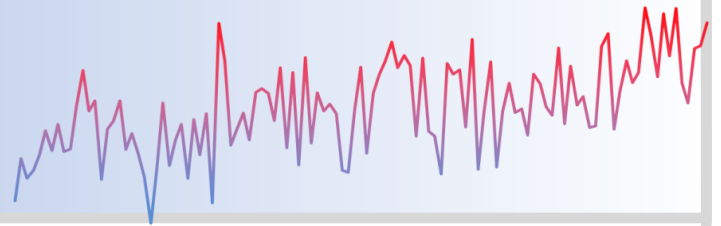


ENVironmental Research and Monitoring SONNBLICK Programme 2021-2025

ENVISON-2025



Sonnblick Advisory Board “Sonnblick Beirat”
Central Institute of Meteorology and Geodynamics



Vienna, March 2021

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PREAMBLE:

ENVISON-2025 describes the science focus of the Sonnblick Observatory for the period 2021-2025. By exploiting the strengths and scientific uniqueness of Sonnblick, the concept paper was formulated in the light of key questions of research by the Sonnblick-Advisory Board¹ through consultation with national and international experts.

ENVISON-2025 is neither a financed program, nor does it exclude other research topics at the SBO. However, it outlines the general research priorities in the frame of international research activities and monitoring programs and is integrated in the strategic plan of the Zentralanstalt für Meteorologie und Geodynamik (ZAMG). Though ENVISON-2025 is not a funding program by itself, it is based on the synergy of running and already funded monitoring programs and research projects as well as considering future activities and research priorities of Austrian funding agencies.

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¹ the advisory board for the development and the coordination of research of the Sonnblick Observatory

FROM THE HOUSE ABOVE THE CLOUDS TO A UNIQUE RESEARCH PLATFORM:

The **Sonnblick Observatory** was established in 1886 by the Austrian climatologist Julius Hann (substantially supported by the owner of the nearby goldmine Ignaz Rojacher) motivated from the need for upper-air measurements in meteorology. Among a larger number of mountain observatories established that time, the Sonnblick Observatory is the only station located in a high-altitude 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 Mt. Hoher 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. Since years, the Sonnblick Observatory is part of monitoring programs of the WMO, like GCW (Global Cryosphere Watch Program, GAW (Global Atmosphere Watch Program), BSRN (Baseline

Surface Radiation Network), etc. With 2017 the Sonnblick Observatory supports the upcoming European research infrastructure LTER (Long-Term Ecosystem Research Network).

With 2018 Austria and the Sonnblick Observatory became part of the process to establish the European Research Infrastructure ACTRIS (Aerosol, Cloud, Trace Gas) and a full member of the ACTRIS Interim Council.

Alpine wide studies on atmospheric chemistry and atmospheric physics already initiated resulted in the acceptance of the site as a future European Center for Cloud in situ intercomparison (ECCINT).

The Sonnblick Observatory is a research infrastructure which can be used by scientist. A series of investments strongly improved the access for scientist to the site. This enabled the participation in EU projects with access funding.

The climate and environmental monitoring and the number of related research projects grew significantly since the late 1990s and shows the internationally outstanding position of the Sonnblick Observatory and its surroundings in the fields of climatology, atmospheric research and glaciology. The activities are annually regularly reported within the brochure 'Scientific Activities at the Sonnblick Observatory' available via sonnblick.net.

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 to the present day, which allow to investigate and understand climate change in the Alpine region from the pre-industrial period to the time of significant human influence
- the unique location of the atmospheric monitoring platform at 3100 m at the summit of Mt. Hoher Sonnblick without any local pollution sources in the surrounding area and thus optimal background conditions, at the same time with easy access to the surrounding high alpine landscape (including glaciers and permafrost sites)

- the highly interlinked monitoring and research programme covering the atmosphere, the hydrosphere, the lithosphere and partly the biosphere including the easy access to all environments – which allows not only to study temporal trends but also exchange and cycling processes in the environment
- the high experimental potential (physical, remote and virtual access is possible) offered by the Sonnblick team, e.g. the onsite technical staff enabling

permanently supervised measurements or sampling campaigns

- the status as key climate monitoring station in Austria

Figure 1 combines two photographs to highlight the unique location of the Sonnblick Observatory, while Figure 2 highlights the position of the Observatory at the interface of atmosphere, cryosphere and biosphere.

