**Conference Volume** | **3rd Symposion of the Hohe Tauern National Park for Research in Protected Areas** *September 15th to 17th, 2005, Castle of Kaprun* | pages 219-222

# Research Activities at the Sonnblick Observatory

**Michael Staudinger**

## Abstract

The Sonnblick Observatory at the national park Hohe Tauern developed within the last years in an unique centre of atmospheric research. Conditions at the observatory are undisturbed by any local emissions and the climatic record of the past 120 years gained at unchanged conditions proves to be very valuable in the climate change discussion. Today a number of more than 30 projects are carried out in and around the summit, ranging from aerosols measurements to gamma radiation and permafrost monitoring.

Fig 1: The measurement site on Mt. Sonnblick. Foto Staudinger

## Keywords

Sonnblick Observatory, meteorology, climate change, air chemistry, background measurements

Contribution received at: 28.07.2005

## Introduction



Since 1886 meteorological measurements are performed at the Sonnblick observatory in an altitude of 3106m, creating a continuous series of measurements, which is unique concerning both quality and duration of all meteorological parameters. These measurements were first thought to be mainly important for synoptic forecasting, today they provide a undisturbed climatic record of a mountaintop situation near the Alpine crest. During the 20$^{th}$ century Astrophysics became additionally to meteorology a very important aspect, leading to the Nobel prize for one of its researchers, Viktor Hess in 1936 for his investigation on cosmic radiation. During the 80ties of the past century more and more air chemistry projects started to make use of the fact, that, the mountain summit is not influenced by any nearby local pollution sources and is therefore ideal for background measurements of the atmospheric constituents. So not only the quantity of the climate change in the past 120 years could be assessed, also a few questions concerning the reasons for the change in the past decades were brought closer to an answer.

## Projects at the observatory

Physics of the atmosphere – climate

Day to day meteorological measurements provide the basis for the interpretation of the data of many projects and is at the same time the basis for the longterm climatological studies. The increase in temperature was with 1,8 deg in 120 years nearly twice as much as in the Austrian lowlands. Thos is due to a change in weather patterns with more high pressure systems connected with a significantly higher number of sunshine hours, increase in mean pressure and a higher number of thunderstorms during the summer season. The climatology of the Sonnblick Observatory was assessed first in 1938 for a 50 year period and 2002 for the whole record available till then, by ZAMG.

Glaciers are affected in a spectacular way by the change in temperature, the altered radiation regime and the higher number of days with rainfall during summer, which makes the white, high Albedo surface layer melt much earlier than during the first half of the 20$^{th}$ century. The volume of the Goldberg glacier next to the observatory was reduced on average by more than 5000 kg/m$^2$ in the period 1987 to 2004, the time where continuous mass balance measurement were undertaken. Together with University of Natural Resources and Applied Life Sciences Vienna, Institute of Water Management, Hydrology and Hydraulic Engineering the runoff of the glaciers was both modeled and measured.

The higher number of days with rainfall instead of snow and the general increased temperature average had large consequences in the static of the rock formation underneath the observatory. For this reason extensive geotechnical provisions were made in the last three years to secure the summit with 105 suspended stainless steel anchors and 8 massive concrete reinforcements. A monitoring program will be undertaken from summer 2005 onwards to assess the temperature changes within the rock itself and to monitor the changes in the permafrost distribution.

Offsprings of the meteorological measurements are data which are gathered for warning systems like the Meteorisk project, where 14 European weather services issue daily warnings on Online basis for extreme weather events and at the Sonnblick observatory provides data from an ultra sonic wind measurement system. The Salzburg Avalanche Warning system gathers data in form of snow profiles and daily snow observations from Sonnblick as its highest station.

Radiation in higher mountain regions show a clear trend in the last decades due to the decreasing content of Ozone in higher layers of the atmosphere. This is measured for the total UV by the University of Natural Resources and Applied Life Sciences Vienna, Institute for Meteorology together with the Institute of Physics, University of Innsbruck as part of an Austrian wide network and early warning system. Two other instruments Brewer spectrometer and the Bentham spectral radiometer measure the longterm changes in the UV radiation and can give thereby clues about the vertical distribution of the $O_3$ in the atmosphere.

Cosmic radiation had been monitored for a couple of years with passive Bonner spectrometers in combination with an Extended Sievert Counter. Resulting values showed a threetime higher radiation than in the Austrian lowlands with an equivalent dose rate of 240 nSv per hour.

Nuclear physics are represented with measurements for Tritium, gamma spektroskopy and the Austrian radiation warning system of the Ministry for Agriculture, Forest, Environment and Water management. Gamma Dose rate are available back to 1986 where the accident in Tschernobyl produced with 1040 nSv/h a daily value 5 times higher than the average. CTBTO the Comprehensive Test Ban Treaty Organisation test at Sonnblick their sampler types for polar measurements.

The link between physics of the atmosphere and air chemistry is perfectly closed by the work done in the GAW (Global Atmospheric Watch) of the WMO, where Sonnblick is together with Zugspitze and Jungfraujoch a background station for central European atmospheric conditions and where various filter functions for the determination of the origin of the air masses at the measuring sites had been developed.

Airchemistry

Air chemistry is presented in various projects ranging from aerosols to POP (persistant organic pollutants) and VOC´s (Volatile organic constituents)

Within the project "Backgroundmeasurements Sonnblick" major inorganic aerosol compounds as well as the trace gases sulphur dioxide, nitric acid and ammonia were collected with filterpacks at the Sonnblick Observatory (SBO). The major inorganic aerosol compounds nitrate, sulphate and ammonia showed average concentrations ranging from 5,5 to 15 nmol/m³, while the trace gases nitric acid, sulphur dioxide and ammonia range from 2,9 to 19 nmol/m³. The calculations of summer to winter ratio represent the seasonal changes of the concentration values of the individual compounds. The highest ratio is found for ammonia, where differences between summer and winter concentrations are very pronounced. Sulphur dioxide, on the contrary does not present a marked seasonal cycle. Scavenging ratios were calculated to compare aerosol data with precipiation samples. (See poster SANCHEZ-OCHOA et. al.)

