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The Lab Above the Clouds
Sonnblick Observatory and Nationalpark Hohe Tauern

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Abstract

Established in 1886 the Sonnblick Observatory provides ideal characteristics for environmental research for more than 100 years now. Located in the core zone of Nationalpark Hohe Tauern a number of benefits arise for both, projects dedicated to well-defined research questions and the idea and aim to foster the awareness of natural heritage in the hearts of people. Here we want to focus on long term research related to atmospheric aerosols and the chemical composition of precipitation and highlight the potential of these data series for supporting the aims of national parks.

Keywords

air quality, wet deposition, atmospheric sciences, background measurements, long term trends

Introduction

The foundation and construction of the Sonnblick Observatory, i.e. the cooperation of Julius Hann and Ignaz Rojacher, is an early and extremely successful example of public science. Among a larger number of mountain observatories established that time, the Sonnblick Observatory is the only station located in a high alpine environment which survived without any breaks until today. Meteorology was the starting point, but very soon the Observatory was recognized as 'Lab Above the Clouds'. Victor Franz Hess reported his experiments on cosmic rays already in 1928. In 1986 the new building allowed the extension of the monitoring and research activites in the fields of air chemistry and physics. Since 2016 the Observatory is accepted as a global GAW-station (GAW-Global Atmosphere Watch).

The Sonnblick Observatory is unique due to its position at 3106m asl without local pollution sources nearby, its direct and easy access to the surrounding environment, and the experimental possibilities offered by the onsite technical staff. Fig. 1 summarizes possible interactions of the environments (i.e. the atmosphere, the hydrosphere, the lithosphere and the biosphere) surrounding the Observatory.

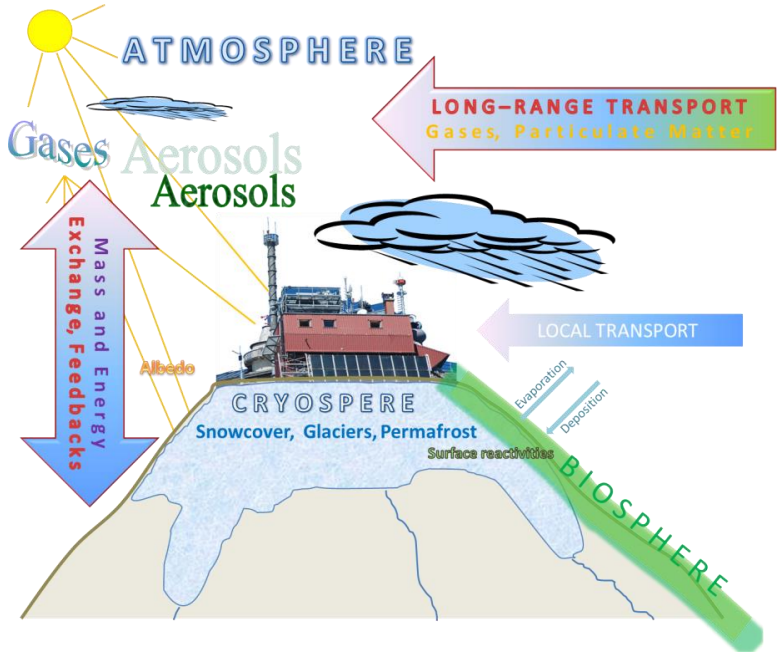

Figure 1: The Sonnblick Observatory at the interface between the atmosphere, cryosphere and biosphere (ENVISON-2, 2016)

The location of the Observatory within the core zone of Nationalpark Hohe Tauern creates mutual benefits regarding the intensity and variety of scientific research, the possibilities to offer environmental education, and the awareness of people to appreciate natural heritage.

Methods

Aerosol Measurements

Measurements of chemical composition (mainly inorganic ions, later also carbonaceous aerosols) based on filter samples date back to 1991, when a two year time series was conducted (KASPER & PUXBAUM, 1998). Later these measurements were continued on a campaign like basis. At present the activities within DUSTFALL (GREILINGER et al. 2017) extend the data set. Aerosol mass, number concentrations and size distributions, as well as optical properties of aerosol particles are determined since 2013 with continuously operating monitors. A brief description of the respective methods is given by SCHAUER et al. (2016). This sampling program is realized in cooperation of the ZAMG with Umweltbundesamt, the local government of Salzburg and Carinthia, the Climate and Air Quality Commission of the Austrian Academy of Sciences and TU-Wien (SONNBLICK OBSERVATORY, 2017).
Atmospheric aerosol particles influence the radiative balance and thus may induce both, warming or cooling of the atmosphere. By providing cloud and ice nuclei they are responsible for the formation of clouds and precipitation. Depending on their size aerosol particles remain airborne for several days and thus are subject to long-range transport. The remote location of the Observatory allows to investigate the impact of such transport events, which can be either of natural (e.g. desert dust, volcanic ash, fires) or anthropogenic (e.g. pollution episodes, fires) origin, without local influence.