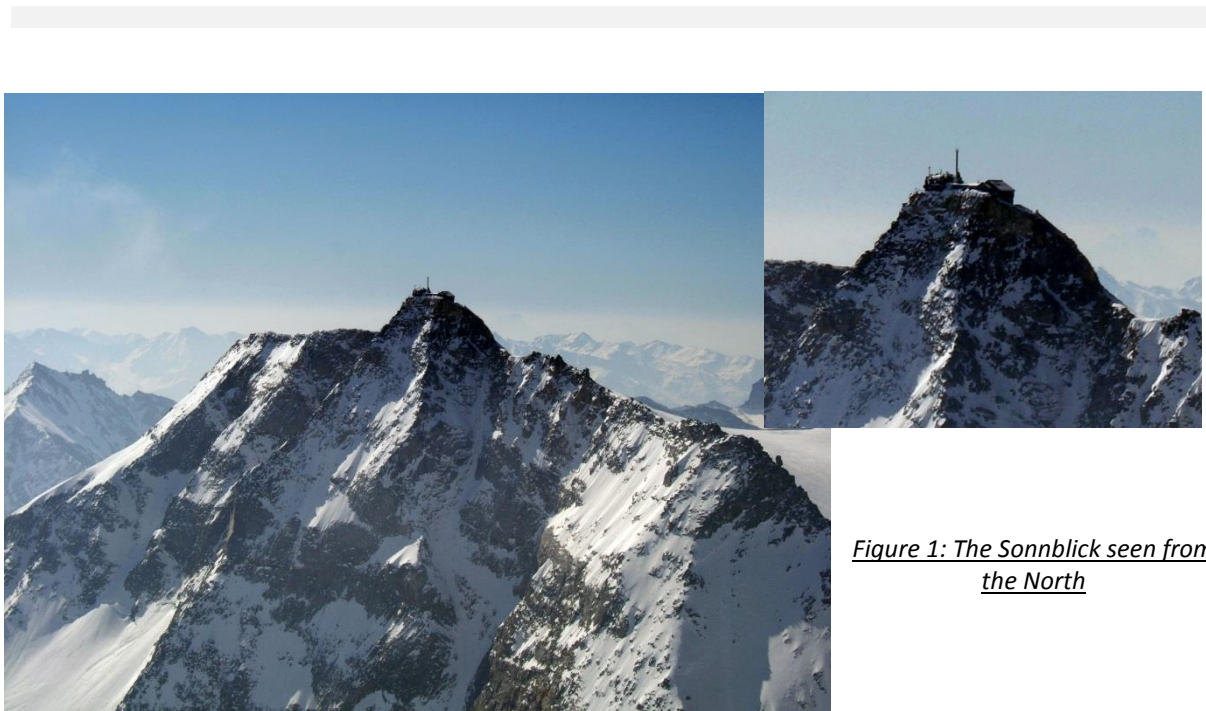


Figure 1: The Sonnblick seen from the North

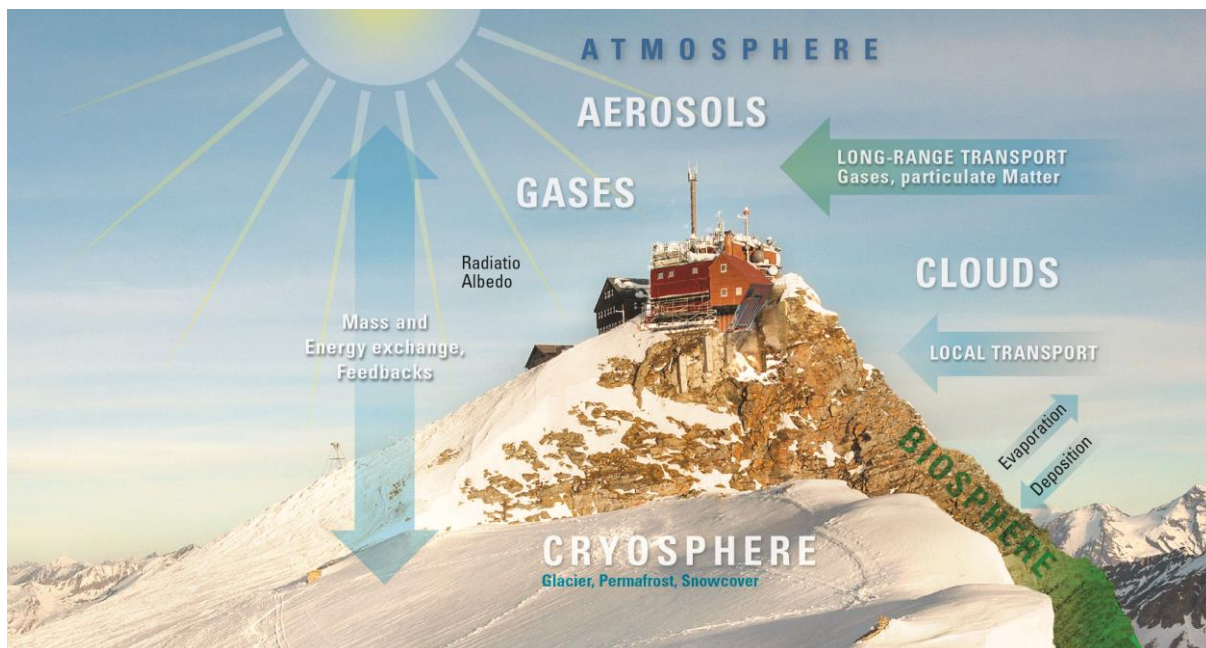


Figure 2: The Sonnblick Observatory at the virtual interface between the atmosphere, the cryosphere and the biosphere

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) as well as of climate impacts on high mountain environment in the Alps.

2) Innovative environmental monitoring with the aim to establish high quality time series on changes of trace compounds in the environment, to distinguish **anthropogenic and natural influence** on concentration levels

(as well as on processes and biogeochemical cycles) with special focus on the atmosphere, the cryosphere and the biosphere.

3) Observation and understanding of **outstanding events** (e.g. long-range transport of air constituents, volcanic activity, active layer thickness, extreme glacier melt) as well as of their impact on humans and the environment.

STRATEGIC CONCEPT OF ENVISON:

Monitoring and research are closely linked and interdependent. Monitoring programs are often initiated by research projects, and research conducted during intensive field campaigns needs to be embedded in longer data series of baseline variables. It is well known in science, that statements on significant changes depend on sufficiently long and homogeneous monitoring time series. ENVISON does not address monitoring and research separately, but intends to combine these activities. Accordingly, it focuses on the major sub-spheres of the Earth (atmosphere, cryosphere and biosphere) which surround the Observatory.

Three sub-programmes are realized as part of ENVISON: ATMON (monitoring of the atmosphere), CRYMON (monitoring of the cryosphere) and BIMON (monitoring of the biosphere).

Each sub-program is guided by an internationally recognised expert. Presently (ENVISON-2025, for 2021-2025) these 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 in Figure 4.

