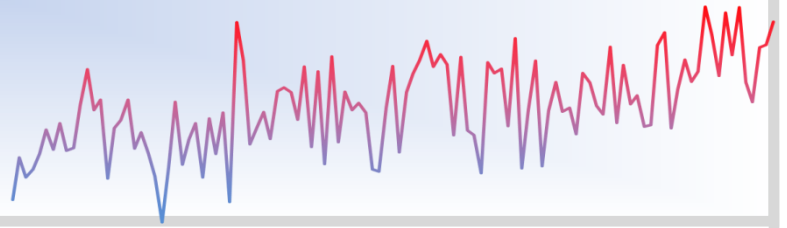


# ENVironmental Research and Monitoring SONNBLICK Programme 2016- 2020

## ENVISON



Sonnblick Beirat  
Zentralanstalt für Meteorologie und Geodynamik



Vienna, August 2016

Sonnblick - Research at the highest level

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## PREAMBLE:

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ENVISON-2 is the research program of the Sonnblick Observatory for the period 2016-2020. It is based on the strengths and scientific uniqueness of this research station and was formulated in the light of recent research topics by the members of the Sonnblick-Beirat (the advisory board for the development and the coordination of research of the Sonnblick Observatory) and national and international experts.

ENVISON-2 is neither a financed project nor does it exclude other research topics at Sonnblick. It, however, outlines the general research focus and structures in the frame of international research activities and monitoring programs and is integrated in the strategy plan of ZAMG. ENVISON-2 is not a funding program by itself. It is based on a synergy of running and already funded monitoring programs and research projects as well as, considering future activities and research foci of Austrian funding agencies.

Members of the Sonnblick Beirat and experts involved in the preparation of ENVISON (in alphabetical order)

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Organization of the Sonnblick Observatory:

Owner: Sonnblick Verein

Operation: Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

Head of the Sonnblick Observatory: Elke Ludewig

Head of the Sonnblick Beirat: Anne Kasper-Giebl

## PAST DEVELOPMENT AND ACTUAL STATUS:

The Sonnblick Observatory was founded in 1886 by the Austrian climatologist Julius Hann, substantially supported by the owner of the nearby goldmine Ignaz Rojacher, and motivated by the need for upper-air measurements in meteorology. Among a larger number of mountain observatories established that time, Sonnblick is the only station located in a high alpine environment which survived without any breaks until today. With meteorology being the starting point for the Sonnblick Observatory, other research disciplines identified the great experimental potential of the site very soon. The Nobel-prize winner V.F. Hess conducted experiments on cosmic rays and glaciology became an important field of investigations at Sonnblick as well, with contributions of Albrecht Penck or Eduard Richter being examples.

With its 100-years anniversary in 1986 the Sonnblick Observatory moved towards a

new scientific era. The monitoring and investigation of the state of the environment including the climate and climate impacts became a new and highly relevant scientific topic. Alpine wide studies on atmospheric chemistry and atmospheric physics initiated at Sonnblick resulted in the acceptance of the site in the Global Atmosphere Watch Program (GAW) of the World Meteorological Organization. Today the funding of the GAW contribution of Sonnblick is based on a national contract. The environmental monitoring and related research projects grew significantly since the late 1990s and show the internationally outstanding position of Sonnblick in the fields of climatology, atmospheric research and glaciology, which is reflected in the increasing number of publications as given in Figure 1.

