SOUNDING ROCKET AND BALLOON ACTIVITIES AND RELATED RESEARCH IN SWITZERLAND 2007 - 2009

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ABSTRACT

Swiss research groups are continuously using high altitude balloons or sounding rockets for their experiments in various fields of science. Researchers from several Swiss institutions are involved in studies mostly related to atmospheric phenomenon. Their observations are embedded in national and international projects such as the Global Atmospheric Watch (GAW), which is a worldwide initiative established by the World Meteorological Organization to monitor trends in the Earth's atmosphere. Due to the topographical situation of Switzerland, high altitude research stations at Jungfraujoch or Gornergrat enables researcher to investigate the upper atmosphere without using balloons or sounding rockets. These two research facilities are frequently used by research teams from all over Europe and overseas.

1. INTRODUCTION

Switzerland has been participating in the Esrange Andoya Special Projects (EASP) program for several years now. Swiss researchers who are engaged in high altitude balloons or sounding rocket campaigns profit from this program like the research group from the Physics Institute, University of Bern, who was conducting a Polar Balloon Atmospheric Composition Experiment testing a new generation of neutral gas mass spectrometer designed for Mars missions. Due to the stratosphere flight altitude of 35 – 40 km the installed instruments were tested under remarkably similar condition like on Mars.

In the near future, an international research team coordinated by the Swiss Zero-g LifeTec Company will be able to carry out experiments on board a sounding rocket to investigate the effects of microgravity on immune cells. This experiment is one of a series of experiments in the field of life sciences led by the Swiss team.

Switzerland offers researchers additional platforms for high altitude investigations. The Jungfraujoch High Altitude Research Station for instance is heavily used by national as well as international teams for global atmospheric watch and other climate projects. Paul Scherrer Institute and MeteoSuisse are currently carrying out aerosol and radiation measurements. Other Swiss institutes like EMPA are monitoring the carbon content or organic compounds of the upper atmosphere. There is even an observation instrument in the astronomical dome available. A team of the École Polytechnique Fédérale de Lausanne (EPFL) is using it for standard air pollution monitoring.

2. GAW SWISS ATMOSPHERIC RADIATION MONITORING PROGRAM (CHARM)

Activities of the research group of Dr. Laurent Vuilleumier (Federal Office of Meteorology and Climatology MeteoSwiss, Payerne) during the past period were mainly devoted to the integration of the data acquisition infrastructure of the GAW Swiss Atmospheric Radiation Monitoring program (CHARM) in the main MeteoSwiss ground measurement network SwissMetNet (SMN). This required the interruption of radiation monitoring while the infrastructure was renewed. Furthermore, the transition was more difficult than anticipated, and the interruption lasted longer than foreseen. CHARM radiation data monitoring at the Jungfraujoch was resumed at the end of October 2007. As a consequence, the data availability is below 10% for radiation parameters at the Jungfraujoch in 2007. In order to mitigate the impact of this transition, an independent and self-sufficient measuring system for short-wave global and long-wave downward radiation (used as travelling reference by the Alpine Surface Budget Network) has been installed to supply data at least for these two parameters during the interruption.

Currently, quality control and analysis is on-going on the data from the new system to ensure at least the same level of quality as in the previous setting. Because SMN will include all standard surface meteorological stations as well as other stations such as the CHARM stations with common data acquisition software, hardware, and a dedicated data transmission network, resources can be

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focused on insuring the reliability of this network, and CHARM will profit from it.