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

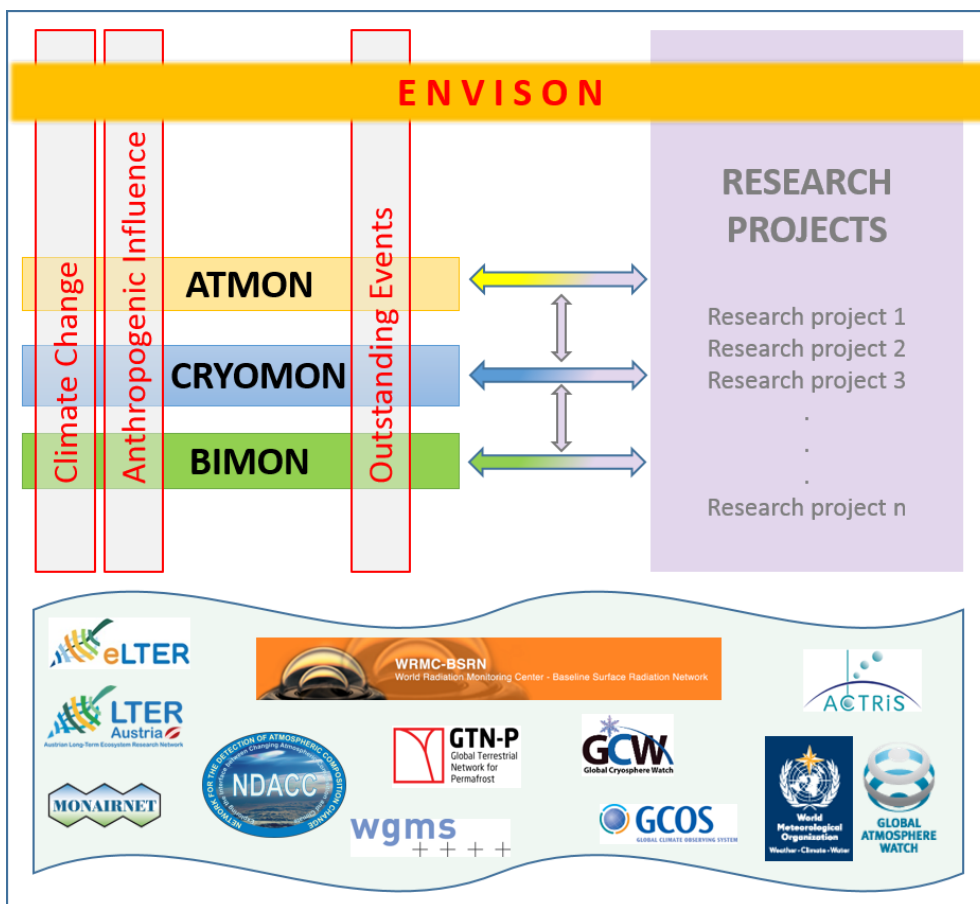


Figure 3: The ENVISON concept

ATMON:

The monitoring includes meteorological variables as well as trace gases, particulate matter and radiation using in-situ and remote sensing techniques. The detached location of the site at 3.106 m a.s.l., clear of any obstacles, provides a unique platform for the observation of the remote background troposphere for both, long-term monitoring and short-term field experiments. Continuous measurements of a wide range of parameters, e.g. defined by the requirements of Global Atmosphere Watch (GAW) create an excellent environment for novel research projects including the development of new methods, short- and long-term observational programs, e.g. related to the investigation of emerging atmospheric pollutants, bioaerosols, microplastic, increased impact of fires, and aerosol-cloud-climate interactions. The continuous monitoring allows to interpret changes over time, to understand the results of short-term ground- and airborne campaigns in the context of long-term observations, to evaluate established and new satellite data products, and provides important boundary conditions for the improvement of modelling capabilities.

Networks involved: NDACC, BSRN, GAW, ACTRIS

CRYMON:

The main objective of CRYMON is to contribute to the monitoring of the state of the cryosphere and related spatial and temporal changes in the Alps. The complexity of climate related changes of the cryosphere requires to establish strong linkages to ATMON and BIMON. CRYMON includes the monitoring of glaciers, perennial snow and permafrost. To cover all these aspects of the monitoring, spatially distributed observations at glaciers, permafrost sites and the snow cover were established. The spatial extent of the cryosphere and the related variability of atmospheric conditions require meteorological observations not only at the summit of Sonnblick but also in the surrounding area. 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).

Networks involved: WGMS, GCW, GTN-P

BIMON:

BIMON establishes a regular monitoring of changes in vegetation, stream-flow ecology and the cryobiota in high altitude ecosystems. Glacial ecosystems are tightly linked to atmospheric properties and are highly sensitive sentinels for climate change. By observing biological activity and diversity, it will be possible to gain 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. BIMON offers most valuable data sets for the network LTER in terms of biodiversity and biogeochemistry of aquatic and terrestrial ecosystems.

