

# SOUNDING ROCKET AND BALLOON ACTIVITIES AND RELATED RESEARCH IN SWITZERLAND 2013–2015

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## ABSTRACT

During the period from 2013 to 2015, many Swiss researchers conducted studies on research platforms such as balloons or sounding rockets, or at the high altitude research stations of Jungfrauoch and Gornergrat. Researchers' increased interest in sounding rockets during the two-year period is especially noteworthy. The use of the high altitude research stations, in contrast, has a long tradition in Switzerland and is, thus, frequently occupied by scientists. An advantage of these stations is the ideal set-up for researchers interested in the long-term measurement of the upper atmosphere, for example. Therefore, numerous experiments in this particular research field were conducted and published in scientific journals.

After a pause, several Swiss scientists became engaged in sounding rocket experiments. RUAG Space in Nyon, for instance, in collaboration with the Swedish Space Corporation (SSC) and University of Freiburg, is focusing on the effect of gravity on plant roots. In order to investigate a gravity-dependent influence, two experiments on *Arabidopsis thaliana* seedlings are being planned for execution during the upcoming MASTER 13 campaign. A team of students from HES-SO Geneva were chosen to participate in the REXUS program with their experiment called CAESAR. A new concept of a propellant management device for space vehicles was introduced and tested on the REXUS 14 rocket by the team from Geneva in the spring of 2013. Last year, another student team, now from the Lucerne University of Applied Sciences and Arts, was selected to fly their experiment on another REXUS rocket. Their proposed biological study is called CEMIOS and pertains to biochemical properties of the cell membrane.

Once more the high altitude research stations of Jungfrauoch and Gornergrat welcomed many national—as well as international—scientists in the past two years. The hours that the researchers spent in either station reached a record high despite the poor weather conditions, particularly in 2014. In order to keep the stations attractive to researchers from all over the world, investment in infrastructure is necessary. New instruments were recently installed at the Jungfrau East

Ridge, for example, that now allow for the recording of additional climate and environmental data.

A short summary of a few Swiss projects within the framework of sounding rocket and balloon activities and related research performed between 2013 and 2015 is provided in the following paragraphs.

## 1. INTRODUCTION

Switzerland has been participating in the Espace Andoya Special Projects (EASP) program for more than 40 years and although there is neither a national space agency in place that supports this kind of research, nor are there particular national research programs available for receiving funding, Swiss researchers are frequently taking part as principal investigators or as collaborators in sounding rocket and balloon experiments.

The intention of this short report is to provide insights into Swiss research activities under the EASP program during the indicated three-year period. A few studies have been chosen for this that are meant to serve as examples, such as the "BIM-LAU-PE" study of RUAG Space Switzerland and collaborators. Examples of student teams that participated in EASP-related mission include the one from Geneva with its study "CAESAR" or the "CEMIOS" study of a student team from Lucerne.

Many experiments, however, were again conducted at the high altitude research stations Jungfrauoch and Gornergrat during the period. The two stations, which are located in the heart of the Swiss Alps at about 3,500 and 3,100 meters, respectively, represent ideal sites for studying the atmosphere. A few of these research studies that were conducted there are presented in this report, such as the investigation on new particle formation in the free troposphere or the "NABEL" study, which is focused on continuously monitoring of several gases in the lower troposphere. In contrast, "SONTEL" is a study that measured continuously high-energy neutrons of energetic processes at the Sun. Even complete observations of solar and galactic cosmic rays are conducted at these high altitude research sites. In

fact, students as well as professional researchers work at the two stations. A team from the Wattwil State College for Higher Education, for example, has performed a human physiology study at the Jungfrauoch station. Additional information on the activities at the high altitude research stations can be found online at <http://www.hfsjg.ch/reports/>.