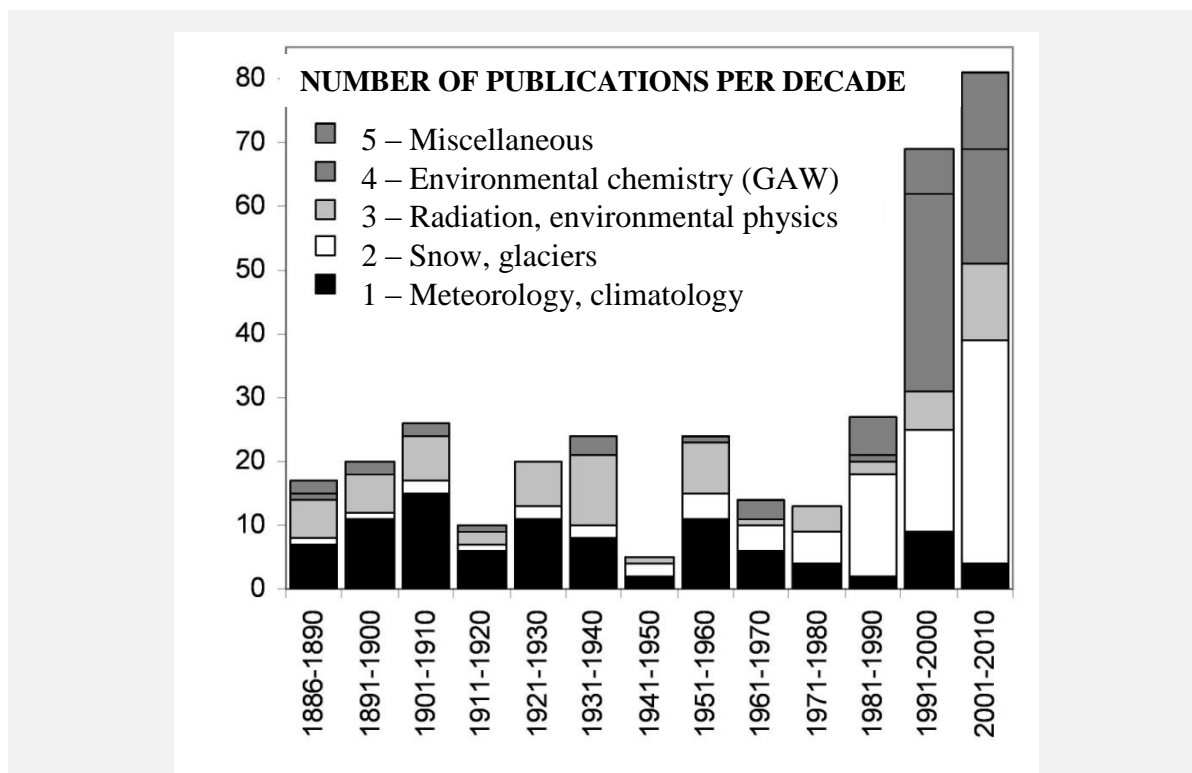


Figure 1: Development of Sonnblick research described by the number of publications and related research tasks

## UNIQUENESS:

In the international context of high-mountain research the Sonnblick Observatory and its science stand out because of:

- the unique climate time-series from 1886 until now which allow to investigate and understand climate change in the Alpine region from the pre-industrial level to the period of significant influence of men
- the unique position of the atmospheric monitoring platform at 3100m at the summit of Sonnblick without local pollution sources around and thus optimum background conditions combined with the direct access to the surrounding glaciers
- the highly interlinked monitoring and research programmes investigating

the atmosphere, the hydrosphere, the lithosphere and the biosphere, taking advantage of the easy access to all environments – thus enabling to study not only temporal trends but also exchange and cycling processes in the environment

- the high experimental potential offered by the onsite technical staff thus enabling permanently supervised measurements or sampling campaigns.

While Figure 2 shows a view of the unique location of the Observatory, Figure 3 highlights the position of the Observatory at the interface of atmosphere, cryosphere and biosphere.