Networks involved: LTER, Biodiversity

INFRASTRUCTURE AND SERVICE FOR RESEARCH:

The Sonnblick Observatory offers a state-of-the-art research platform in 3.106 m altitude including infrastructure and personnel support. Physical, remote and virtual access is provided. The access is easy and safe via a 10 minutes cable-car ride starting in Kolm Saigurn, close to the village Rauris. The station is electrically operated and thus almost emission-free. A (collective) fiber network at the site, access to and from the internet via VPN (broad band link 60MBit/s, fail-safe) 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 www.sonnblick.net data can be visualised. Data access and information is provided via the SBO Data Portal (<https://data.sonnblick.net/>) which allows the presentation of all retrieved data on the site. Considering the growing interest of the scientific community and especially research groups being active at the Sonnblick Observatory 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-2025.

The Sonnblick Observatory has started to 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.

Technicians are available 24/7 at the station who can assist to projects. Special advice on weather conditions for field experiments are provided from the ZAMG regional office at Salzburg.

Accommodation for longer field experiments is available from the adjacent mountain hut "Zittelhaus". Several mountain huts around Mt. Hoher Sonnblick offer accommodation for field trips covering the area between the base station Kolm Saigurn and the top of Mt. Hoher Sonnblick.

The Sonnblick Observatory is partner in several access projects funded by the European Union. Such access projects support scientist's travel to, the access and the stay at the Sonnblick Observatory.

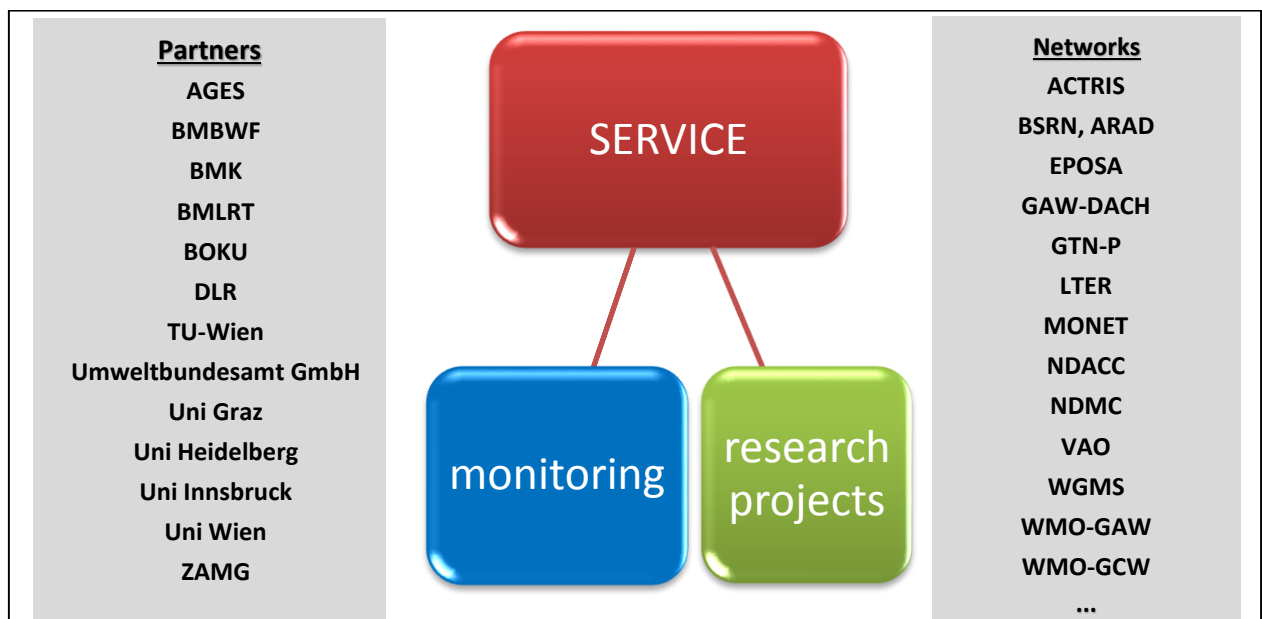


Figure 4: ENVISON in the frame of international networks and partners

ENVISON FOCUS FOR 2021-2025:

ENVISON-3 will focus on two major research tasks:

FOCUS 1: Climate and environmental research, focusing on clouds, aerosols, gases and their interaction

Aerosol-cloud interactions still pose the largest uncertainty in the current understanding of climate change (e.g. IPCC). Key elements to answer open questions in aerosol and cloud research are the vertical and horizontal aerosol and cloud distribution, chemical aerosol properties, and microphysical and optical aerosol and cloud properties as well as cloud phase, liquid water content, and meteorological parameters like temperature, relative humidity, and vertical wind speed.