## 2. BIM-LAU-PE: CULTIVATING SEEDLINGS IN MICROGRAVITY

*RUAG Space, Nyon*

RUAG Space Switzerland, in collaboration with the Swedish Space Corporation (SSC) and the University of Freiburg (Germany), has developed the “BIM-LAU-PE” (Biology in Microgravity Late Access Unit Plant Experiment) module, which is designed to be operated on board sounding rockets. The module can hold up to 36 cassettes for the cultivation of plant seedlings inside. There is even a 1-g in-flight centrifuge available in the module to run reference experiments of up to 12 cassettes in parallel. The module itself is temperature controlled to ensure optimal cultivation conditions for the plant seedlings.

The first real use of the “BIM-LAU-PE” module is foreseen on board MASER 13, which should be launched in Fall 2015. Two plant experiments will be conducted inside the hardware during the flight and are called “GRAMAT” (GRAvity Analysis on Maser rocket of *A. thaliana*) and “SPARC” (Specialized Phospholipase A, and Relocalization in auxin-transporting Cells in  $\mu$ g).



Figure 1. Launch of the microgravity rocket MASER 12.  
Credits SSC.

## 3. PROPELLANT MANAGEMENT IN MICROGRAVITY – FURTHER ANALYSIS OF AN EXPERIMENT FLOWN ON REXUS 14

*Haute école du paysage, d'ingénierie et d'architecture de Genève, University of Applied Sciences, Western Switzerland*

The student team from Geneva’s “CAESAR” (Capillarity-based Experiment for Spatial Advanced Research) experiment was conducted on board the REXUS rocket 14 and launched in May 2013. It concerned a new propellant management device (PMD) that is installed at the bottom of a satellite fuel tank to keep the propellant near the outlet. The system is designed to work even when the vehicle undergoes small accelerations.

The device performed very well during the flight and, thus, additional analysis of the CAESAR experiment is now possible to verify whether the PMD behaved according to theory and whether the test settings produce the same results on the ground as during in flight under microgravity conditions.

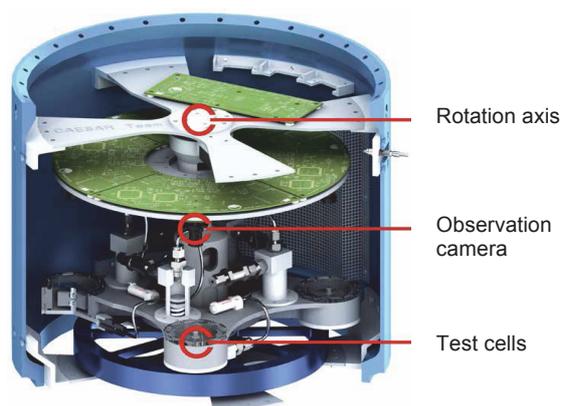


Figure 2. Sketch of the “CAESAR” module.

## 4. CELLULAR EFFECTS OF MICROGRAVITY-INDUCED OOCYTE SAMPLES (CEMIOS)

*Lucerne University of Applied Sciences and Arts and University of Bern*

Prolonged exposure to microgravity has severe effects on human physiology. Muscle atrophy, as well as loss of bone density are among the most obvious adaptation processes observed in humans during space flights.

Extensive research has demonstrated that cells have multiple mechanisms to detect external mechanical forces. However, the exact mechanism by which cells detect and interpret gravity is still unknown. Previous

studies have shown that mechano-sensitive ion channels could be among the key players. In this project, the effect of microgravity on a mechano-sensitive ion channel will be analyzed during a sounding rocket flight that is foreseen for Spring 2016.

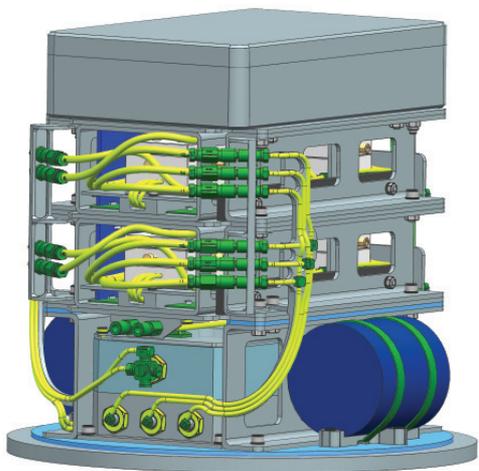


Figure 3. Sketch of the “CEMIOS” experiment hardware.