A project focused on analyzing the time evolution of aerosol optical depth (AOD) and shortwave radiation in Switzerland and Germany has been initiated in 2006. Solar irradiance from various regions around the globe shows a decrease after the mid-1950s followed by an increasing trend since the mid-1980s [1]. This solar dimming and brightening cannot be explained by variations of the sun radioactive output [2], and is therefore rather expected to be a consequence of changing atmospheric transmission due to the increases and subsequent decreases in anthropogenic aerosol concentrations and possible related cloud effects. Aerosols are known to affect atmospheric transmission and hence temperature via the direct aerosol effect (scattering and absorption of sunlight by aerosol particles). However modeling studies expect indirect aerosol effects, like the cloud albedo effect (enhancement of cloud albedo due to smaller droplets) [3] or the cloud lifetime effect (extension of cloud lifetime due to smaller droplets and less precipitation loss) [4] to have an even larger impact than the direct aerosol effect [5, 6].

Aerosol optical depth (AOD) has been determined by sun photometry in an automated and continuous way since the end of the 1980's in Germany [7], and the middle of the 1990's in Switzerland. The longest series of spectral AOD measurements from the German Weather Service and MeteoSwiss are used in this study from six sites covering mainland Europe from the Baltic Sea to the Alps. A BAS type sun photometer was used at the German sites Zingst (ZIN), Lindenberg (LIN) and Hohenpeissenberg (HOP), and SPM2000 sun photometers [8] and PFR precision filter radiometers were used at the Swiss sites Payerne (PAY), Davos (DAV) and Jungfraujoch (JUN). Figure 1 shows the AOD sites (left) and AOD measurements at λ = 500 nm (right), ordered by increasing altitude from ZIN at sea level up to JUN at 3580 m a.s.l.

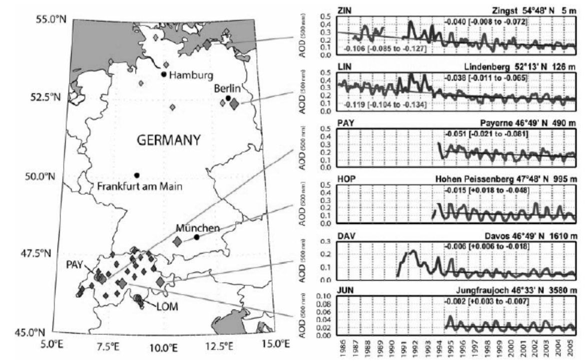

Figure 1: Location of surface observation sites in Germany and Switzerland used in this study (left) and the corresponding AOD reading (right). AOD trends are given per decade and are shown for different time periods.

The longest data series are from ZIN and LIN, with LIN showing an uninterrupted record from February 1986 to 2005. Continuous records are available at all stations since January 1995. Monthly values are shown with a three month running mean to better illustrate AOD seasonality. Since AOD data are log-normally distributed, trends for different time periods were estimated by fitting the logarithm of the monthly mean AOD with a Least Mean Square (LMS) approximation.

A considerable decrease in AOD with a statistically significant trend is observed at Zingst and Lindenberg over the 1986 to 2005 measurement period. A statistically significant reduction is also observed for the 1995 to 2005 period at the three lowland stations ZIN, LIN, PAY. Despite a reduction in AOD at the alpine stations HOP, DAV and JUN over the same period, the trends are not statistically significant due to lower absolute AOD and larger relative variability.

Zingst and Lindenberg show an overall AOD decrease of about 60 percent from 1986 to 2005. From 1995 to 2005 AOD decreases between 20 and 30 percent at the three lowland stations and by 10 to 15 percent at the higher sites. The large aerosol decrease at low altitude suggests declines that are primarily due to reduced anthropogenic aerosol emissions [9]. Since around 2000 the AOD stabilizes at low values.

With decreasing AOD, global solar irradiance or shortwave downward radiation (SDR) is expected to increase particularly at low altitudes, where aerosol and hence solar transmission changes are largest. SDR measurements from low-altitude sites in Switzerland and Germany were used to study the relationship between AOD change and SDR change.