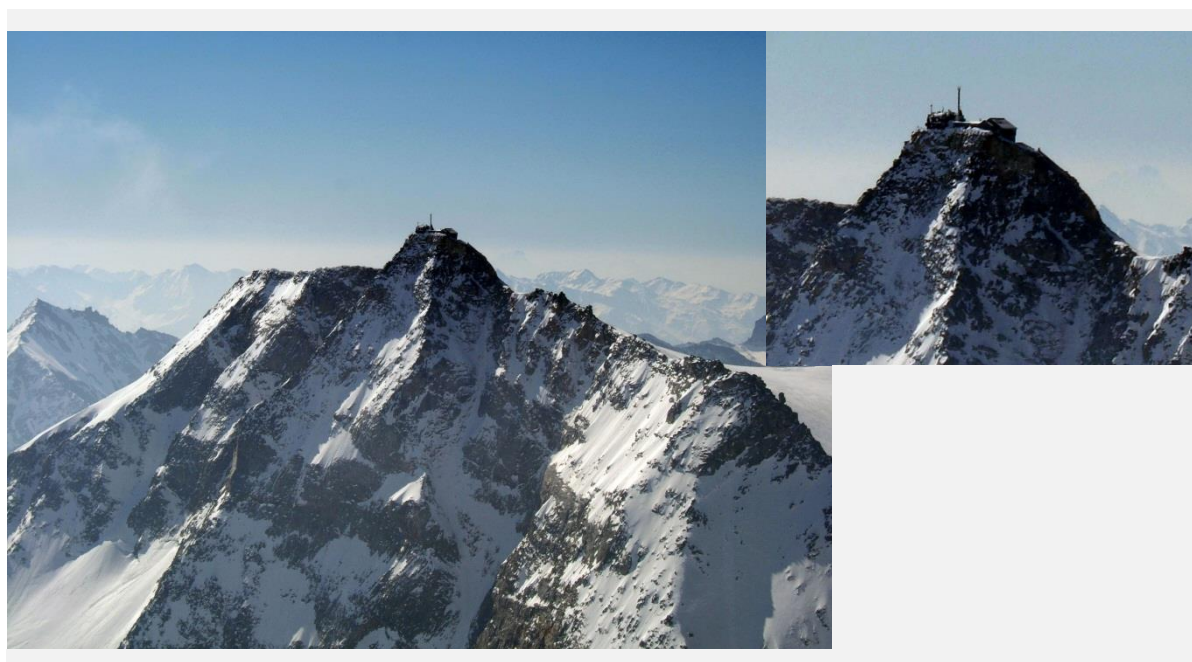


Figure 2: The Sonnblick seen from the North



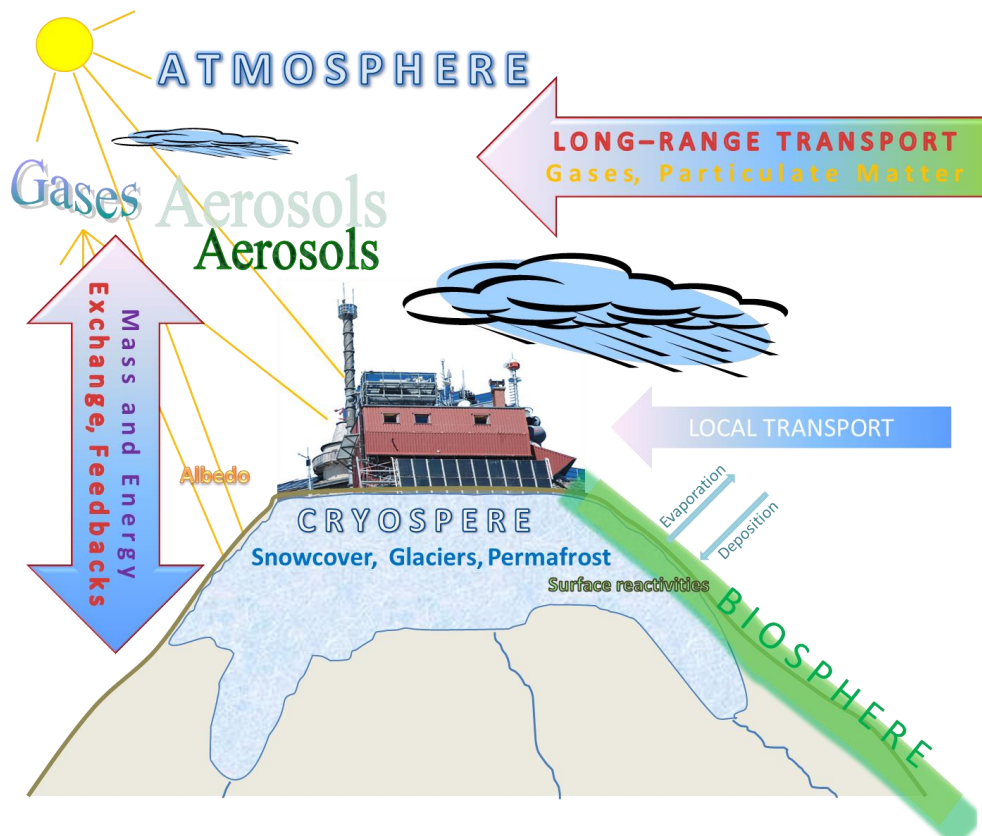


Figure 3: The Sonnblick Observatory at the virtual interface between the Atmosphere, the Cryosphere and the Biosphere

## ENVISON RELEVANT RESEARCH TOPICS:

- 1) Observation and understanding of climate change including its natural and anthropogenic driving forces in Austria and the Alpine Region (Baseline Climate Monitoring Station of Austria) and of climate impact on various spheres of the nature in the Alps as the region with most significant changes observed based on the advantage of using long term data series.
- 2) Observation and understanding of the anthropogenic influence on concentration

levels of trace species (gases, aerosols) as well as on processes and biogeochemical cycles in the background environment (with special focus on the atmosphere, the cryosphere and the biosphere).

- 3) Observation of outstanding events (e.g. dust falls, volcanic activity, long range transport, active layer thickness, extreme glacier melt) and understanding of their impact on the environment

## CONCEPT:

**Monitoring** and **research** are highly interlinked and depend on each other. Monitoring programs are often complemented by research projects, and research conducted during intensive field campaigns needs to be imbedded in longer data series of baseline parameters. Significant statements on changes depend on sufficiently long monitoring series. ENVISON does not address monitoring and research separately, but intends to connect these activities. Accordingly it splits into three major sub-programmes representing the surroundings of the Observatory. Within those programmes - ATMON (monitoring of the atmosphere), CRYMON (monitoring of the cryosphere) and BIMON (monitoring of the Biosphere) - monitoring and research activities are closely combined.

Each sub-program is guided by an internationally accepted expert. Presently (ENVISON-2, 2016-2020) this tasks will be fulfilled by:

**ATMON** – Bernadett Weinzierl, University of Vienna

**BIMON** – Birgit Sattler, University of Innsbruck

**CRYMON** – Wolfgang Schöner, University of Graz

The general structure of ENVISON is outlined below in Figure 4.

The complexity and extensiveness of the three sub-programmes varies, depending on the general research topics of ENVISON and the needs of shorter-term research projects.