A discontinuous method for measuring nitrogen dioxide (NO2) on a daily average basis hzad been adapted to the background ambient at the Sonnblick Observatory also by the Institute for Chemical Technologies and Analytics; Vienna University of Technology. Originating from the basic Saltzmann method (SALTZMANN 1954) it uses a solid sorbent, based on the findings of FERM et al. (1984) consisting out of sodium iodide (NaI) and sodium hydroxide (NaOH) (see poster of KOLLER et. al).

The components O3, CO and CO2 are continuously recorded with a TE 49C (O3), Horiba Apma 360 (CO) and an Infrared two chamber system with calibration gases for CO2 developed by the Federal Enironment Agency Austria. All instruments had been modified for the 700 hPa level with special adaptations to compensate the pressure change.

Volatile Organic Components (VOC) are precursors of the Ozon in higher layers of the atmosphere and stem partly from natural, partly from anthropogenic processes. University of Innsbruck, Institute for Ion Physics and Max-Planck-Institute Mainz employed a proton transfer reaction mass spectrometry (PTR-MS) to measure very short term fluctuation of benzol, toluol, isoprens and other volatile components, showing clear transport mechanisms with the circulation of the alpine valleys surrounding the observatory.

The group around Vienna Environmental Research Accelerator and the Max-Planck Institute for atmospheric chemistry determined OH indirectly with the measurements of $^{14}C$ and $^{14}CO$, concluding from the speed of the oxidation process the very low concentrations of the aggressive OH radicals. Very high volumes of air sampled at Sonnblick and analyzed in Vienna.

Persistant Organic Pollutants (POP) are constituents which persist for long periods of time like DDT and Dioxins. In higher layers of the atmosphere with cooler temperatures the concentrations accumulate over longer periods as the reduction mechanisms are reduced here. The filter samplings taken at Sonnblick are focused on very small concentrations and have to integrate longer periods of time, characteristically more than 10 days. Meteorological forecast for trajectories are used to sample data coherent for one source region, like northern Europe or pure maritime Atlantic air masses.

Precipitation in Europe contains considerable quantities of acidic components like SO2, $NO_x$ and $NH_3$ which lead to consequences features summarized as "acidic rain" To assess in details the quantities of the acidic components a device in employed at Sonnblick since 1984 called WADOS (wet and dry only sampler) which differs between acidic components in the precipitation and dry deposition, which can be considerable if a sampler is exposed all the time to catch the rainfall. The resulting trends for this rare 20-year period of a mountaintop site show a decreasing trend for the sulphur components attributable to the reduction of sulphur in the oil and rather steady conditions on the nitrate part, which is due to constant emissions from the traffic.

The pH values of precipitation are not only measured in the falling rain, but also in the snow cover, where dry deposition on the snow surface is also part the integrated consideration of the acidic input to the water cycle. Results and trends here are similar and can be considered to be representative for larger areas.

Bacteria in Clouds was a project of the Institute for Limnology at the University of Innsbruck, where the cleanm air conditions of the Sonnblick site allowed to trace carbonyls in aerosols which gave clear indiciaton for bacteria as condensation nucleus.

On the ground little vegetations can be found, but lichen as the most durable and primitive form of vegetation survive directly on stones, having metabolism even directly under the snow cover, if the light and radiation conditions are favourable. The measurements of the CO2 metabolism of the lichen species by the Institute for Botanics of the University of Salzburg on Sonnblick are unique in this form in Europe.

Above ground insects traverse the alpine crest in considerable numbers and use different systems for their orientation. The University of Graz, Institute for Nature Protection and Ecology of the Environment investigated these mechanisms by tracking the animals at various sites.

## References

AUER I., BÖHM, R. LEYMÜLLER M., SCHÖNER W. (2002) Das Klima des Sonnblicks.

Österreichische Beiträge zur Meteorologie und Geophysik, Wien.

KARL, T., CRUTZEN, P.J., MANDL, M., STAUDINGER, M., GUENTHER, A., JORDAN, A., FALL, R. and W. LINDINGER, Variability-lifetime relationship of VOCs observed at the Sonnblick Observatory 1999 Estimation of HO-densities, Atmospheric Environment, 5287-5300, 2001

KAISER, A., R. NEMETH (2000): Luftchemische Messungen am Sonnblick: Der österreichische Beitrag zum Global Atmosphere Watch Programme der WMO. 96.-97. Jahresbericht

PSENNER R., SATTLER B. (1998). Microbial communities Life at the freezing point. Science 280(5372): 2073-2074.

Scavenging efficiency of lead and sulfate in supercooled clouds at Sonnblick, 3106m asl, Austria. Kasper, A.; Puxbaum, H.; Brantner, B.; Paleczek, S. Atmospheric Environment, Volume: 32, Issue: 23, December, 1998

SIMIC, S., WEIHS, P., KROMP-KOLB, H., VACEK, A., LAUBE, W. (2004): Modification of spectral UV irradiance by clouds at the Sonnblick Observatory (3106 m, Austria). In: European Geophysical Union: EGU General Assembly 2004, 25.-30. April 2004, Nice Frankreich; Geophysical Research Abstracts, 6, 5675; ISSN 1029-7006

## Contact

Dr. Michael Staudinger
Staudinger@zamg.ac.at

ZAMG – Regional office for Salzburg and Upper Austria
Freisaalweg 16
A 5020 Salzburg
Austria