Anomalies with respect to the mean irradiance from 1981 to 2005, of cloud-free shortwave downward radiation appeared strongly related to the observed 60% decrease in AOD at low elevation (i.e. direct aerosol effect) from 1986 to 2005. By subtracting SDRcf from SDRas anomalies we obtained the changes in shortwave downward radiation anomalies that are due to changes in cloud cover (SDRcloud). SDRcloud anomalies show large year-to-year variability and the average trend of +1.84 Wm-2 dec-1, but it is strongly influenced by the summer 2003.

With the observed large AOD decreases SDRcloud increases are expected due to indirect aerosol cloud effects, but these cloud trends may also have been affected by long-term variations of large scale circulation patterns. The extreme summer 2003 however, is different from such long-term changes. Time series of shortwave radiation fluxes from 1981 to 2005, without the year 2003 were therefore used for computing changes, and the increase in the resulting modified SDR cloud is reduced by about one third and is no longer statistical significant. This reduction and hence the impact of 2003 is mainly affecting SDR cloud, whereas trends on cloud-free SDR radiation

fluxes show almost no change and remain statistical significant.
Our analyses show solar brightening to be more affected by direct aerosol effects under cloud-free skies than by indirect aerosol cloud effects, and to affect mainly low-altitude sites. The fact that despite the 60 percent aerosol decline indirect aerosol cloud effects remain small is unexpected. It is though not impossible that part of the effect was balanced by increasing cloud amounts with changing large scale circulation. With respect to climate, direct aerosol forcing is found to be five times larger than cloud forcing, which is partly compensated by long wave cloud effects. Estimations of the impact of the observed radioactive forcings on surface warming using mean climate sensitivity factors show, that with the observed strong aerosol decline the direct aerosol forcing and the indirect cloud forcing combined may have produced up to 50 percent of the recent rapid temperature increase observed in Central Europe since the 1980s.

3. A NEUTRAL GAS MASS SPECTROMETER TO MEASURE THE CHEMICAL COMPOSITION OF THE STRATOSPHERE

The Polar Balloon Atmospheric Composition Experiment (P-BACE), led by Peter Wurz (Physics Institute, University of Bern) and Stas Barabash (Swedish Institute of Space Physics, Kiruna, Sweden) is a new generation of neutral gas mass spectrometer based on the time-of-flight principle. P-BACE is the scientific experiment on the Mars Environment Analogue Platform (MEAP) flown successfully on a balloon mission in summer 2008. The MEAP mission was flown with a 334,000 m3 helium balloon in the stratosphere on a semicircular trajectory from northern Sweden around the North Pole to Canada using the summer northern hemispheric wind current. The atmospheric conditions at an atmospheric altitude of 35 – 40 km are remarkably similar to those on the surface of Mars and thus the balloon mission was an ideal test bed for our mass spectrometer P-BACE. Originally this instrument was designed for in situ measurements of the chemical composition of the Martian atmosphere.
P-BACE has a unique mass range from 0 to 1,000 amu / q with a mass resolution $m/\Delta m$ (FWHM) > 1,000, and the dynamic range is at least six orders of magnitude. During this experiment, the acquisition of one mass spectrum is a sum of 65,535 single spectra, recorded in a time frame of 66 seconds.
The balloon mission lasted five days and had successfully demonstrated the functionality of the P-BACE instrument during flight conditions. We had recorded more than 4,500 mass spectra. With little modifications, P-BACE can be used on a planetary mission for Mars, but for example also for Venus or Mercury, if placed on a satellite.