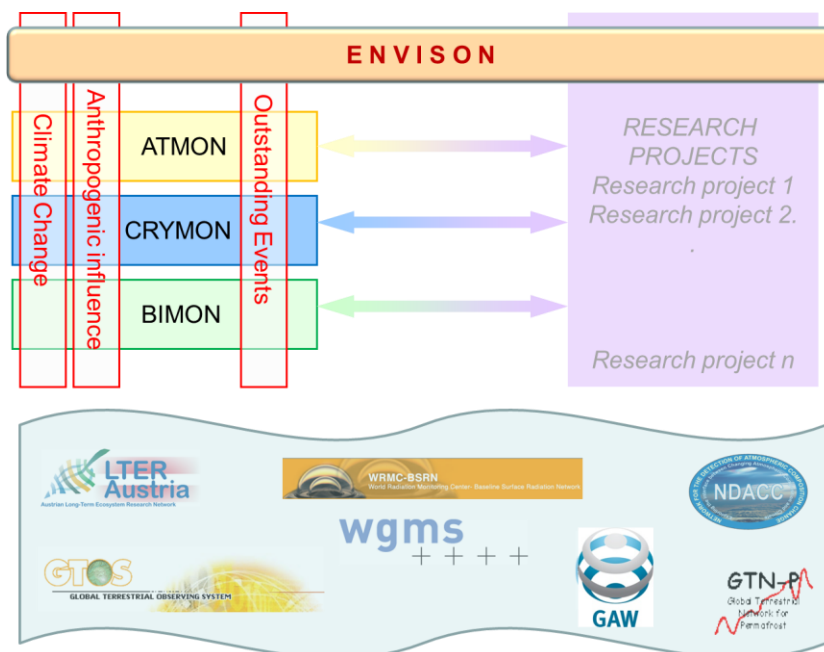


Figure 4: The ENVISON concept

**ATMON:**

The monitoring of the Atmosphere covers the acquisition of meteorological parameters as well as the determination of atmospheric trace gases, particulate matter and radiation by in-situ and remote sensing techniques. Regarding air constituents the Sonnblick Observatory allows a determination of the background boundary layer as well as free tropospheric air masses. While a limited set of parameters, e.g. defined by the demands of GAW (Global Atmosphere Watch), is determined on a routine basis, research projects introduce additional components, novel techniques and additional short term programs.

The continuous monitoring of the above mentioned parameters allows the evaluation of satellite data, model calculations and the interpretation of short term programs (e.g. measuring campaigns, vertical profile data obtained by airplane measurements) in the scope of long term observations.

**CRYMON:**

The general aim of CRYMON is to monitor the status and the changes of the Cryosphere in the spatiotemporal domain at high elevation sites of the Alps as well as its linkages to the atmosphere and the biosphere. This includes the measurements of glaciers, perennial snow and permafrost. In order to capture all these aspects of the monitoring spatially distributed observations at glaciers, test fields of permafrost distribution and the snow cover are established. The spatial variability of atmospheric conditions in the region demands for meteorological observations not only at the summit of Sonnblick but also at various sites covering local variability. CRYMON contributes to various international monitoring programmes as e.g. WGMS (World Glacier Monitoring Service) GTN-P (Global Terrestrial Network for Permafrost) and WMO GCW (Global Cryosphere Watch).

**BIMON:**

BIMON establishes a regular monitoring of vegetation changes and of changes of stream-flow ecology. Thus it will be possible to explore high added value from linking atmospheric changes to changes in the cryosphere and finally to the consequences for the biosphere, not observed elsewhere in the Alps. Several ecological observations are currently performed as part of research projects. The co-operation with NP Hohe Tauern is part of BIMON.



## INFRASTRUCTURE AND SERVICE:

Sonnblick offers a state-of-the-art research platform at the 3100m level with full power supply. A (collective) fiber network at the site, access to and from the internet via VPN (broad band link) and a central SQL database as a cloud service facilitate the technical aspects of undisturbed data exchange from the observatory to users in all parts of the world. Via Sonnblick.net data can be visualised. Considering the growing interest of the scientific community and especially research groups active at the Sonnblick for near-real-time data, the presentation of data via this gateway and the submission of data to international networks will be further pursued within ENVISON-2.

The Sonnblick Observatory has started co-operation with external partners in order to provide a robust WLAN in the broader area of the observatory capturing the

distributed network of sensors and stations in the field and to include them into the Sonnblick data base and offering online access via the internet.

Accommodation for longer field experiments is available from the adjacent mountain hut "Zittelhaus". Several mountain huts around Sonnblick offer accommodation for field trips covering the area between the base station Kolm Saigurn and the top of Sonnblick. The Observatory can be accessed by cable-car by 20 minutes ride from base-station Kolm Saigurn. Special advice on weather conditions for field experiments are provided from the ZAMG regional office at Salzburg.

