12, 2012.

De Mazière, M., K. Hocke, A. Richter, S. Godin-Beekmann, S. Henne, T. Blumenstock, S. Niemeijer, and E. Mahieu, NORS: Demonstration Network Of ground-based Remote Sensing Observations in support of the GMES Atmospheric Service, poster presentation at the 12th International Global Atmospheric Chemistry (IGAC) Science Conference, Beijing, China, September 17-21 2012.  
<http://hdl.handle.net/2268/131119>

Demoulin, P., E. Mahieu, C. Servais, B. Lejeune, W. Bader, G. Roland, R. Zander, K.A. Walker, P.F. Bernath, M. Van Roozendaal, and F. Hendrick, Long-term trends of NO<sub>y</sub> above northern mid-latitudes as inferred from Jungfraujoch, HALOE and ACE-FTS infrared solar observations, poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, Canada, August 27-31, 2012.  
<http://larss.science.yorku.ca/QOS2012pdf/5997.pdf>

Emmenegger, L., J. Mohn, P. Sturm, S. Henne, P. Wunderlin, J. R. Köster, S. Eyer and B. Tuzson, Application of direct absorption mid IR laser spectroscopy for isotope specific detection of greenhouse gases, 15<sup>th</sup> International Conference on Laser Optics, St. Petersburg, Russia, June 25-29, 2012.

- Fröhlich R., M. Cubison, J. Slowik, A. Prévôt, U. Baltensperger, U. Rohner, M. Gonin, J. Kimmel, D. Worsnop and J. Jayne, *A novel compact aerosol mass spectrometer - the ToF-ACSM: Instrument performance and first field deployment*, European Aerosol Conference (EAC), Granada, Spain, September 02-07, 2012.
- Girard, L., S. Gruber, S. Weber, J. Beutel, Continuous monitoring of near-surface damage in a freezing rock-wall, 10<sup>th</sup> Swiss Geoscience Meeting, Bern, Switzerland, 2012.
- Gruber, S., L. Girard, D. Amitrano, J. Beutel, S. Weber, Can improved understanding of frost cracking help anticipating focal zones for rockfall from degrading permafrost?, The Geological Society of America, Annual meeting, Charlotte, North Carolina, USA, 2012.
- Henneberger J., O. Stetzer, U. Lohmann, Field measurements of the microstructure of mixed-phase clouds, 16<sup>th</sup> International Conference on Clouds and Precipitation, ICCP-2012, Leipzig, Germany, July 30 – August 3, 2012.
- Hueglin, C., Measurements of ambient air in Switzerland (NABEL) and Europe (EMEP), HS\_Course Oeschgerzentrum/Medizinische Fakultät Uni Bern/Empa, Dübendorf, Switzerland, January 23-26, 2012.
- Iori, M., Test of a new concept of EAS detector for UHE neutrinos, European Cosmic Ray Conference, Moscow, Russia, July, 2012.
- Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfraujoch, International Symposium on Tropospheric Profiling, Oral Presentation, L'Aquila, Italia, September, 2012.
- Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfraujoch, International Conference on Clouds and Precipitation, Poster Presentation, Leipzig, Germany, July 2012.
- Kienast-Sjögren E. et. al, Lidar measurements of cirrus cloud properties at the high alpine research station Jungfraujoch, WMO Cloud Modeling Workshop, Oral Presentation, Warsaw, Poland, July 2012.
- Kolonjari, F., E. Mahieu, K.A. Walker, Y. Kasai, A. Kagawa, R. Lindenmaier, R.L. Batchelor, K. Strong, C.D. Boone, and P.F. Bernath, Validation of ACE-FTS using ground-based FTIR measurements of CFC-11, CFC-12 and HCFC-22, poster presentation at the 2012 Summer School in Arctic Atmospheric Science, Alliston, Canada, July 23-27, 2012.  
<http://hdl.handle.net/2268/130119>
- Lejeune, B., E. Mahieu, P. Demoulin, C. Servais, W. Bader, B. Bovy, O. Flock, R. Zander, and G. Roland, Trend evolution of carbonyl sulfide above Jungfraujoch deduced from ground-based FTIR and ACE-FTS satellite observations, oral presentation at the “ACE Science Team Meeting”, University of Waterloo, Waterloo, ON, Canada, May 23-24, 2012.  
<http://hdl.handle.net/2268/123804>
- Lejeune, B., E. Mahieu, M. Schneider, F. Hase, C. Servais, and P. Demoulin, Long-term series of tropospheric water vapour amounts and HDO/H<sub>2</sub>O ratio profiles above Jungfraujoch, poster presentation at the “EGU 2012 General Assembly”, Vienna, Austria, April 22-27, 2012.  
<http://hdl.handle.net/2268/117439>
- Mahieu, E., the GIRPAS- and the ACE-teams, Post-peak trend in inorganic chlorine (Cl<sub>y</sub>) from Jungfraujoch, ACE-FTS and HALOE infrared solar observations, oral presentation at the “ACE / SAGE III-ISS International Workshop”, Old Dominion University, Norfolk, VA, USA, October 15-17, 2012.  
<http://hdl.handle.net/2268/132600>
- Mahieu, E., W. Bader, B. Bovy, B. Lejeune, C. Vigouroux, P. Demoulin, C. Servais, G. Roland, and R. Zander, Retrieval of methanol (CH<sub>3</sub>OH) from the high-altitude Jungfraujoch station (46.5°N): preliminary total column time series, long-term trend and seasonal modulation, poster presentation at the “NDACC-IRWG Annual Meeting”, Wengen, Switzerland, June 11-15, 2012.  
<http://hdl.handle.net/2268/124069>
- Mahieu, E., W. Bader, B. Lejeune, C. Vigouroux, P. Demoulin, C. Servais, G. Roland, and R. Zander, Seeking for the optimum retrieval strategy of methanol (CH<sub>3</sub>OH) using ground-based high-resolution FTIR solar observations recorded at the high-altitude Jungfraujoch station (46.5°N), poster presentation at the “EGU 2012 General Assembly”, 22-27 April 2012, Vienna, Austria, April 22-27, 2012.  
<http://hdl.handle.net/2268/116957>
- Parrish, D. D., K.S. Law, J. Staehelin, R. Derwent, O.R. Cooper, H. Tanimoto, A. Volz-Thomas, S. Gilge, H.-E. Scheel, M. Steinbacher, E. Chan, Earlier seasonal maximum in lower tropospheric ozone at northern mid-latitudes, 2012 AGU Fall Meeting, San Francisco, USA, December 3-7, 2012.
- Pastel, M., S. Godin-Beekmann, E. Mahieu, P. Demoulin, and K. Hocke, A new methodology for integrating ground-based ozone profile data, poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, Canada, August 27–31, 2012.  
<http://larss.science.yorku.ca/QOS2012pdf/6009.pdf>
- Rea, S. P., M. Renker, B.P. Moyna, D. Gerber, M. Whale, A. Murk, First-light atmospheric observations with a 340 GHz sideband-separating Schottky diode receiver, 37<sup>th</sup> International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), doi: 10.1109/IRMMW-THz.2012.6380381, September, 2012.
- Reimann, S., Global and Regional F-gas emissions, SPARC-SSC meeting, Zuerich, Switzerland, February 9, 2012.