4. NEUTRON MONITORS – STUDY OF SOLAR AND GALACTIC COSMIC RAYS

The Cosmic Ray Group of the Division for Space Research and Planetary Sciences of the Physics Institute at the University of Bern, (led by Erwin Flückiger), 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 with the plasma and the magnetic fields in the heliosphere and about the production of energetic cosmic rays at the Sun, 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 cosmic ray detectors. By using the Earth's magnetic field as a giant spectrometer, this network determines the energy dependence of primary cosmic ray intensity variations in the GeV range. Furthermore, the high altitude of Jungfraujoch provides good response to solar protons ≥ 3.6 GeV and to solar neutrons with energies as low as ~250 MeV.
In 2008, 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 on the webpage (http://cosray.unibe.ch). Although it seems that Solar Cycle 24 has started in January 2008 with the first appearance of a reversed-polarity sunspot, the solar activity was extremely low in 2008. The monthly smoothed sunspot numbers where even lower than in 2007, and March/April 2008 marked the preliminary sunspot minimum. The mean yearly count rate of the IGY NM at Jungfraujoch in 2008 was about 0.5% higher than in 2007. The cosmic ray conditions near Earth were undisturbed during the whole year as can be seen from Figure 2, which shows the daily counting rates of the IGY NM for 2008. As a consequence of the low solar activity, no Ground Level Enhancements (GLEs), and no major Forbush decreases (Fd) were observed. The pseudo-periodic variations are mostly a consequence of the sector structure of the interplanetary magnetic field (IMF).
In 2008 the European Seventh Framework (FP7) project Neutron Monitor Database (NMDB) has started. In a test phase 12 NM stations including the Jungfraujoch NMs send data in real-time to a database server. The Bern group is developing a software package to determine the ionization and radiation dose rates in the Earth's atmosphere based on real-time NM data from the NMDB server.
In October 2008 the IGY NM at Jungfraujoch marked 50 years of operation. When the Swiss confederation

decided to join the International Geophysical Year in 1957-1958, Prof. Friedrich G. Houtermans, head of the Physikalisches Institut of the University of Bern (1952-1966) proposed to build a NM at Jungraujoch. A promising young student was entrusted with the construction of this detector: Hermann Debrunner, later head of the cosmic ray group at the University of Bern (1964-1997), director of the High Alpine Scientific Stations Jungfraujoch and Gornergrat (1964-1999) and president of the board of the International Foundation HFSJG (International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat, 1973-1999). The IGY NM with 12 counter tubes was put in operation first on the roof of the building of the research station, and from August 1959 inside the Sphinx laboratory. In summer 1966 the detector was moved to today's position on the terrace of the Sphinx laboratory, and by adding six counter tubes it was enlarged to an 18-IGY NM.

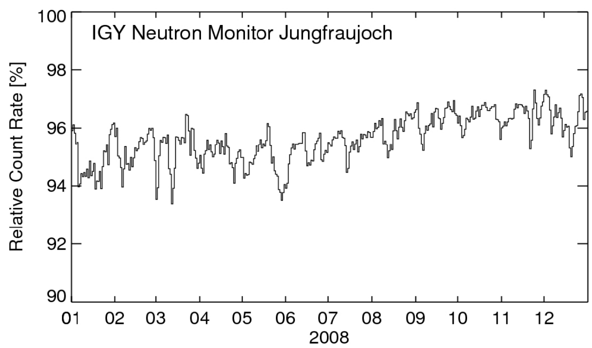

Figure 2: Relative pressure corrected daily counting rates of the IGY neutron monitor at Jungfraujoch for 2008.

Bieber et al. [10] have shown that the 1997 peak rate of the South Pole NM was ~8% lower than the 1965 peak rate. However, this decrease was not observed at other South polar NM stations. In their investigations Bieber et al. therefore do not rule out detector tube aging as the reason for the decline in the count rate. If this hypothesis is correct, a detector tube aging effect should also be present at the NM64 NM at Jungfraujoch, because the NM64 NM at Jungfraujoch has the same type of counter tubes and a similar counting rate per tube as the South Pole NM, i.e. 100 cts/second.
For the time period 1985-2008 Figure 3 shows the monthly count rate ratio of the IGY and NM64 NMs at Jungfraujoch. It seems that the average count rate ratio IGY/NM64 tends to increase by 0.12% per year after 1988. The step like decrease in Figure 3 in 1988 was caused by a recalibration of a barometer. The partly well pronounced seasonal variations are due to snow accumulations on the roof and around the detector housings. At the IGY NM the custodians at Jungfraujoch remove the snow from the roof of the detector housing at least once a day. At the NM64 NM snow removal is not possible. Therefore the seasonal effect is more dominant in the data of the NM64 NM compared to the IGY NM. From our analysis we can at present time neither confirm nor exclude an aging of counter tubes over periods of decades.