## 5. STUDY OF NEW PARTICLE FORMATION IN THE FREE TROPOSPHERE

*Laboratory of Atmospheric Chemistry, Paul Scherrer Institute*

The aim of the project is to study the nucleation process in the troposphere. It is well known that atmospheric aerosols can affect the climate directly by absorbing or scattering light and indirectly through their ability to act as cloud condensation nuclei (CCN).

A recent study claims that up to half of the CCNs formed are originating from a gas-to-particle conversion mechanism (nucleation). Unfortunately only scant information about the nucleation process is available for the free troposphere. To study this process in greater detail and over an extended period of time, several instruments were deployed at the Jungfraujoch. These instruments include an atmospheric pressure interface, time-of-flight mass spectrometers, a neutral and air ion spectrometer, a nano scanning mobility particle sizer, a condensation particle counter, a particle size magnifier etc. The measurements enable the comparison of different atmospheric conditions: free troposphere vs. boundary layer influence, vertical air mass transport, wind direction and speed, seasonal variation and cloud coverage influence.

So far, the resulting data point out that the vertical transport has an important influence on the ion

composition, which implies that the vertical transport may contribute species that later will participate in nucleation processes.

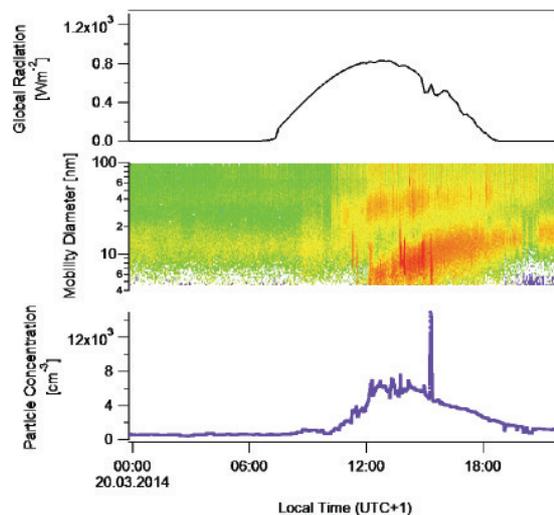


Figure 4. Nucleation event with subsequent growth during the long-term measurement campaign 2013–2014.

## 6. NATIONAL AIR POLLUTION MONITORING NETWORK (NABEL)

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

The “NABEL” initiative is a joint activity between the Swiss Federal Office for the Environment (BAFU/FOEN) and Empa. Its network was established in 1978, initially with 8 air pollution monitoring sites. In 1990–1991 the NABEL network was extended to 16 monitoring stations that were distributed all over Switzerland.

The current measurement includes continuous 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>), carbon dioxide (CO<sub>2</sub>) nitrous oxide (N<sub>2</sub>O) and many more.

The particular measuring site at Jungfraujoch goes beyond the standard equipment of other “NABEL” stations. This is due to the different scientific goals that are planned to achieve at this particular “NABEL” station, but also as a response to the various international projects and programs in which Jungfraujoch is embedded.

The NABEL station at Jungfraujoch is representing a background station for the lower troposphere in central Europe.

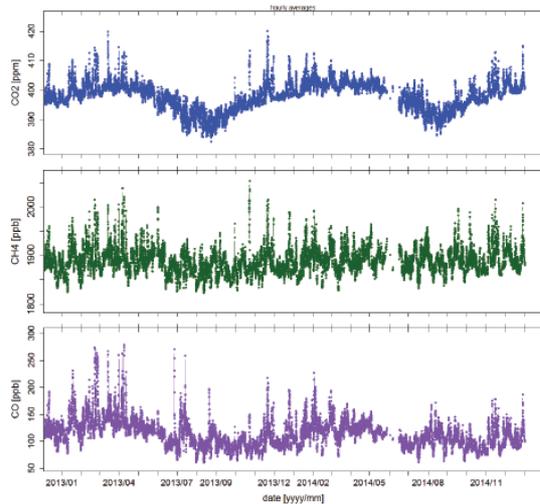


Figure 5. Time series of high-precision CO<sub>2</sub>, CH<sub>4</sub> and CO observations (hourly averages) from January 2013 to December 2014.