Precipitation Sampling – Wet Deposition

Since 1987 wet deposition samples are collected daily with a 'Wet And Dry Only Sampler' – also called WADOS. Most of the year precipitation is in the form of snow. Only during some weeks in summer time rain is observed. Chemical analyses comprise inorganic anions and cations like sulfate, nitrate and ammonium. The trace gases sulfur dioxide, nitrogen oxides and ammonia, which are emitted by industry, traffic and agriculture, are precursors of these compounds. Emissions occur near the ground, but get transported to higher regions. Precipitation scavenges the pollutants and deposits them back onto the ground – thus cleaning the atmosphere. Additionally chloride and the basic cations sodium, potassium, calcium and magnesium are analysed. The determination of the pH-value (a measure for the acidity) and the electrical conductivity complement the data set (SONNBLICK OBSERVATORY, 2017).

Results and Discussion

The time the measurements of the chemical composition of precipitation samples at Sonnblick were started, the phenomenon of 'Acid Rain' urged scientists to have a closer look at the situation in high alpine environments. Usually concentration values in snow and rain samples collected at the Sonnblick Observatory are low. Still the high precipitation amounts can lead to deposition loads which are similar to conditions observed at lower altitudes. The measurements of major ions in aerosol samples complement this data set, as aerosol particles act as cloud condensation nuclei and thus are efficiently transferred into cloud water and precipitation by scavenging processes. Results of the aerosol measurements are exemplarily shown in Fig.2. Especially for sulfate a decrease of mass concentrations can be seen. This trend is in accordance with the reduction of sulfate concentrations in precipitation and snow samples determined at Sonnblick and other sampling sites in Salzburg (FIRMKRANZ et al. 2017, GREILINGER et al. 2016).

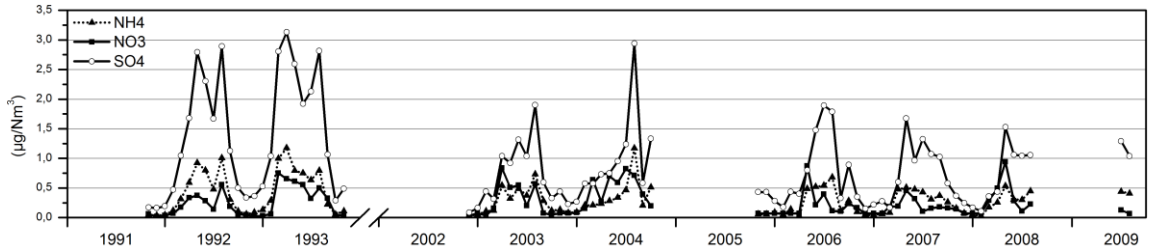

Figure 2: Temporal variation of monthly averages of selected inorganic ions in particulate matter (WINIWARTER et al. 2014)

The decrease of sulfate concentrations is caused by a reduction of emissions, due to the use of fuels containing less sulfur and the desulfurization of flue gases. Consequently the acidity of the samples decreased as well. Today the deposition of nitrogen containing compounds is in the focus of interest as no decreasing trends of total nitrogen (nitrate and ammonium) depositions are observed. The elevated input of nitrogen leads to eutrophication and influences biodiversity. Based on the available data sets joint research could include the impact of deposition loads on the biosphere in the alpine environment.

Other ongoing activities of atmospheric aerosol characterization and precipitation sampling are related to the monitoring of mineral dust, especially dust originating from long range transport from the Sahara (e.g. GREILINGER et al. 2017). Again a close connection to the nutrient input into the alpine environment glacial ecosystems and biodiversity is given.

Considering aerosol particles still airborne optical properties are relevant. Visibility is a parameter which is readily experienced by visitors of the Nationalpark Hohe Tauern. At the same time it is closely linked to airborne particulate matter concentrations. Here interesting possibilities exist to connect the monitoring activites at Sonnblick with topics of environmental education or citizen science.

Conclusion

Long term monitoring activities as well as campaign like projects conducted at the Sonnblick Observatory can be used as complementary information for research projects organized within the framework of the national parks but also for activities related to environmental education or citizen science.

Research at the Sonnblick Observatory is open for all topics. Within ENVISON, which is formulated for 5 years at a time, research foci are defined. Present foci are 'Outstanding events – analysis and forecast' and 'Aerosols and albedo and their interaction with snow cover and clouds' (ENVISON-2 2016).

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