The way forward combines synergistic measurements on different scales (ground-based long-term monitoring, time-restricted aircraft experiments, large-scale satellite observations, and modelling) and different measurement methods, each with its individual strengths and limitations. However, extensive measuring programs going beyond the routine monitoring are rare, and the number of stations observing both, aerosol and cloud properties, are surprisingly scarce. This poses a serious barrier for understanding the climate interaction of clouds and aerosols.

The European Strategy Forum on Research Infrastructures (ESFRI) has reacted to the need mentioned above and is closing the gap through the European research infrastructure ACTRIS (Aerosol, Clouds and Trace gases Research Infrastructure). ACTRIS is a pan-European infrastructure involving ground-based stations, instrument calibration centres and a data centre for high-quality observations of aerosols, clouds, trace gases and their interactions.

Within ACTRIS, the Sonnblick Observatory is going to play an important role. Besides measurements of critical aerosol and cloud parameters, the European Centre for Cloud

Intercomparison (ECCINT) will be established at the Sonnblick Observatory. ECCINT is expected to attract many users within and beyond ACTRIS for calibration workshops and measurement campaigns.

FOCUS 2: Climate and environmental change in the high mountains

The Sonnblick Observatory is located in the high-mountains, within the „Nationalpark Hohe Tauern“. The environment around the station is visibly impacted and changed by climate change. This is observed by the extensive climate and environmental monitoring (e.g. of the cryosphere, the stream ecology, ...) the SBO and around (valleys of Rauris und Heiligenblut)

Natural ecosystems offer a wide range of services that are useful or even indispensable for human beings. Biodiversity not only shapes the character of ecosystems, it is also crucial for the provision of many of these services. The aim of biodiversity and nature conservation research is to gain insights into the complex and multifaceted interrelationships between biological diversity, ecosystem functions and ecosystem services. The investigation of terrestrial and aquatic systems is a major concern, like the glaciers, snowfield and permafrost areas around the Sonnblick Observatory or connected streams and lakes. The focus is intended to support research activities supporting Long Term Ecological Research LTER. The retreat of glaciers, the emerging effect of bioalbedo, the shift of vegetation borders to higher altitudes, stress induced resettlement of species are a few examples of ecosystem changes that can be seen at Mt. Hoher Sonnblick and potential subject for further studies. The areas of retreating glaciers (glacier forefields) of mountain regions are particular dynamic (eco)systems and areas of interest in mountain research.

NATIONAL AND INTERNATIONAL INVOLVEMENT OF ENVISON:

Table 1: Already established participation in networks – a selection:

Abbreviation	Name	Link
ACTRIS	Aerosols, Clouds, and Trace gases Research Infra Structure	https://www.actris.eu/
ARAD	Strahlungsmonitoring & Strahlungsmessnetz Österreich	https://www.zamg.ac.at/cms/de/forschung/klima/daten/arsaetze/arad
BSRN	Baseline Surface Radiation Network	https://bsrn.awi.de/products/quality-code/comparisons/sonnblick-son/
Copernicus	Monitoring atmospheric composition and climate	https://www.copernicus.eu/en/monitoring-atmospheric-composition-and-climate
GTN-P	Global Terrestrial Network for Permafrost	www.gtnp.org http://gtnpdatabase.org/boreholes
LAWI SBO	Lawinenmessstation Sonnblick Observatorium	http://www.lawine.salzburg.at
LTER	European Long-Term Ecosystem Research Network	www.lter-europe.net https://deims.org/b2015216-ac0a-433f-8044-8ba8c46cc6c9
MONET MonAirNet	Monitoring Network of persistent organic compounds	https://www.monairnet.eu/index-de.php?pg=uber-das-projekt
NDACC	Network for the Detection of Atmospheric Climate	http://www.ndaccdemo.org/stations/hoher-sonnblick-austria
NDMC	Network for the Detection of Mesospheric Change	https://ndmc.dlr.de/ndmc/operational-data-products/sonnblick-observatorium
GTS, TAWES	Global telecommunication system, Teilautomatische Wetterstation	https://public.wmo.int/en/programmes/global-telecommunication-system https://www.zamg.ac.at/cms/de/klima/messnetze/wetterstationen
WGMS	World Glacier Monitoring Service	www.wgms.ch https://wgms.ch/products_ref_glaciers/
WMO-GAW	Global Atmosphere Watch	https://gawsis.meteoswiss.ch/GAWSIS/#/search/station/stationReportDetails/0-20000-0-11343 https://public.wmo.int/en/programmes/global-atmosphere-watch-programme
WMO-GCW	Global Cryosphere Watch	http://globalcryospherewatch.org/cryonet/sitepage.php?surveyid=13

- To be continued and established participation in networks in the period 2021-2025:TEAM-X (<http://www.teamx-programme.org/observations/>)
- Access projects, like the transnational access projects (TNA) of the European Union, for example INTERACT, the International Network for Terrestrial Research and Monitoring in the Arctic and adjacent forests and alpine regions (<https://eu-interact.org/field-sites/sonnblick-observatory/>).

Moreover, ENVISON-2025 co-operates 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. ENVISON-2025 emphasizes the relevance of data submission to the respective networks.

FINANCIAL MEANS FOR ESTABLISHING ENVISON:

a) Agreement GAW-DACH

The majority of measurements of the ENVISON monitoring are funded by the national GAW-DACH agreement. The agreement is supported by the BMK², the BMWFW³, the province of Salzburg, the province of Carinthia and the Austrian Environmental Agency (Umweltbundesamt).

b) Memorandum of Understanding ACTRIS

The ACTRIS (Aerosols, Clouds, Trace gases) activities at the Sonnblick Observatory, the National Facilities for aerosol and cloud in situ and the operation of the planned European Centre for Cloud Intercomparison is financed by ZAMG following an MoU which was delivered to the BMBWF in 2019.

The membership fee for the European research infrastructure ACTRIS is planned to be supported by the BMBWF (in negotiation).

c) Monitoring and research programmes at BMK

The cryosphere monitoring is performed with funding from BMK², including the projects GCW-Glacier and GCW-Permafrost.

The long-term investigations of spectral UV radiation and total ozone are currently supported by the project "Long-Term Measurements of Total Ozone and High-Resolution Spectral UV Radiation at Hoher Sonnblick and Groß-Enzersdorf 2019-2029", which builds on a longer series of research projects.

d) BMBWF via ZAMG:

The operation of the Sonnblick Observatory is a mandatory function of ZAMG. Since 2012 a series of ZAMG internal projects significantly contributes to ENVISON. The project ASBO (Active Sonnblick Observatory) supports activities in the frame of national and international monitoring programmes and networks in which the observatory is involved ASBO contributes to BSRN, ARAD, GAW, GCW, ACTRIS (see Table 1).

e) national and international research funds

Researchers are encouraged to initiate research projects within national and international research funds for specific questions apart from monitoring activities (e.g. FFG, FWF, ÖAW, EU, or international cooperation)

f) national and international access funds

Researchers being interested in conduction research at the Sonnblick Observatory are encouraged to apply for funds via the access projects in which the observatory is involved in. Such funding is mainly provided by the European Union and supports transnational, remote and virtual access to the Sonnblick Observatory.

g) PhD School ISAR-SBO

The BMBWF and ZAMG agreed to carry out a doctoral school around the Sonnblick Observatory financing PhD students having a Sonnblick related research topic. That PhD school called "International School for Alpine Research at Sonnblick Observatory (ISAR-SBO)" is in development. ISAR-SBO will support research including the ENVISON foci.