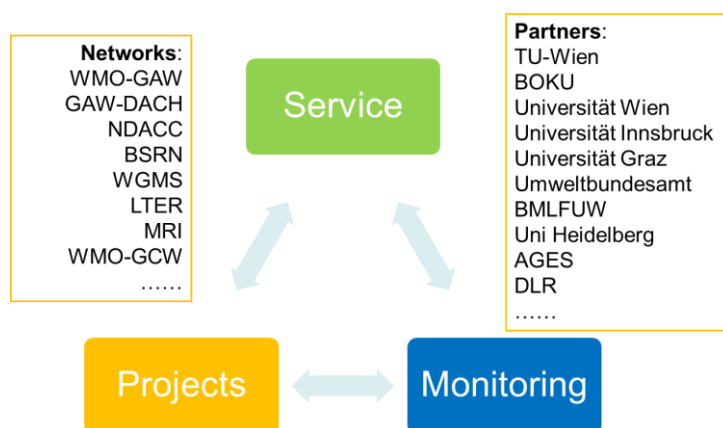


Figure 5: ENVISON in the frame of international networks and partners

## ENVISON-2 FOCUS FOR 2016-2020:

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ENVISON-2 will focus on two major research tasks:

### **FOCUS 1: Outstanding Events – analysis and forecast**

The occurrence of outstanding events like long range transport of mineral dust, plumes of forest fires, anthropogenic pollution or volcanic activity may influence the ecological system (e.g. via changes of the radiation budget or the nutrient input) and can also be of major importance for air quality. Utilizing the special features and the know-how already available at the Sonnblick Observatory and within the cooperating research groups, forecast and analysis of outstanding events will be pursued.

Since spring 2016, a ceilometer operated by ZAMG close to Sonnblick (Kolm Saigurn) renders continuous time-series of the vertical aerosol distribution and cloud and mixing layer heights. The latter supports the distinction between boundary layer air and free tropospheric air contributing to the gas and aerosol observations at Sonnblick Observatory.

The combination of the aerosol and trace gas monitoring, the remote sensing of the Alpine boundary layer in combination with operational chemical weather forecasts (WRF-Chem) and backwards atmospheric transport modeling (FLEXPART) is pursued to allow analysis of trends, the detection and analysis of outstanding events aiming at a deeper understanding of processes linked to air quality, climate and radiation and to develop respective tools for forecast and analysis. should be pursued.

### **FOCUS 2: Aerosols and Albedo and their interaction with snow cover and clouds**

The Global Climate Observing System identifies the albedo as a terrestrial

Essential Climate Variable and a product required for climate change purposes. Due to its unique position the Sonnblick Observatory offers the possibility for a comprehensive investigation of parameters influencing the albedo.

Snow is an important component of land surface and a powerful driver of climate because of its high reflectivity of incoming solar radiation. The snow albedo influences the surface radiation balance and plays a crucial role for climate studies e.g. regional climate models, radiative transfer models and satellite applications. However, only few networks are able to measure snow albedo operationally. This opens an interesting and promising field for research at the Sonnblick Observatory. The need for high quality long term albedo measurements is e.g. discussed in the recent Global Terrestrial Observing System assessment, emphasizing the importance of in situ measurements with spectral radiometers as a contribution to regional characterization and satellite product. For a successful and meaningful snow albedo measurement, daily maintenance by a human observer and a well-chosen measurement place and setup are a prerequisite as this kind of measurement is very critical (e.g. large errors due to the tilt of the sensor and the underlying terrain slope, question of representativeness of the measurement, also for later comparison to satellite data (spatial resolution, pixel size). Spectral snow albedo measurements should be realised with instruments that enable the integration and direct comparison to other incoming broadband radiative fluxes at Sonnblick (e.g. BSRN) and coordinated with the latter which also links to surface radiation balance and other climate variables recorded at Sonnblick.

Aerosols, especially light absorbing particles, may influence the snow albedo after being deposited on the snow cover via wet or dry deposition. Furthermore they also constitute important factors of direct radiative forcing in the atmosphere. Thus aerosol measurements conducted routinely at the Sonnblick Observatory will be increasingly used as input parameters for evaluation of the radiation measurements. This also implies the need to extend the current pure in-situ aerosol measurements towards (longterm) measurements of aerosols in the entire atmospheric column above Sonnblick (e.g. aerosol optical depth (AOD) using a sunphotometer) which is relevant for the incoming spectral or broadband radiative fluxes measured at Sonnblick. Such measurements would also allow the comparison to chemical weather forecast models and a linkage to Focus 1.

Besides aerosol–radiation interactions, aerosol particles are also linked to cloud formation. Clouds play an important role in regard to solar and terrestrial radiation.

As a consequence, clouds have an impact on the energy budget and global climate. A sophisticated hemispheric sky imager (HSI) could be used at Sonnblick to support the climatological investigations. With the HSI the following parameters may be derived as a function of time (Cloud cover, Cloud type, Luminance, Radiance, Irradiance).

The focus on clouds also serves as a starting point to intensify cloud research at the Observatory. As the site remains within the clouds for a considerable amount of time studies dealing with cloud formation (including ice nucleation) and cloud chemistry and physics should be promoted. The latter would also enhance the understanding of diverse feedbacks on the radiative flux and thus on the surface radiation balance, energy balance and other climate variables. Furthermore the influence on chemical reaction schemes (e.g. oxidation processes in liquid phase in comparison to the gas phase) can be investigated.