- Reimann, S., Re-evaluation of lifetime of ozone-depleting substances, SPARC/ESRL/NOAA annual meeting, Boulder, USA, May 17, 2012.
- Reimann, S., VOCs in AGAGE, VOC WMO expert meeting, York, UK, September 12, 2012.
- Reimann, S., Evolution of Emissions of Ozone Depleting Substances in Europe, 25th Anniversary of the Montreal Protocol, WMO, Geneva, Switzerland, November 11, 2012.
- Servais C. and Roland G., Soixante ans de spectroscopie solaire et atmosphérique depuis le Jungfraujoch, Swiss Academy of Sciences, Les chercheurs de l'extrême, Interlaken, Switzerland, October 25-26, 2012.  
<http://kongress12.scnat.ch/f/jahreskongress/presentationen/>
- Steinbacher, M., Long-term continuous ground-based in-situ trace gas observations at Jungfraujoch, NDACC-IRWG/TCCON 2012 Meeting, Wengen, Switzerland, June 11-13, 2012.
- Steinbacher, M., Neues von der DACH-Station Jungfraujoch, Sitzung der GAW-DACH-Arbeitsgruppe, Munich, Germany, September 12-13, 2012.
- Steinbacher, M., Ozone in the free troposphere - Results from recent JFJ studies, Sitzung der GAW-DACH-Arbeitsgruppe, Munich, Germany, September 12-13, 2012.
- Sturm, P., B. Tuzson, S. Henne, and L. Emmenegger, Tracking isotopic signatures of CO<sub>2</sub> at Jungfraujoch with high-precision laser spectroscopy: analytical improvements, calibration and exemplary results, Joint European Stable Isotope Users group Meeting (JESIUM 2012), Leipzig, Germany, September 02-07, 2012.
- Sturm, P., B. Tuzson, S. Henne, and L. Emmenegger, Tracking isotopic signatures of CO<sub>2</sub> at Jungfraujoch with high-precision laser spectroscopy, Fall Meeting of the Swiss Chemical Society, Zürich, Switzerland, September 13, 2012.
- Vigouroux, C., M. De Mazière, P. Demoulin, C. Servais, F. Hase, T. Blumenstock, R. Kohlhepp, S. Barthlott, O. García, M. Schneider, J. Mellqvist, G. Personn, M. Palm, J. Notholt, J. Hannigan, and M. Coffey, Ozone tropospheric and stratospheric trends (1995-2011) at six ground-based FTIR stations (28°N to 79°N), poster presentation at the Quadrennial Ozone Symposium QOS 2012, Toronto, Canada, August 27-31, 2012.  
<http://larss.science.yorku.ca/QOS2012pdf/6018.pdf>
- Weber, S., S. Gruber, L. Girard, J. Beutel, Acoustic emission measurement system to investigate rock damage driven by freezing, 10th Int. Conference on Permafrost, Salekhard, Russia, 2012.
- Weber, S., S. Gruber, L. Girard, J. Beutel, Let rock crack, let crack rocks, AK Permafrost meeting, Potsdam, Germany, 2012.
- Weber, S., S. Gruber, L. Girard, Design of a Measurement Assembly to Study In-Situ Rock Damage Driven by Freezing, in Proceedings of the tenth international conference on Permafrost, Russia, June 2012.
- Yilmaz, A., A. Aydemir, H. Denizli, M. Iori, Test Results of Low-Level Discriminator Board for TAUWER Experiment, Turkish Physical Society, 29<sup>th</sup> International Physics Congress, Bodrum, Turkey, September 5-8, 2012.

### **Books / Edited Books**

- Beer, J., K.G. McCracken, R. von Steiger, Cosmogenic Radionuclides: Theory and Applications in the Terrestrial and Space Environments, Springer-Verlag, 2012.
- Häberlin H., Photovoltaik - Strom aus Sonnenlicht für Verbundnetz und Inselanlagen, Electrosuisse-Verlag, ISBN 978-3-905214-62-8, 2012.
- Häberlin H., Photovoltaics - System Design and Practice, John Wiley&Sons Ltd., ISBN 978-1-119-99285-1, 2012.
- Schneider, M., P. Demoulin, R. Sussmann, and J. Notholt, Fourier Transform Infrared Spectrometry, Chapter 6 in Monitoring Atmospheric Water Vapor: Ground-Based Remote Sensing and In-Situ Methods, ISSI Scientific Report Series, **vol. 10**, ISBN 978-1-4614-3908-0, Springer New York, 2012.  
<http://link.springer.com/book/10.1007/978-1-4614-3909-7/page/1>

### **Popular publications and presentations**

- Mahieu, E., Atmosphère? Atmosphère!, interview of E. Mahieu in Athena, **277**, 38-41, January, 2012.  
<http://recherche-technologie.wallonie.be/servlet/Repository/athena-277.pdf?IDR=11102&EXT=PDF>
- Schnee, Gletscher und Permafrost 2010/2011 (Snow, Glaciers and Permafrost 2010/2011), Die Alpen/Les Alpes, 8/2012.
- Häberlin H., Wie mit PV-Strom durch den Winter?, Elektrotechnik, **1**, 44-49, 2012.  
<http://www.pvtest.ch/index.php?id=393>



### **Data books and reports**

Aktueller Bericht der Leitstellen: Umweltradioaktivität in der Bundesrepublik Deutschland Stand 2011, ISSN 1864-2810, März 2012.

BAFU 2012: NABEL – Luftbelastung 2011, Messresultate des Nationalen Beobachtungsnetzes für Luftfremdstoffe (NABEL), pp. 128, Bundesamt für Umwelt, Bern, Umwelt-Zustand Nr. 1221, 2012.

Leuenberger M., S. van der Laan, I.T. van der Laan-Luijckx, M.F. Schibig, Comparison of continuous in-situ CO<sub>2</sub> observations at Jungfraujoch using two different measurement techniques, Third GCOS interim report, 2012.

Leuenberger M., WMO World Data Centre for Greenhouse Gases, c/o Japan Meteorological Agency 1-3-4, Otemachi, Chiyoda-ku Tokyo 100-8122, Japan, CO<sub>2</sub> Data from Jungfraujoch (downloaded 182 times since 1.3.2011).