² Federal Ministry of the Republic Austria for Climate Action, Environment, Energy, Mobility, Innovation and Technology

³ Federal Ministry of the Republic Austria for Education, Science and Research

STATUS OF MONITORING ACTIVITIES AND RESEARCH PROJECTS AT THE SONNBlick OBESRVATORY IN 2020:

The status of monitoring and research activities are yearly summarized within the Sonnblick brochure “Sonnblick Observatory -Scientific Activities” which can be downloaded via the Sonnblick webpage (<https://www.sonnblick.net/de/daten/download-portal/reports/>). Everyone conducting research and monitoring at the Sonnblick Observatory has to contribute to the brochure. Research activities comprises the meteorology, the upper atmosphere, radiation, deposition, air chemistry, aerosols and bio aerosols, clouds, glaciology, permafrost, seismology, biology, natural hazards and projects outside the ENVISON frame.

The Sonnblick Observatory provides a data portal which allows a good overview of measures and parameters taken at Mt. Hoher Sonnblick and its surrounding. The data portal can be visit via the Sonnblick website <https://www.sonnblick.net/en/data/download-portal/sbo-data-portal/> or directly using <https://data.sonnblick.net/>.

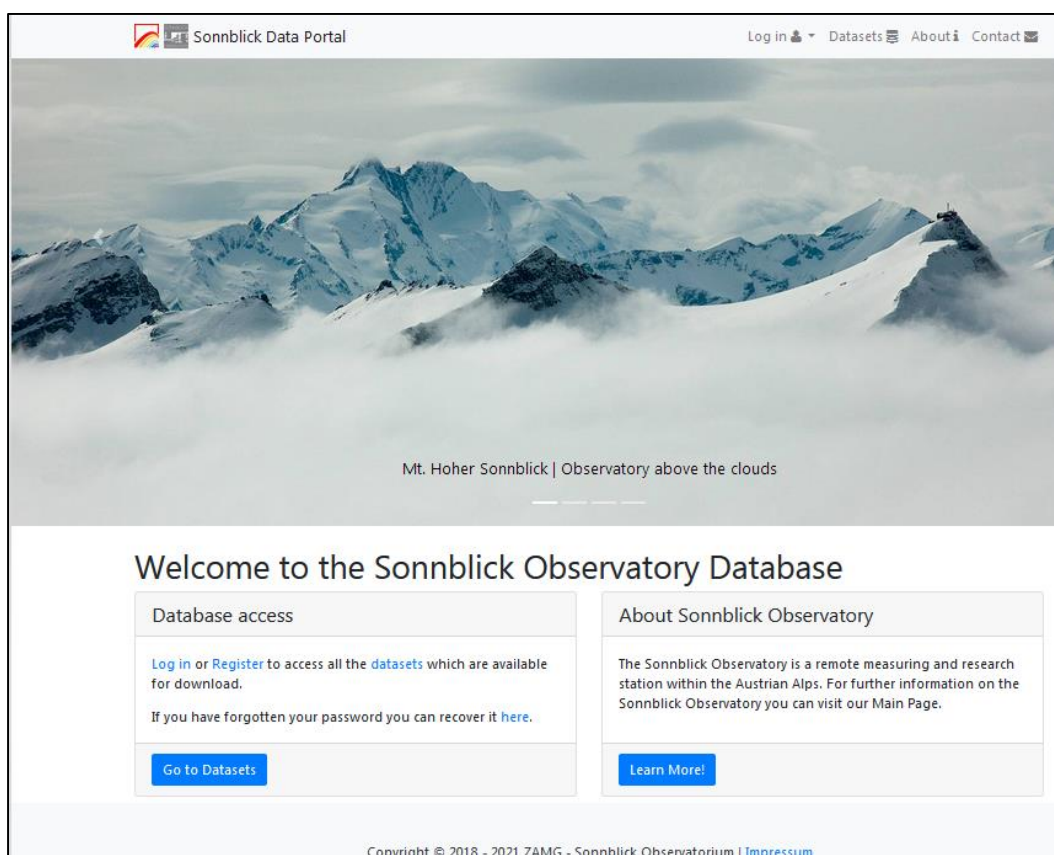


Figure 5: Front page of Sonnblick Observatory’s data portal