## **NATIONAL AND INTERNATIONAL INVOLVEMENT OF ENVISON:**

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### ***Already established participation in networks:***

**WMO-GAW** (Global Atmosphere Watch [www.wmo.int/pages/prog/arep/gaw/gaw\\_home\\_en.html](http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html))

**GAW-DACH** (GAW-cooperation Germany, Austria, Switzerland)

**NDACC** (Network for the Detection of Atmospheric Climate Change [www.ndsc.ncep.noaa.gov](http://www.ndsc.ncep.noaa.gov))

**WGMS** (World Glacier Monitoring Service [www.wgms.ch](http://www.wgms.ch))

**GTN-P** (Global Terrestrial Network for Permafrost [www.gtnp.org](http://www.gtnp.org))

**Copernicus** (Monitoring atmospheric composition and climate [www.gmes-atmosphere.eu](http://www.gmes-atmosphere.eu))

**BSRN** (Baseline Surface Radiation Network [www.gewex.org/bsrn.html](http://www.gewex.org/bsrn.html))

**WMO GCW** (Global Cryospheric Watch [globalcryospherewatch.org](http://globalcryospherewatch.org))

**LTER** (European Long-Term Ecosystem Research Network [www.lter-europe.net](http://www.lter-europe.net))

**INTERACT** (International Network for Terrestrial Research and Monitoring in the Arctic and adjacent forests and alpine regions [www.eu-interact.org](http://www.eu-interact.org))

**MONET** (Monitoring Network of persistent organic compounds [www.recetox.muni.cz](http://www.recetox.muni.cz))

### ***To be established participation in networks in the period 2016-2020:***

**ACTRIS 2** associated partner (Aerosols, Clouds, and Trace gases Research Infra Structure Network ([www.actris.net](http://www.actris.net)))

Moreover ENVISON-2 will cooperate with strategic partners such as e.g. MRI (Mountain Research Initiative), VAO (Virtuelles Alpenobservatorium) and Nationalpark Hohe Tauern. Initiatives which promote the location for validation and development of satellite products are supported.

In addition to fostering all of the already established participation in international research networks ENVISON-2 will especially promote active participation in following programs:

**WMO-GAW** (Global Atmosphere Watch)

Special focus is put on the further development of the Sonnblick Observatory as global GAW station, e.g by extending the monitoring programme in respect to greenhouse gases (N<sub>2</sub>O).

**LTER** (Longterm Ecosystem Research)

To date, the Sonnblick Observatory still remains at the basic status within LTER and has not been sufficiently recognized within the LTER community. Thus a better visibility of Sonnblick has to be pursued,

**WMO-GCW** (Global Cryosphere Watch)

The Global Cryosphere Watch Programme is implemented during the second phase of ENVISON. The CRYMON programme of Sonnblick should play a leading role and best practices example during this phase of GCW, finally resulting in approval of Sonnblick as a CryoNet site of GCW.

ENVISON-2 emphasizes the relevance of data submission to the respective networks.

## MANAGEMENT:

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**a) ENVISON scientific steering group:**

Station manager, deputy station manager, Monitoring programme chairs, chair of the Scientific Advisory Board (Sonnblickbeirat), national experts, international experts

**b) Sonnblickbeirat (Scientific Advisory Board)**

Scientific Advisory Board of the Director of the Central Institute for Meteorology and Geodynamics for the development and the coordination of research of the Sonnblick Observatory

## FINANCIAL MEANS FOR ESTABLISHING ENVISON:

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### a) MoU GAW-DACH

The majority of measurements of the ENVISON monitoring are funded by the national GAW-DACH MoU. The MoU is supported by the BMLFUW, the BMWF, the province of Salzburg, the province of Carinthia and the Austrian Environmental Agency (Umweltbundesamt).

- Evaluation of satellite data for integration into the monitoring program
- Operationalization of services related to outstanding events (especially Sahara dust) enabling a FFG funded PhD project.

### b) Monitoring programmes at BMLFUW (Austrian Lebensministerium)

The cryospheric monitoring is performed with funding from BMLFUW including the projects GCW-G and PERSON-GCW.

### d) FWF research focus (NFN or DACH)

ENVISON researchers are encouraged to initiate research projects for the ENVISON foci. A PhD project within the framework of the FWF DK GIScience (University Salzburg) is carried out during ENVISON-2.

### c) BMWF via ZAMG:

The operation of Sonnblick Observatory is a sovereign function of ZAMG. Since 2012 a series of ZAMG internal projects significantly contributes to ENVISON. Activities include:

- ARAD which is a follow-up for the monitoring of the radiation balance established at Sonnblick as a BSRN standards station.
- Integration of measurements from BMLFUW and ÖAW projects
- Measures for advanced instrumentation and data quality assurance for GAW as well as GCW

### e) ÖAW research programmes

The Austrian Academy of Sciences (ÖAW) is already supporting ENVISON for permafrost monitoring. This kind of funding should be extended (according to the competitive rules of ÖAW for research projects). ENVISON researchers are encouraged to consider relevant national and international calls (e.g. Earth System Sciences).