PERMOS 2012, Permafrost in Switzerland 2008/2009 and 2009/2010, Noetzli, J. (ed.), Glaciological Report (Permafrost) No. 10/11 of the Cryospheric Commission of the Swiss Academy of Sciences, in prep., for publication in 2012.

PREMIER: Report for Mission Selection, ESA SP-1324/3, May 2012.

[http://esamultimedia.esa.int/docs/EarthObservation/SP1324-3\\_PREMIERr.pdf](http://esamultimedia.esa.int/docs/EarthObservation/SP1324-3_PREMIERr.pdf)

Reimann, S., M. K. Vollmer, D. Brunner, M. Steinbacher, M. Hill, A. Wenger, C. Keller, and B. Buchmann, Kontinuierliche Messung von halogenierten Treibhausgasen auf dem Jungfraujoch (HALCLIM-4), Empa project No 201'203, Final Report, August 2012.

[http://www.empa.ch/plugin/template/empa/\\*/124295](http://www.empa.ch/plugin/template/empa/*/124295)

Renker M., A. Murk, M. Whale, S. Rea, A. Emrich, U. Frisk, Breadboard receiver testing for STEAMR/PREMIER, IAP Research Report, No. 2012-06-MW, Institut für Angewandte Physik, Universität Bern, 2012.

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Physik Institut Universität Zürich Winterthurerstrasse 190 CH-8050 Zürich Contact: Marc Schumann Tel.: +41 44 635 6692	Measurement of cosmogenic activation of ultra-pure xenon <a href="http://www.physik.uzh.ch/groups/groupbaudis">http://www.physik.uzh.ch/groups/groupbaudis</a>	60
Physikalische Chemie Bergische Universität Wuppertal Gaussstrasse 20 42119 Wuppertal, Germany Contact: Jörg Kleffmann Tel.: +49 202 439 3534	Measurements of NO <sub>2</sub> and O <sub>3</sub> in the free troposphere by a LOPAP instrument <a href="http://www.uni-wuppertal.de">http://www.uni-wuppertal.de</a>	88
Physikalisches Institut Abteilung Klima- und Umwelphysik Universität Bern Sidlerstrasse 5 CH-3012 Bern Contact: Markus Leuenberger Tel.: +41 31 631 44 70	Combined oxygen and carbon dioxide concentration measurements <a href="http://www.climate.unibe.ch/?L1=people&amp;L2=personal&amp;L3=leuenberger">http://www.climate.unibe.ch/?L1=people&amp;L2=personal&amp;L3=leuenberger</a>	68
Physikalisches Institut Universität Bern Sidlerstrasse 5 CH-3012 Bern Contact: Rolf Bütikofer Tel.: +41 31 631 4058	Neutron monitors - Study of solar and galactic cosmic rays <a href="http://cosray.unibe.ch/">http://cosray.unibe.ch/</a>	52

Research group / institute	Project title	Page
Physikalisches Institut Universität Bern Sidlerstrasse 5 CH-3012 Bern Contact: Rolf Bütikofer Tel.: +41 31 631 4058	SONTEL - Solar Neutron Telescope for the identification and the study of high-energy neutrons produced in energetic eruptions at the Sun <a href="http://cosray.unibe.ch/">http://cosray.unibe.ch/</a>	153
PMOD/WRC Dorfstrasse 33 CH-7260 Davos Dorf Contact: Stephan Nyeki Tel.: +41 81 417 51 39	Aerosol Optical Depth <a href="http://www.pmodwrc.ch">http://www.pmodwrc.ch</a>	40
PMOD/WRC Dorfstrasse 33 CH-7260 Davos Dorf Contact: Julian Gröbner Tel.: +41 81 417 51 11	Cloud Climatology and Surface Radiative Forcing over Switzerland (CLASS) <a href="http://www.pmodwrc.ch">http://www.pmodwrc.ch</a>	37
Pneumologie Medizinische Klinik V Ziemssenstrasse 1 80336 München, Germany Contact: Rainald Fischer Tel.: + 49 89 5160 7546	Effect of gender on high altitude adaptation: Comparison of Angiotensin-Converting-Enzyme 2-activity in plasma between men and women <a href="http://www.rainald.de">http://www.rainald.de</a>	114
Société Astronomique de Liège Avenue de Cointe 5 B-4000 Liège Contact : Lempereur Benoît Tel.: +32 474 24 07 65	Observing the sky and describing the objects <a href="http://www.societeastronomiquedeliege.be/">http://www.societeastronomiquedeliege.be/</a>	146
Swiss Cardiovascular Center Bern University Hospital CH-3010 Bern Contact: Jean-Paul Schmid Tel.: +41 31 632 89 72	Safety and exercise tolerance of acute high altitude exposure (3454m) in adolescents with congenital heart disease <a href="http://kardiorehab.insel.ch">http://kardiorehab.insel.ch</a>	108
Swiss Federal Institute of Technology (ETH Zurich) Wolfgang-Pauli-Strasse 10 HCI G135 CH-8093 Zürich Contact: Christian Bogdal Tel.: +41 44 632 5951	Background air monitoring of gaseous elemental mercury at the High Altitude Research Station Jungfraujoch – Source apportionment of atmospheric mercury and emission estimates in Europe. <a href="http://www.sust-chem.ethz.ch">http://www.sust-chem.ethz.ch</a>	102
Swiss Federal Office of Topography swisstopo Seftigenstrasse 264 CH-3084 Wabern Contact: Elmar Brockmann Tel.: +41 31 963 22 56	Automated GNSS Network Switzerland <a href="http://www.swisstopo.ch">http://www.swisstopo.ch</a>	132

Research group / institute	Project title	Page
University of Applied Sciences Bern, Department of Engineering and Information Technology PV Laboratory Jlcoweg 1 CH-3400 Burgdorf Contact: Heinrich Haeberlin Tel.: +41 34 426 68 53	High Alpine PV (photovoltaic) Plant Jungfrauoch <a href="http://www.pvtest.ch">http://www.pvtest.ch</a>	142
University of Geneva Institute for Environmental Sciences Chemin de Drize 7 CH-1227 Carouge Contact: Markus Stoffel Tel.: +41 31 631 87 73	ACQWA – Assessing Climate Change Impacts on the Quantity and Quality of Water <a href="http://www.acqwa.ch">http://www.acqwa.ch</a>	144
University of Liège Department of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Sart Tilman (Liège, Belgique) Contact: Christian Servais Tel.: +32 4 366 97 84	Atmospheric and solar physics. Spectroscopy by Fourier Transform Interferometry <a href="http://girpas.astro.ulg.ac.be/">http://girpas.astro.ulg.ac.be/</a>	6
WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf Switzerland Contact: Marcia Phillips Tel.: +41 81 417 02 18	Permafrost monitoring in the Jungfrau East ridge. Construction techniques in permafrost <a href="http://www.slf.ch">http://www.slf.ch</a>	123
Zingg, Peter E. Spielhoelzli 8 Ch-3800 Unterseen Contact: Peter E. Zingg Tel.: +41 79 670 58 15	High Altitude Migration of bats over the Jungfrauoch	107