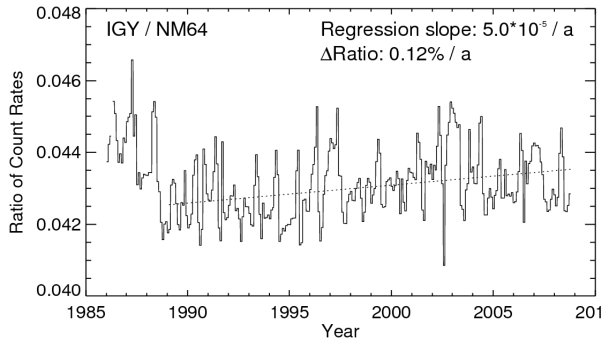

Figure 3: Ratio IGY/NM64 NM of monthly averaged count rates.

5. STARTWAVE: ESTABLISHMENT OF A WATER VAPOUR DATABASE AND THE STUDY OF WATER VAPOUR DISTRIBUTION

Water vapour plays an important role in the Earth's energy balance in that it only weakly absorbs sunlight but strongly absorbs infrared radiation. When water vapour condenses to form clouds, however, it becomes a very good reflector of sunlight. An increase in atmospheric water vapour due to increasing surface temperature could therefore lead to both positive and negative climate feedbacks [11]. The most recent Intergovernmental Panel on Climate Change report states that "Water vapour feedback continues to be the most consistently important feedback accounting for the large warming predicted by general circulation models in response to a doubling of CO2", IPCC, 2001.
The aim of the STARTWAVE (**St**udies in **A**tmospheric **R**adiative **T**ransfer and **Wa**ter **V**apour **E**ffects) project is to study the temporal and spatial distribution of water vapour, and in particular its effect on the Earth's radiation budget. This will be achieved firstly through the development of new techniques to monitor atmospheric water vapour.
A research team of Niklaus Kämpfer from the Institute of Applied Physics, University of Bern, is developing such new techniques like the **Mi**ddle **A**tmospheric **Wa**ter Vapour **Ra**diometer (MIAWARA) for obtaining profiles of stratospheric water vapour [12] and the **A**ll **S**ky **Mu**lti **Wa**velength **Ra**diometer (ASMUWARA) for studying the distribution of integrated water vapour across the whole sky [13]. The second goal is to achieve advancements in radiative transfer modelling, in order to both improve the retrieval of water vapour from

remote instruments and to increase our understanding of the role of water vapour in the radiation budget. The third activity is to incorporate water vapour measurements from existing instruments in Switzerland in a database which is suitable for climatic studies.

One challenge in the measurement of water vapour is the fact that unlike temperature or pressure measurements, there is no established standard. Radiosonde humidity sensors provide the only direct measurement yet there have been a number of changes in instrumentation and reporting techniques [14] and sensitivity to low water vapour values depends on the sensor type [15]. In the establishment of a database, it is important to optimize retrieval algorithms and avoid spurious trends in water vapour due to a change in retrieval algorithm or instrumentation. At the University of Bern, integrated water vapour (IWV) is being monitored using sun photometry and microwave radiometry as well as by measuring the delay in the Global Positioning System (GPS) signals. Data from these instruments will be inter−compared in order to verify the different techniques and also to obtain a more accurate water vapour measurement than can be achieved by a single instrument. Figure 4 compares IWV measurements from the sun photometer, TROWARA (**Tro**pospheric **Wa**ter Vapour **Ra**diometer) and GPS receiver at the University of Bern with radiosonde measurements from Payerne.