### f) International programmes for science and research

Groups interested in conducting research at SBO will try to gain funds from international funding programs.



## MEASURE OF SUCCESS - EVALUATION:

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Increased national and international recognition of ENVISON research is the key task of this program. Significant measures of the success of this programme are:

- Significant number of relevant peer-reviewed journal papers
- Number of academic works (Master and Bachelor thesis, Doctor thesis)
- Number of research projects
- Participation in high quality international networks
- Enhancing the ecological monitoring
- Enhancing measuring equipment and the quantity and quality of available data

The success of ENVISON 2 will be evaluated by an international group of experts in 2020

# STATUS LIST OF MONITORING ACTIVITIES AND RESEARCH PROJECTS AT SONNBLICK IN 2016:

## a) MONITORING

Topic	Major objective	Monitoring Program	Institution	Current funding
Meteorology	WMO standard meteorological elements	A	ZAMG	BMWFW
Trace gases	NO, NO <sub>2</sub> , CO <sub>2</sub> , CO, SO <sub>2</sub> , O <sub>3</sub> , CH <sub>4</sub>	A	Umweltbundesamt	BMLFUW
Organic Pollutant	POPs		Umweltbundesamt	BMLFUW
Aerosols	Mass, size distribution, number concentration, absorption and scattering coefficients	A	ZAMG, TUW-AC, L-SBG, ÖAW	ZAMG, TUW-AC
Radon	<sup>222</sup> Rn, air mass characterisation	A	UHEID	UHEID
StratoUV	UV, total ozone	A	BOKU-MET	BMLFUW
ARAD	Shortwave and longwave radiation	A	ZAMG	BMWFW
Precipitation	Wet deposition chemistry	A, C	L-SBG, TUW-AC, ZAMG	L-SBG, ZAMG
d <sup>18</sup> O, d <sup>2</sup> H	Stable isotopes of O and H in precipitation	A, C	UHEID	UHEID
Radioactivity	Radioactivity aerosol monitoring, Beryllium	A	AGES	BMLFUW
Glaciology	Discharge, glacier mass balance, water temperature	C	ZAMG, TUW-AC	BMLFUW
Permafrost	Ground temperatures (GST, BTS, snow cover), temperature profiles and geophysics in boreholes geophysical methods	C	ZAMG	BMLFUW, BMWFW

AGES	Austrian Federal Office for Safety in Health Care
BOKU-MET	University of Natural Resources and Life Science, Vienna, Institute of Meteorology
L-SBG	Federal State of Salzburg
ÖAW	Austrian Academy of Sciences
TUW-AC	Vienna University of Technology, Institute of Chemical Technologies and Analytics
UHEID	University of Heidelberg, Institute of Environmental Physics
Umweltbundesamt	Environmental Agency Austria
ZAMG	Central Institute for Meteorology and Geodynamics
BMLFUW	Federal Ministry of Agriculture, Forestry, Environment and Water Management
BMWFW	Federal Ministry of Science, Research and Economy
A	ATMON
B	BIMON
C	CRYMON

## b) RESEARCH PROJECTS

Name of project	Major objective	Link to Monitoring	Institution	Funding	Involvement
SSBO	Development project Sonnblick Observatory	A,C	ZAMG	BMWF	+++
SAMURAI	Snow modelling and monitoring	C	ZAMG	BMWF	+
DK GIScience	Freeze-thaw cycling from satellite data	C	Uni Salzburg/ZAMG	FWF	++
GCW-G	Snow and Glacier monitoring	C	ZAMG	BMLFUW	+++
PERSON-GCW	Permafrost monitoring	C	ZAMG	BMLFUW	+++
DUSTFALL	Sahara dust event monitoring	A	ZAMG/TUW-AC Wien	FFG	+++
EUBREWNET	Network of European Brewer Spectrophotometer (QC/QA)	A	BOKU-MET	EU-Cost	+
StratoUV	Driving factors for changes, modelling, impacts on man and ecosystem	A	BOKU-MET	BMLFUW	+++
SeisRockHT	Rockfall monitoring	C	ZAMG	ÖAW	+++
AtmoPerm	Permafrost monitoring with geophysical methods	C	Uni Graz/GBA	ÖAW	+++
Glaciolive	Glacier monitoring with Webcams	C	ZAMG/Uni Graz	BMWF-Sparkling Science	+++
GlobPermafrost	Global permafrost monitoring with satellite data	C	ZAMG, Uni Oslo, Gamma ...	ESA	+
VAO-Sub-project III/03 Alpine Water Balance	Impacts of Climate Change on the Alpine Water Balance and the Environmental Radioactivity	C	GRCEH, ISS	Bay. StMUV	+
VAO-Sub-project: LUDWIG	gravity waves, airglow	A	DLR	DLR, Bay. StMUV	+
ICE	Analysis of ice load	A,C	ZAMG	BWMFW	++