## Collaborations and networks

Institutions collaborating with research projects at Jungfraujoch and Gornergrat in 2012:

Institution / network	Country	Collaborating with project:
Ecotech Pty Ltd	Australia	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
McCracken, K.G. Australia	Australia	Cosmogenic radionuclides in precipitation  Eawag Überlandstr. 133 CH-8600 Dübendorf
Belgian Institute for Space Aeronomy Atmospheric physics and chemistry Dr. Katrijn Clemer, Dr. Michel Van Roozendaal Ringlaan 3 B-1180 Brussels Belgium	Belgium	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
IASB (Institut d'Aéronomie Spatiale de Belgique)	Belgium	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Institut d'Astrophysique et de Géophysique Allée du six Août, 17 - Bâtiment B5a B-4000 Sart Tilman (Liège, Belgique)
Université Libre de Bruxelles for IASI FORLI data validation	Belgium	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium
Université de Liège Institut d'Astrophysique et de Géophysique and NDACC Partners Allée du VI août, 17 - Bâtiment B5a B-4000 Sart Tilman (Liège, Belgique)	Belgium	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium

Institution / network	Country	Collaborating with project:
University Hospital Copenhagen	Denmark	Cardiovascular adjustments to prolonged altitude exposure  University of Zurich Institute of Physiology Winterthurerstrasse 190 CH-8057 Zürich
Collaboration with European FTIR and UV-Vis teams and modelling teams in the frame of the EU project NORS	European network	The Polythermal Structure of Gornergletscher (Valais)  Swiss Federal Office of Technology, ETH Zürich Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW) Gloriastrasse 37/39 CH-8092 Zürich
Collaboration with European FTIR and UV-Vis teams and modelling teams in the frame of the EU project NORS	European network	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium
E-GVAP II (EUMETNET GPS Water Vapor Programme)	European network	Automated GPS Network Switzerland (AGNES)  Swiss Federal Office of Topography (swisstopo) Seftigenstrasse 264 CH-3084 Wabern
European FP7 project ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network)	European network	Aerosol Chemical Speciation Monitor (ACSM) measurements on the Jungfraujoch within the frame of the EU project ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network)  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
European FP7 Project Real-Time Database for High Resolution Neutron Monitor Measurements (NMDB) <a href="http://nmbd.eu/">http://nmbd.eu/</a>	European network	Neutron monitors - Study of solar and galactic cosmic rays  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern

Institution / network	Country	Collaborating with project:
GAW-CH	European network	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  Université de Liège Institut d'Astrophysique et de Géophysique Allée du VI août, 17 - Bâtiment B5a B-4000 Sart Tilman (Liège, Belgique)
GAW-CH	European network	Monitoring of halogenated greenhouse gases  Empa Laboratory for Air Pollution and Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf
ICOS Integrated Carbon Observation System <a href="http://www.icos-infrastructure.eu">http://www.icos-infrastructure.eu</a>	European network	Long-term observations of $^{14}\text{CO}_2$ and $^{222}\text{Rn}$ at Jungfraujoch  Universität Heidelberg Institut für Umweltphysik Im Neuenheimer Feld 229 D-69120 Heidelberg
IMECC partners <i>IMECC Infrastructure for Measurements of the European Carbon Cycle</i> partners <a href="http://imecc.ipsl.jussieu.fr/">http://imecc.ipsl.jussieu.fr/</a>	European network	Flask comparison on Jungfraujoch  Isotope Research — Energy and Sustainability Research Institute Groningen Nijenborgh 4 9747 AG Groningen / The Netherlands
IMECC partners <i>IMECC Infrastructure for Measurements of the European Carbon Cycle</i> partners <a href="http://imecc.ipsl.jussieu.fr/">http://imecc.ipsl.jussieu.fr/</a>	European network	Flask comparison on Jungfraujoch  Max-Planck-Institut für Biogeochemie Hans Knöll Str. 10 D-007745 Jena
IMECC partners <i>IMECC Infrastructure for Measurements of the European Carbon Cycle</i> partners <a href="http://imecc.ipsl.jussieu.fr/">http://imecc.ipsl.jussieu.fr/</a>	European network	Combined oxygen and carbon dioxide concentration measurements  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern
Partners of the EC-project NORS <a href="http://nors.aeronomie.be">http://nors.aeronomie.be</a> and GEOMon <a href="http://geomon.ipsl.jussieu.fr/">http://geomon.ipsl.jussieu.fr/</a>	European network	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  Université de Liège Institut d'Astrophysique et de Géophysique Allée du VI août, 17 - Bâtiment B5a B-4000 Sart Tilman (Liège, Belgique)

Institution / network	Country	Collaborating with project:
University of Helsinki Department of Physics Prof. M. Kulmala Helsinki, Finland	Finland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
INRA Dr. Cindy Morris 147 rue de l'université 75338 Paris Cedex 07 FRANCE	France	Flux of biological ice nucleators to cloud altitudes (using Rn-222 as a tracer for atmospheric transport and mixing)  University of Basel Institute for Environmental Geosciences Bernoullistrasse 30 CH-4056 Basel
ISTerre, CNRS Université J. Fourier Grenoble, France	France	PERMASENSE: Permafrost measurements (temperature, conductivity, acoustic emission) with wireless sensor networks  University of Zurich Department of Geography, Glaciology, Geomorphodynamics & Geochronology Winterthurerstr. 190 CH-8057 Zurich, Switzerland
LATMOS-CNRS, UVSQ Verrières le Buisson France	France	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium
Université J. Fourier Laboratoire de Glaciologie et Géophysique de l'Environnement CNRS Dr. P. Laj Grenoble, St Martin d'Hères Cedex, France	France	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Université Blaise Pascal Laboratoire de météorologie physique Dr. K. Sellegri 63170 Aubiere, France	France	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland

Institution / network	Country	Collaborating with project:
Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover	Germany	The Polythermal Structure of Gornergletscher (Valais)  Swiss Federal Office of Technology, ETH Zürich Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW) Gloriastrasse 37/39 CH-8092 Zürich
Bundesanstalt für Materialforschung und –prüfung Berlin, Deutschland	Germany	Transport and survival of desert soil- and rock surface inhabiting micro-organisms in atmospheric mineral dust  Universität Bern Institut für Veterinär Bakteriologie Länggassstrasse 122 CH-3012 Bern
Freie Universität Berlin Prof. Dr. J. Fischer and Dr. T. Ruhtz	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoeh  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Freie Universität Berlin Fachbereich Biologie, Chemie und Pharmazie & Geowissenschaften, Berlin	Germany	Transport and survival of desert soil- and rock surface inhabiting micro-organisms in atmospheric mineral dust  Universität Bern Institut für Veterinär Bakteriologie Länggassstrasse 122 CH-3012 Bern
IMK (Forschungszentrum Karlsruhe) Satellite experiment	Germany	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
Institute of Atmospheric Physics, DLR Oberpfaffenhofen, Germany	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoeh  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland

Institution / network	Country	Collaborating with project:
Johann Wolfgang Goethe Universität Frankfurt am Main Institut für Atmosphäre und Umwelt Frankfurt am Main, Deutschland	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Karlsruhe Institute of Technology (KIT) Institute of Meteorology and Climate Research Karlsruhe, Germany	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Leibniz Institut für Troposphärenforschung Leipzig, Germany	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Max-Planck Institute for Biogeochemistry Hans Knöll Str. 10 D-007745 Jena Deutschland	Germany	Continuous measurement of stable CO <sub>2</sub> isotopes at Jungfraujoch, Switzerland  Empa Abt. Luftfremdstoffe / Umwelttechnik Überlandstrasse 129 CH-8600 Dübendorf
Max-Planck Institute Mainz, Germany	Germany	The microstructure of ice crystals and cloud droplets in mixed-phase clouds measured with HOLIMO II. The microstructure of crystals clouds The time series of ice nuclei number concentration and properties measured with PINC.  Swiss Federal Office of Technology, ETH Zürich Institute for Atmospheric and Climate Science Universitätsstr. 16 CH-8092 Zürich, Switzerland
Max-Planck-Institut für Chemie Biogeochemistry Department Mainz	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland

Institution / network	Country	Collaborating with project:
University of Bonn Germany	Germany	Evolution of high mountain permafrost rockwalls (Jungfrau Ostgrat)  WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf
Universität Darmstadt Institut für Mineralogie Darmstadt, Germany	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
University of Mainz Particle Chemistry Mainz, Germany	Germany	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
ACE-FTS science team <a href="http://www.ace.uwaterloo.ca/participants.html/">http://www.ace.uwaterloo.ca/participants.html /</a>	International network	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
AGAGE (Advanced Global Atmospheric Gases Experiment)	International network	Halogenated Greenhouse Gases at Jungfraujoch  Empa Laboratory for Air Pollution and Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf, Switzerland
Both the UV-Vis and FTIR observations contribute to the international Network for the Detection of Atmospheric Composition Changes (NDACC)	International network	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium

Institution / network	Country	Collaborating with project:
Global Atmosphere Watch (GAW)	International network	National Air Pollution Monitoring Network (NABEL)  Empa Laboratory for Air Pollution and Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf, Switzerland
Global Atmosphere Watch (GAW) AOD network	International network	Remote sensing of aerosol optical depth  Physikalisch-Meteorologisches Observatorium Davos PMOD World Radiation Center WRC Dorfstrasse 33 CH-7260 Davos Dorf
Collaboration with the GOME, ENVISAT, OMI, ACE and MetOp GOME-2 and IASI satellite communities.	International networks	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium
International Council of the Scientific Union's (ICSU) Scientific Committee on Solar-Terrestrial Physics (SCOSTEP)	International network	Neutron monitors - Study of solar and galactic cosmic rays  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern
NASA Langley Research Center <a href="http://www.nasa.gov/centers/langley/home/index.html">http://www.nasa.gov/centers/langley/home/index.html</a> /	International network	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
NDACC (Network for the Detection of Atmospheric Composition Change, previously NDSC; <a href="http://www.ndacc.org/">http://www.ndacc.org/</a> ) /	International network	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium



Institution / network	Country	Collaborating with project:
Radiation data submitted to the World Radiation Data Centre (WRDC, St. Petersburg, Russian Federation) within the framework of the Global Atmosphere Watch.	International network	Global Atmosphere Watch Radiation Measurements  Federal Office of Meteorology and climatology MeteoSwiss Atmospheric Data Department ch. de l'Aérologie CH-1530 Payerne
Satellite experiments: IASI ((Infrared Atmospheric Sounding Interferometer)), AURA, OMI, ACE-FTS, ENVISAT	International network	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
The XENON Dark Matter Project	International network	Measurement of cosmogenic activation of ultra-pure xenon  Universität Zürich Physik Institut Winterthurerstrasse 190 CH-8057 Zürich
World Data Centers A (Boulder), B (Moscow), C (Japan), International GLE database	International network	Neutron monitors - Study of solar and galactic cosmic rays  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern
World Meteorological Organization (WMO)	International network	Monitoring of halogenated greenhouse gases  Empa Laboratory for Air Pollution and Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf
Konan University Prof. Y Muraki Nada-ku Kobe 657-0000, Japan	Japan	SONTEL - Solar Neutron Telescope for the identification and the study of high-energy neutrons produced in energetic eruptions at the Sun  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern

Institution / network	Country	Collaborating with project:
Nagoya University Solar Terrestrial Environment Laboratory Prof. Y. Matsubara, Dr. T. Sako, Dr. S. Masuda, Nagoya 464-8601, Japan	Japan	SONTEL - Solar Neutron Telescope for the identification and the study of high- energy neutrons produced in energetic eruptions at the Sun  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern
University of Oslo	Norway	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
Universidad Pablo de Olavide División de Neurociencias Sevilla	Spain	Effects of physical exercise and Vascular Endothelial Growth Factor on the neuroglial vascular adaption to hypoxia  Enrike G. Argandoña Boulevard Pérolles 75 CH-1700 Fribourg
Omnisys Instruments AB Göteborg	Sweden	STEAMR  Universität Bern Institut für Angewandte Physik Sidlerstrasse 5 CH-3012 Bern, Switzerland
Alpes Lasers SA 1-3 Max.-de-Meuron C.P. 1766 CH-2001 Neuchâtel	Switzerland	Continuous measurement of stable CO <sub>2</sub> isotopes at Jungfrauoch, Switzerland  Empa Laboratory for Air Pollution & Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf
Brenet	Switzerland	"In der Helle der Nacht" (In the Brightness of the Night): Single frame time-lapse video.  Walter Bersinger Obermattenstrasse 9 CH-8153 Rümlang, Switzerland

Institution / network	Country	Collaborating with project:
Bundesamt für Umwelt (BAFU)/ Federal Office for the Environment (FOEN)	Switzerland	National Air Pollution Monitoring Network (NABEL)  Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf
Bundesamt für Umwelt (BAFU)/ Federal Office for the Environment (FOEN)	Switzerland	Monitoring of halogenated greenhouse gases  Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf
Burgergemeinde Zermatt Bahnhofstrasse 53 CH-3920 Zermatt	Switzerland	Stellarium Gornergrat  Centre for Space and Habitability Universität Bern Sidlerstrasse 5 CH-3012 Bern
Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf	Switzerland	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium
Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf	Switzerland	Combined oxygen and carbon dioxide concentration measurements  Universität Bern Physikalisches Institut Sidlerstrasse 5 CH-3012 Bern
Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf	Switzerland	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium

Institution / network	Country	Collaborating with project:
Empa Laboratory for Air Pollution/Environmental Technology CH-8600 Dübendorf	Switzerland	Background air monitoring of gaseous elemental mercury at the High Altitude Research Station Jungfraujoch - Source apportionment of atmospheric mercury and emission estimates in Europe  Swiss Federal Institute of Technology, ETH Zurich Wolfgang-Pauli-Strasse 10 CH-8093 Zürich
Empa Laboratory for Air Pollution/Environmental Technology CH-8600 Dübendorf	Switzerland	Measurements of NO <sub>2</sub> and O <sub>3</sub> in the free troposphere by a New LOPAP Instrument (MINI)  Bergische Universität Wuppertal Physikalische Chemie / FBC Gaussstrasse 20 D-42119 Wuppertal
Empa NABEL + Group for climate gases Laboratory for Air Pollution/Environmental Technology CH-8600 Dübendorf	Switzerland	Flux of biological ice nucleators to cloud altitudes (using Rn-222 as a tracer for atmospheric transport and mixing)  University of Basel Institute for Environmental Geosciences Bernoullistrasse 30 CH-4056 Basel
ETH Zürich Swiss Federal Institute of Technology Computer Engineering and Networks Laboratory Dr. Jan Beutel Gloriastrasse 35 CH-8092 Zurich	Switzerland	Evolution of high mountain permafrost rockwalls (Jungfrau Ostgrat)  WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf
ETH Zürich Swiss Federal Institute of Technology Institute for Quantum Electronics Wolfgang-Pauli-Str.16 CH-8093 Zurich	Switzerland	Continuous measurement of stable CO <sub>2</sub> isotopes at Jungfraujoch, Switzerland  Empa Laboratory for Air Pollution & Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf
ETH Zürich Swiss Federal Institute of Technology Institute for Atmospheric and Climate Science Universitätstrasse 16 CH-8092 Zürich	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland

Institution / network	Country	Collaborating with project:
ETH Zürich Swiss Federal Institute of Technology Institute of Geodesy and Photogrammetry	Switzerland	Automated GPS Network Switzerland (AGNES)  Swiss Federal Office of Topography (swisstopo) Seftigenstrasse 264 CH-3084 Wabern
ETH Zürich Swiss Federal Institute of Technology Institute of Plant, Animal and Agroecosystem Sciences Dr. W. Eugster	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Institut für Aerosol- und Sensortechnik, Fachhochschule Nordwestschweiz, Windisch	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
KWO	Switzerland	"In der Helle der Nacht" (In the Brightness of the Night): Single frame time-lapse video.  Walter Bersinger Obermattenstrasse 9 CH-8153 Rümlang, Switzerland
MeteoSwiss	Switzerland	Lidar measurements of cirrus cloud properties in the midlatitudes  Swiss Federal Office of Technology, ETH Zürich Institute for Atmospheric and Climate Science Universitätsstrasse 16 CH-8092 Zürich, Switzerland
MeteoSwiss, Zurich and Payerne	Switzerland	National Air Pollution Monitoring Network (NABEL)  Empa Laboratory for Air Pollution/Environmental Technology Ueberlandstrasse 129 CH-8600 Dübendorf
MeteoSwiss	Switzerland	Remote sensing of aerosol optical depth  Physikalisch-Meteorologisches Observatorium Davos PMOD World Radiation Center WRC Dorfstrasse 33 CH-7260 Davos Dorf

Institution / network	Country	Collaborating with project:
MeteoSwiss	Switzerland	Longwave Infrared radiative forcing trend assimilation over Switzerland (LIRAS)  Physikalisch-Meteorologisches Observatorium Davos PMOD World Radiation Center WRC Dorfstrasse 33 CH-7260 Davos Dorf
MeteoSwiss, Payerne Office fédéral de météorologie et de climatologie MétéoSuisse Station Aérologique ch. de l'Aérologie CH-1530 Payerne	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
MeteoSwiss, Zurich and Payerne	Switzerland	Automated GPS Network Switzerland (AGNES)  Swiss Federal Office of Topography (swisstopo) Seftigenstrasse 264 CH-3084 Wabern
Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland	Switzerland	Lidar measurements of cirrus cloud properties in the midlatitudes  Swiss Federal Office of Technology, ETH Zürich Institute for Atmospheric and Climate Science Universitätsstrasse 16 CH-8092 Zürich, Switzerland
Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland	Switzerland	The microstructure of ice crystals and cloud droplets in mixed-phase clouds measured with HOLIMO II. The microstructure of crystals clouds The time series of ice nuclei number concentration and properties measured with PINC.  Swiss Federal Office of Technology, ETH Zürich Institute for Atmospheric and Climate Science Universitätsstrasse 16 CH-8092 Zürich, Switzerland
Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland	Switzerland	Measurement of <sup>222</sup> Rn for atmospheric tracer applications  University of Basel Institute for Environmental Geosciences Bernoullistrasse 30 CH-4056 Basel

Institution / network	Country	Collaborating with project:
Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland	Switzerland	Flux of biological ice nucleators to cloud altitudes (using Rn-222 as a tracer for atmospheric transport and mixing)  University of Basel Institute for Environmental Geosciences Bernoullistrasse 30 CH-4056 Basel
PermaSense University of Zurich Department of Geography Dr. Stephan Gruber Winterthurerstrasse 190 CH-8057 Zurich	Switzerland	Evolution of high mountain permafrost rockwalls (Jungfrau Ostgrat)  WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf
PERMOS (Permafrost Monitoring Switzerland) <a href="http://www.permos.ch/">http://www.permos.ch/</a> <a href="http://www.permos.ch/partner.html">http://www.permos.ch/partner.html</a>	Switzerland	Evolution of high mountain permafrost rockwalls (Jungfrau Ostgrat)  WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf
Physikalisch-Meteorologisches Observatorium Davos PMOD World Radiation Center WRC Dr. Julian Gröbner Davos Switzerland	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Studiengesellschaft Mont Soleil	Switzerland	"In der Helle der Nacht" (In the Brightness of the Night): Single frame time-lapse video.  Walter Bersinger Obermattenstrasse 9 CH-8153 Rümlang, Switzerland
Study of solar photometry (aerosol optical depth) and longwave infrared radiative forcing in collaboration with the Physikalisch Meteorologisches Observatorium Davo (PMOD), World Radiation Center (WRC) Dorfstrasse 33 CH-7260 Davos Dorf	Switzerland	Global Atmosphere Watch Radiation Measurements  Federal Office of Meteorology and climatology MeteoSwiss Atmospheric Data Department ch. de l'Aérologie CH-1530 Payerne
SUPSI	Switzerland	"In der Helle der Nacht" (In the Brightness of the Night): Single frame time-lapse video.  Walter Bersinger Obermattenstrasse 9 CH-8153 Rümlang, Switzerland