## 7. SONTEL – SOLAR NEUTRON TELESCOPE FOR THE IDENTIFICATION AND THE STUDY OF HIGH-ENERGY NEUTRONS PRODUCED IN ENERGETIC ERUPTIONS AT THE SUN

Physics Institute, University of Bern

The solar neutron telescope (“SONTEL”) at Gornergrat, Switzerland, is in continuous operation since 1998 and represents a European cornerstone of a worldwide network for the study of high-energy neutrons produced in energetic processes at the Sun.

There are seven solar neutron telescopes, which are located at high altitudes and at low to mid latitudes (short path through atmosphere), as well as at different longitudes, forming a network.

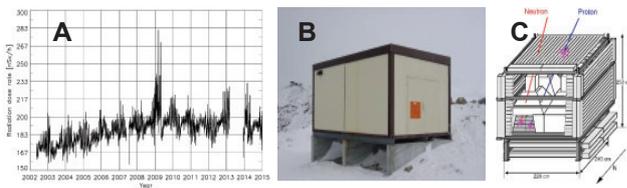


Figure 6. A) Daily averaged radiation dose rates measured by the Gamma Tracer; B) The laboratory container housing SONTEL; C) Detector principle of the Solar Neutron Telescope.

## 8. STUDY OF SOLAR AND GALACTIC COSMIC RAYS

Physics Institute, University of Bern

The two neutron monitors (NM) are operated at Jungfraujoch—an 18-IGY NM since 1958 and a 3-NM64 NM since 1986. They are both providing key information, such as a) the production of solar cosmic rays, as well details about geomagnetic, atmospheric, and environmental effects and b) the interactions of galactic cosmic radiation with the plasma and the magnetic fields in the heliosphere. Like other instruments installed at the high altitude research stations, these NMs at “Jungfraujoch” are also part of a worldwide network of standardized CR detectors. Their recorded data are published almost in real time in the neutron monitor database NMDB ([www.nmdb.eu](http://www.nmdb.eu)).

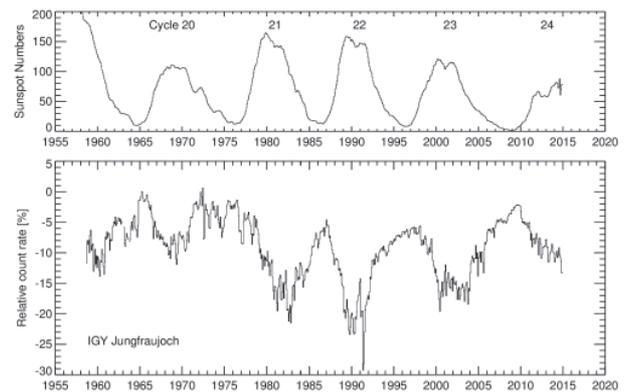


Figure 7. Smoothed sunspot numbers (top panel) and counting rates of the neutron monitor at “Jungfraujoch” (bottom panel), 1958 - 2014.

## 9. EDUCATIONAL PROJECT FOR TESTING, EVALUATION AND APPLICATION OF SELF-DEVELOPED METHOD FOR RECORDING AND ANALYSIS OF SLEEP AT HIGH ALTITUDE

Youth research group of the Wattwil State College for Higher Education

The goal of this study was to test and evaluate a self-developed recording device for the quantification of several physiological parameters during sleep. The idea for such a research project came from members of the State College for Higher Education who were interested in the natural sciences. They conducted the project during their spare time, supervised by several college teachers.

The study design foresaw sleep recordings of volunteers at low (410 m) and high altitude (3'450 m). Several non-invasive techniques, such as electrophysiology, breathing sensors, an accelerometer, pulse oximetry, and skin conductivity, were used.

Their results reveal severe changes in the respiratory and cardiovascular systems. In addition, the EEG readings indicate a reduced sleep quality at high altitude.

## **10. ACKNOWLEDGEMENT**

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