AGES	Austrian Federal Office for Safety in Health Care
BOKU-MET	University of Natural Resources and Life Science, Vienna, Institute of Meteorology
ÖAW	Austrian Academy of Sciences
TUW-AC	Vienna University of Technology, Institute of Chemical Technologies and Analytics
Uni Graz	University of Graz, Department for Geography and Regional Science
Uni Oslo	University of Oslo
Uni Salzburg	University of Salzburg
ZAMG	Central Institute for Meteorology and Geodynamics
Bay. StMUV	Bavarian State Ministry of Environment and Consumer Protection
BMLFUW	Federal Ministry of Agriculture, Forestry, Environment and Water Management
BMWF	Federal Ministry of Science, Research and Economy
ACRP	Austrian Climate Research Program
ESA	European Space Agency
EU-Cost	European Cooperation in Science and Technology
FFG	Austrian Research Promotion Agency
GRCEH	Helmholtz Zentrum Munich, German Research Center of Environmental Health
VAO	Virtual Alpine Observatory
ISS	Institute of Radiation Protection
A	ATMON
B	BIMON
C	CRYMON

# ANNEX: MAP OF SONNBLICK AND SURROUNDING NETWORK OF OBSERVATIONS

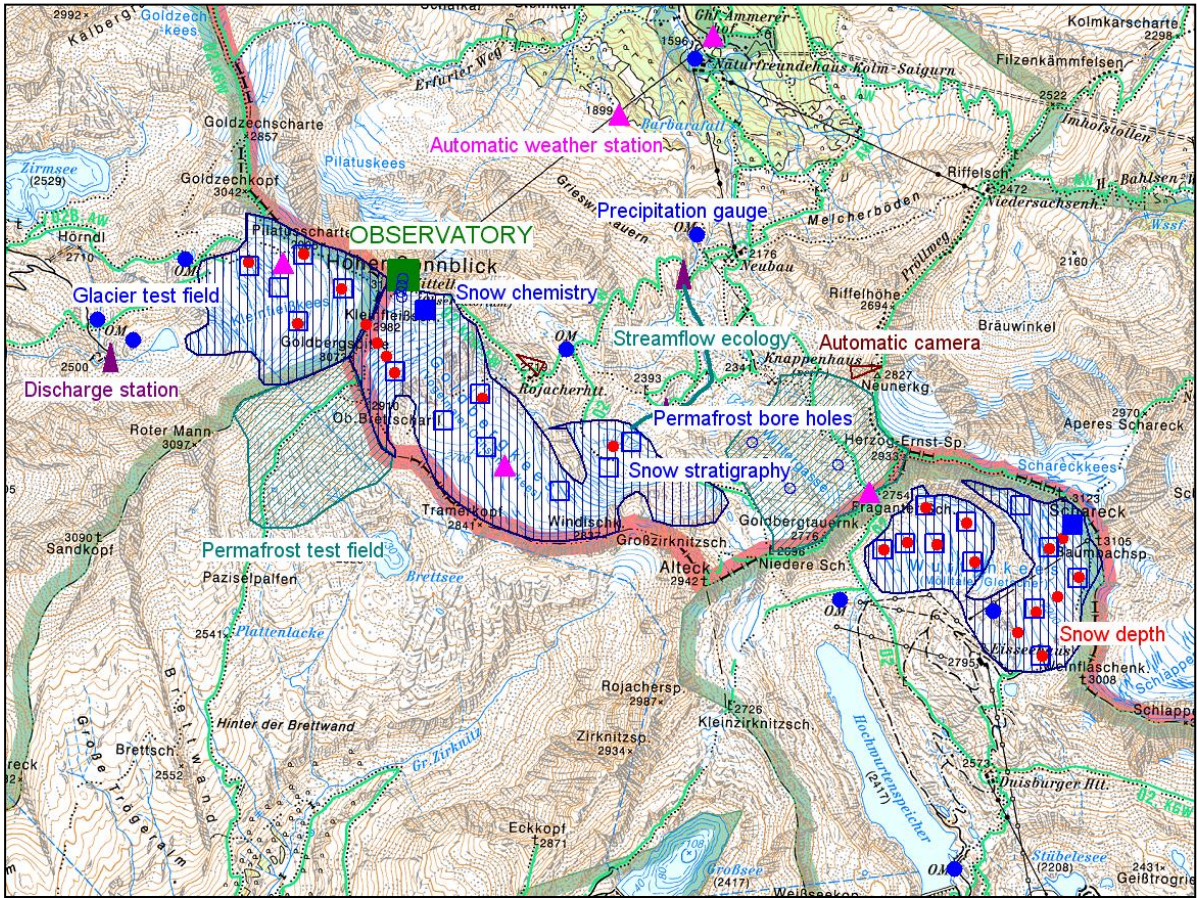


Figure 6: Map showing the Sonnblick Observatory and the observational network around the Observatory. All symbols are explained in the map