Institution / network	Country	Collaborating with project:
Swiss GCOS office <a href="http://www.proclim.ch/4dcgi/proclim/all/News?33566">http://www.proclim.ch/4dcgi/proclim/all/News?33566</a>	Switzerland	Combined oxygen and carbon dioxide concentration measurements  Universität Bern Physikalisches Institut Klima- und Umweltphysik Sidlerstrasse 5 CH-3012 Bern
Swiss Glacier Monitoring Network, Federal Office for the Environment (BAFU)	Switzerland	Glaciological investigations on the Grosser Aletschgletscher  Swiss Federal Office of Technology, ETH Zürich Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie (VAW) Gloriastrasse 37/39 CH-8092 Zürich
Tofwerk AG CH-3600 Thun	Switzerland	Aerosol Chemical Speciation Monitor (ACSM) measurements on the Jungfrauoch within the frame of the EU project ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network)  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Universität Basel Institut für Umweltgeowissenschaften Dr. Franz Conen Bernoullistrasse 30 CH-4056 Basel	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfrauoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
University of Bern Astronomical Institute (AIUB), Sidlerstrasse 5 CH-3012 Bern	Switzerland	Automated GPS Network Switzerland (AGNES)  Swiss Federal Office of Topography (swisstopo) Seftigenstrasse 264 CH-3084 Wabern
University of Bern Institute of Applied Physics (IAP)	Switzerland	Automated GPS Network Switzerland (AGNES)  Swiss Federal Office of Topography (swisstopo) Seftigenstrasse 264 CH-3084 Wabern



Institution / network	Country	Collaborating with project:
University of Bern Physics Institute Climate and Environmental Physics Sidlerstrasse 5 CH-3012 Bern	Switzerland	National Air Pollution Monitoring Network, temporary extension  Empa Laboratory for Air Pollution & Environmental Technology Ueberlandstrasse 129 CH-8600 Duebendorf
University of Bern Physics Institute Climate and Environmental Physics Sidlerstrasse 5 CH-3012 Bern	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
University of Bern Physics Institute Climate and Environmental Physics Sidlerstrasse 5 CH-3012 Bern	Switzerland	Continuous measurement of stable CO <sub>2</sub> isotopes at Jungfraujoch, Switzerland  Empa Laboratory for Air Pollution & Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf
University of Bern Physics Institute Climate and Environmental Physics Sidlerstrasse 5 CH-3012 Bern	Switzerland	"In der Helle der Nacht" (In the Brightness of the Night): Single frame time-lapse video.  Walter Bersinger Obermattenstrasse 9 CH-8153 Rümlang, Switzerland
Universität Bern Physikalisches Institut Climate and Environmental Physics Dr. Roland Purtschert Sidlerstrasse 5 CH-3012 Bern	Switzerland	85Kr Activity Determination in Tropospheric Air  Bundesamt für Strahlenschutz Rosastrasse 9 D-79098 Freiburg
Universität Fribourg Departement für Geowissenschaften Prof. Dr. B. Grobéty Chemin du Musée 6 CH-1700 Fribourg	Switzerland	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Universität Fribourg Department of Geosciences Prof. Martin Hoelzle Chemin du Musée 6 CH-1700 Fribourg	Switzerland	Evolution of high mountain permafrost rockwalls (Jungfrau Ostgrat)  WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf

Institution / network	Country	Collaborating with project:
Université de Fribourg Département des Géosciences Prof. Martin Hoelzle Dr. Matthias Huss Chemin du Musée 6 CH-1700 Fribourg	Switzerland	Climate reconstruction from high-alpine ice cores  Paul Scherrer Institut Labor für Radio- und Umweltchemie CH-5232 Villigen Switzerland
Université de Genève Département de Biologie, végétale	Switzerland	Transport and survival of desert soil- and rock surface inhabiting micro-organisms in atmospheric mineral dust  Universität Bern Institut für Veterinär Bakteriologie Länggassstrasse 122 CH-3012 Bern
University of Geneva Geneva Observatory Astronomy Department Prof. Didier Queloz 51, Chemin des Maillettes CH-1290 Sauverny	Switzerland	Stellarium Gornergrat  Centre for Space and Habitability University of Bern Sidlerstrasse 5 CH-3012 Bern
University Hospital Zurich	Switzerland	Cardiovascular adjustments to prolonged altitude exposure  University of Zurich Institute of Physiology Winterthurerstrasse 190 CH-8057 Zürich
University of Zurich Veterinary Physiology Winterthurerstr. 190 CH-8057 Zurich, Switzerland	Switzerland	Effects of physical exercise and Vascular Endothelial Growth Factor on the neurogliovascular adaption to hypoxia  Enrike G. Argandoña Boulevard Pérolles 75 CH-1700 Fribourg
WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 CH-7260 Davos Dorf	Switzerland	PERMASENSE: Permafrost measurements (temperature, conductivity, acoustic emission) with wireless sensor networks  University of Zurich Department of Geography Glaciology, Geomorphodynamics & Geochronology Winterthurerstr. 190 CH-8057 Zürich, Switzerland

Institution / network	Country	Collaborating with project:
Abant Izzet Baysal University Department of Physics Experimental Nuclear and High Energy Group Prof. Dr. Haluk Denizli Bolu / Turkey	Turkey	Test of a prototype for a new concept of an EAS detector  University of Rome La Sapienza Departement of Physics P.zza A. Moro 5 I-00198 Rome
Kafkas Universitesi Fen Edebiyat Fakultesi Dr. Mithat Kaya Fizik Bolumu 36000 Kars / Turkey	Turkey	Test of a prototype for a new concept of an EAS detector  University of Rome La Sapienza Departement of Physics P.zza A. Moro 5 I-00198 Rome
University of Leeds School of Earth and Environment Collaboration with Martin Chipperfield Leeds, LS2 9JT United Kingdom <a href="http://www.see.leeds.ac.uk/people/m.chipperfield">http://www.see.leeds.ac.uk/people/ m.chipperfield</a>	UK	Atmospheric physics and chemistry  Belgian Institute for Space Aeronomy Ringlaan 3 B-1180 Brussels Belgium
University of Leeds	UK	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
University of Manchester School of Earth, Atmospheric and Environmental Sciences (SEAES) Prof. H. Coe and Prof. T. Choularton Choularton Manchester, England	UK	The Global Atmosphere Watch Aerosol Program at the Jungfraujoch  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
STFC Rutherford Appleton Laboratory Didcot, Oxfordshire	UK	STEAMR  Universität Bern Institut für Angewandte Physik Sidlerstrasse 5 CH-3012 Bern, Switzerland