The TROWARA microwave radiometer [16] provides the longest running source of IWV measurements at Bern from 1994 to 2002. The radiometer and retrieval algorithm are currently being revised. Past data will be reanalysed with the revised retrieval algorithm and the dataset will be compared with Payerne radiosonde data and used to study water vapour variability and trends.

The database will eventually consist of water vapour measurements from sites throughout Switzerland. The network AGNES GPS network operated by Swiss topography [17] was established in 1998 and there are currently 29 stations. GPS is a reliable, more or less continuous source of IWV measurements and it is hoped that the relatively dense network of GPS sensors in Switzerland can be used to study the spatial distribution of water vapour.

There are four stations with a sun photometer measuring IWV within the CHARM radiation network [18]. The strength of this data source lies in the fact that water vapour measurements are collocated with extensive radiation measurements.

Satellite data is also a valuable source of water vapour information in that it provides wide spatial coverage and spatially averaged rather than point measurements as well as information on the vertical distribution of water vapour. The data from microwave spaceborne sensors is affected by surface emission and at present water vapour information over land is only available from spaceborne sensors operating in the infrared or visible region of the spectrum. Once a database of measurements from ground−based instruments has been established, it can be used to validate satellite measurements.

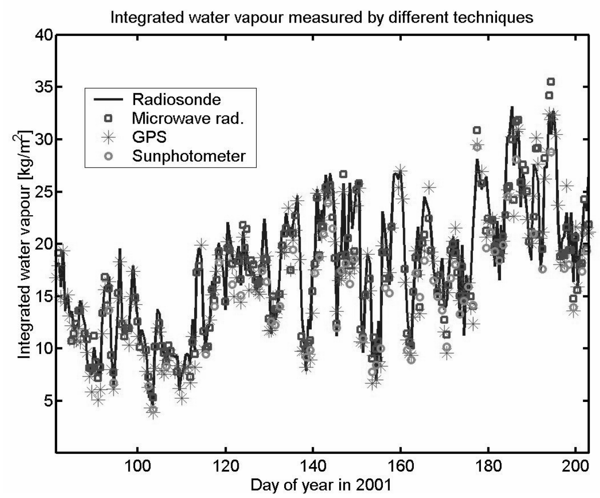

Figure 4 − Integrated water vapour (IWV) measured over a three month period at the University of Bern using the sun photometer, TROWARA microwave radiometer and Global Positioning System (GPS) receiver.

6. SIGNAL TRANSDUCTION IN HUMAN T CELLS IN MICROGRAVITY EXPRESSION AND FUNCTION OF CHEMOKINES, CYTOKINES AND THEIR RECEPTORS, EPIGENETIC ALTERATIONS

Zero-g LifeTec – a spin-off company of the space biology group of the ETH Zürich – is coordinating a Swiss/Italian research team which is preparing an experiment scheduled to fly on the sounding rocket MASER 12 in 2010 in order to further investigate the effects of microgravity on early and intermediate events linked to T-lymphocyte activation. This experiment is one of a series of experiments performed by the team of A. Cogoli since 1983. It is well known that *in vitro* activation of T-cells is severely hampered under microgravity conditions [19]. Early events can be observed within seconds and minutes, after the cells have been activated. The early response of the T-cells is divided in several consecutive steps which will be analysed separately. When specific activator molecules are recognized by the cell, a signal is generated which is transferred, via a complex network of molecular pathways, into the inner parts of the cell to end up inside the nucleus. Although certain aspects of the signaling pathways have gradually been clarified, the picture is far from complete. In this new investigation, T-cells will be activated in micro-g and at 1g on the in-flight reference centrifuge. By analysing and comparing the two groups, the signal transduction can be further explored and possibly, more light can be shed on the reason why T-cells cannot be activated in micro-*g*.

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8. ACKNOWLEDGEMENT

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