Institution / network	Country	Collaborating with project:
Aerodyne Research Inc. Billerica MA-01821	USA	Direct and continuous measurement of NO <sub>2</sub> , NO and NO <sub>y</sub> in ambient air using quantum cascade laser absorption spectroscopy  Empa Laboratory for Air Pollution and Environmental Technology Überlandstrasse 129 CH-8600 Dübendorf
Aerodyne Research Inc. Billerica MA-01821	USA	Aerosol Chemical Speciation Monitor (ACSM) measurements on the Jungfraujoch within the frame of the EU project ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network)  Paul Scherrer Institute Laboratory of Atmospheric Chemistry CH-5232 Villigen Switzerland
Carnegie Mellon University Dept. of Physics Prof. James Russ 5000 Forbes Ave. Pittsburgh, PA 15213 USA	USA	Test of a prototype for a new concept of an EAS detector  University of Rome La Sapienza Departement of Physics P.zza A. Moro 5 I-00198 Rome
NASA JPL	USA	High resolution, solar infrared Fourier Transform spectrometry. Application to the study of the Earth atmosphere  University of Liège Dept. of Astrophysics, Geophysics & Oceanology Allée du six Août, 17 - Bâtiment B5a B-4000 Liège, Belgium
University of Gainesville Microbiology, Florida	USA	Transport and survival of desert soil- and rock surface inhabiting micro-organisms in atmospheric mineral dust  Universität Bern Institut für Veterinär Bakteriologie Länggassstrasse 122 CH-3012 Bern

**Picture Gallery 2012 from <http://www.hfsjg.ch>**



January: The Sphinx at Jungfrauoch. Keystone/Gaëtan Bally.



February: Renovation work on the lab 10 cavern is now completed (see Picture of the Month December 2011).





March: This new Switch panoramic camera was recently installed at the Sphinx at Jungfrauoch. Link: <http://webcam.switch.ch/jungfrauoch/>



April: Inauguration of the new Scientific Exhibition at Jungfrauoch.



May: Non-invasive measurement of cardiac output using an inert gas rebreathing method during a constant work load exercise test in an adolescent with minor congenital heart disease (a recent study of Prof. Jean-Paul Schmid from the Swiss Cardiovascular Center Bern at the research station Jungfrauoch).



June: Study at Jungfrauoch of cardiovascular adjustments to prolonged altitude exposure. The medical experiment was carried out by the Institute of Physiology of the University of Zurich (Prof. Carsten Lundby).





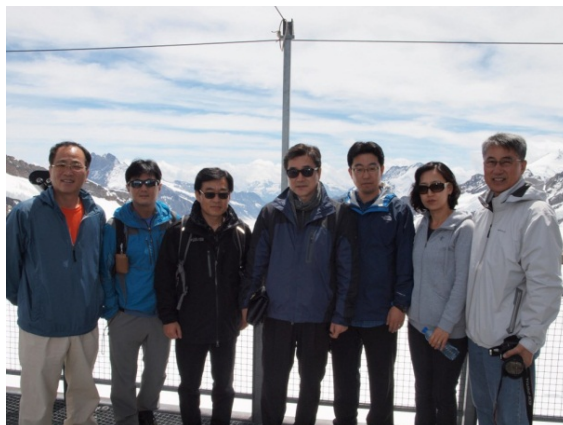
July: Annual maintenance work on the photovoltaics plant at Jungfrauoch, operated by the University of Applied Sciences Bern, Department of Engineering and Information Technology.



August: At the end of July, the International Foundation HFSJG had the pleasure to welcome five NASA and ESA astronauts at the research station Jungfrauoch. In 2011, STS-134 was the penultimate mission of NASA's Space Shuttle program and marked the final flight of Space Shuttle Endeavour. This flight delivered - among other things - an Alpha Magnetic Spectrometer of the CERN to the International Space Station (ISS). Photo: 2012 copyright by martinkeller.ch



September: The Sphinx observatory on Jungfraujoch with its weather station is of great interest to many visitors. It especially was for the visitors from the Korea Meteorological Administration as well as for the group from the Deutscher Wetterdienst.



October: The foundation's custodians at the research station Jungfraujoch: Maria and Urs Otz, Martin and Joan Fischer, their dogs Amira and Sherpa.



November: In the course of the annual [SCNAT](#) (Swiss Academy of Sciences) congress in Interlaken at the end of October 2012 on the subject 'Höher und kälter - Forschung am geographischen Limit', a visit to the High Alpine Research Station Jungfraujoch was organised for the participants. In the picture, from left to right: Prof. Markus Leuenberger, Director HFSJG; Prof. Thierry Courvoisier, President SCNAT; Prof. Martin C.E. Huber, President of the Jungfraujoch Commission of the SCNAT.



December: The Matterhorn during sunrise - view from Gornergrat.





## 192. Jahreskongress SCNAT: “Höher und kälter – Forschung am geographischen Limit”

Von den Pionierleistungen Alfred de Quervains zur heutigen Polar- und Höhenforschung  
**25. und 26. Oktober 2012, Kongresszentrum Kursaal, Interlaken**

### Some impressions



Bernhard de Quervain narrated the story of his grand-father Alfred de Quervain (left)

Dr. de Quervains Havn on Greenland (right)



Prof. Paul Messerli, president of the organizing committee, Stefan Kern, PH Zürich

sc | nat <sup>+</sup>

Swiss Academy of Sciences  
Akademie der Naturwissenschaften  
Accademia di scienze naturali  
Académie des sciences naturelles

**HFSJG**  
Hochalpine Forschungsstationen  
**Jungfrauoch & Gornergrat**



Prof. Thierry Courvoisier, president of SCNAT, Prof. Heinrich Miller, Alfred Wegener Institute



Prof. Erwin Flückiger, president of HFSJG and Prof. Martin Huber, president Jungfrauoch Commission SCNAT (left); Christian Preiswerk, SCNAT and Prof. Christian Schlüchter (right)



Dr. Ginette Roland, Université de Liège (B), Prof. Urs Baltensperger, Paul Scherrer Institute

sc | nat <sup>+</sup>

Swiss Academy of Sciences  
Akademie der Naturwissenschaften  
Accademia di scienze naturali  
Académie des sciences naturelles

**HFSJG**

Hochalpine Forschungsstationen  
**Jungfrauoch & Gornergrat**



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Scientific Exhibition at Jungfrauoch

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And our thanks to all the women and men who worked at Jungfrauoch and Gornergrat in 2012 and who contributed throughout the year to the continuation and the strengthening of the renown of these stations.