



**GCOS**

Global Climate Observing System  
**Austrian Inventory Report**  
2020

---

### **Editor and publisher**

Zentralanstalt für Meteorologie und Geodynamik  
Hohe Warte 38, 1190 Vienna, Austria

[www.zamg.ac.at](http://www.zamg.ac.at)

First edition: December 2017

Update: December 2020

### **Editorial team**

Silke Adler, GCOS Coordinator, ZAMG  
Hermine Fürst, ZAMG

**[www.gcos.at](http://www.gcos.at)**

### **Picture credits**

<http://www.meteopics.eu/>

Heidi Schützinger, Daniel Loretto, Maximilian Ziegler (Cover)  
Peter Lichtenauer (Wagrain-Tappenkarsee, P. 3)

# Contents

---

Introduction.....	12
Contributing Institutes .....	14
<b>Atmospheric Observations – Surface .....</b>	<b>23</b>
Climate Monitoring ZAMG .....	24
VAMES .....	27
Aerodrome Met stations in Austria .....	30
Sunshine duration - Measurements Austria .....	33
UV Radiation.....	35
Solar and terrestrial radiation monitoring networks (TAWES, ARAD) .....	38
BSRN - Baseline Surface Radiation Network .....	40
HISTALP - Homogenized monthly long-term climate dataset.....	43
<b>Atmospheric Observations – Upper Air .....</b>	<b>46</b>
Radiosonde ZAMG .....	47
Radiosonde AUSTRO CONTROL.....	49
Austrian Weather Radar Network .....	51
<b>Atmospheric Observations - Composition .....</b>	<b>54</b>
Stratospheric Ozone.....	55
Air quality monitoring network.....	58
Air quality monitoring of the federal states of Austria .....	61
Sonnblick Observatory - High-altitude research station .....	79
<b>Terrestrial Observations – Hydrosphere .....</b>	<b>83</b>
Hydrological Service of Austria (eHYD) .....	84
Tuxer Alps .....	86
Torrent Research Areas – Monitoring data .....	87
ISMN - In situ soil moisture observations.....	89
ASCAT surface soil moisture data records.....	91
<b>Terrestrial Observations – Cryosphere .....</b>	<b>94</b>
SNOW .....	95
Glaciers.....	100
Permafrost.....	105
ARGE LWD Austrian snow station network .....	111

<b>Terrestrial Observations – Biosphere .....</b>	<b>114</b>
National Forest Inventory of Austria .....	115
Monitoring hydrological data of forest ecosystems .....	116
Phenology ZAMG .....	118
<b>Long term data sustainability .....</b>	<b>122</b>
<b>Annex .....</b>	<b>123</b>

Parameter	Atmospheric Observation – Surface	Atmospheric Observation – Upper Air	Atmospheric Observation - Composition	Terrestrial Observations – Hydrosphere	Terrestrial Observations - Cryosphere	Terrestrial Observations - Biosphere
Aerosols			<a href="#">Sonnblick Observatory - High altitude research station</a> <a href="#">Air quality monitoring network</a>			
Air Glow via GRIPS 16 Mesopause			<a href="#">Sonnblick Observatory - High altitude research station</a>			
Air Temperature	<a href="#">Climate Monitoring ZAMG</a> <a href="#">VAMES</a> <a href="#">Aerodrome Met stations in Austria</a> <a href="#">HISTALP</a>	<a href="#">Radiosonde ZAMG</a> <a href="#">Radiosonde AUSTRO CONTROL</a>	<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a> <a href="#">ISMN</a>	<a href="#">ARGE LWD</a>	<a href="#">Monitoring hydrological data of forest ecosystems</a>
Clouds	<a href="#">Climate Monitoring ZAMG</a> <a href="#">VAMES</a> <a href="#">Aerodrome Met stations in Austria</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>			
Development of Plants						<a href="#">Phenology ZAMG</a>
Dew Point	<a href="#">VAMES</a> <a href="#">Aerodrome Met stations in Austria</a>	<a href="#">Radiosonde ZAMG</a> <a href="#">Radiosonde AUSTRO CONTROL</a>	<a href="#">Sonnblick Observatory - High altitude research station</a>			
Diffuse Radiation	<a href="#">Solar and terrestrial radiation monitoring networks (TAWES, ARAD)</a> <a href="#">BSRN – Baseline Surface Radiation Network</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>			
Direct Solar Radiation	<a href="#">Solar and terrestrial radiation monitoring networks (TAWES, ARAD)</a> <a href="#">BSRN – Baseline Surface Radiation Network</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>			
Electrical Field Strength			<a href="#">Sonnblick Observatory - High altitude research station</a>			

Parameter	Atmospheric Observation – Surface	Atmospheric Observation – Upper Air	Atmospheric Observation - Composition	Terrestrial Observations – Hydrosphere	Terrestrial Observations - Cryosphere	Terrestrial Observations - Biosphere
Fractional Snow Cover Extent					<a href="#">SNOW</a>	
Glacier - Calving Fronts					<a href="#">Glaciers</a>	
Glacier - Ice Surface Velocity					<a href="#">Glaciers</a>	
Glacier Facies					<a href="#">Glaciers</a>	
Glacier Lengths					<a href="#">Glaciers</a>	
Glacier Mass Balance			<a href="#">Sonnblick Observatory - High altitude research station</a>		<a href="#">Glaciers</a>	
Glacier Outlines/Extent					<a href="#">Glaciers</a>	
Global Radiation	<a href="#">Climate Monitoring ZAMG</a> <a href="#">Solar and terrestrial radiation monitoring networks (TAWES, ARAD)</a> <a href="#">BSRN – Baseline Surface Radiation Network</a>		<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>	<a href="#">ARGE LWD</a>	<a href="#">Monitoring hydrological data of forest ecosystems</a>
Ground Temperature			<a href="#">Sonnblick Observatory - High altitude research station</a>		<a href="#">Permafrost</a>	
Grounding Lines					<a href="#">Glaciers</a>	
Groundwater Level				<a href="#">Hydrological Service of Austria (eHYD)</a> <a href="#">Torrent Research Areas</a>		
Groundwater Temperature				<a href="#">Hydrological Service of Austria (eHYD)</a> <a href="#">Torrent Research Areas</a>		
Heavy Metals			<a href="#">Air quality monitoring network</a>			
Humidity	<a href="#">Climate Monitoring ZAMG</a>		<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>	<a href="#">ARGE LWD</a>	<a href="#">Monitoring hydrological data of forest ecosystems</a>

Parameter	Atmospheric Observation – Surface	Atmospheric Observation – Upper Air	Atmospheric Observation - Composition	Terrestrial Observations – Hydrosphere	Terrestrial Observations - Cryosphere	Terrestrial Observations - Biosphere
Light Pollution			<a href="#">Air quality monitoring network</a>			
Precipitation	<a href="#">Climate Monitoring ZAMG HISTALP</a>		<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Hydrological Service of Austria (eHYD)</a> <a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a> <a href="#">ISMN</a>	<a href="#">ARGE LWD</a>	<a href="#">Monitoring hydrological data of forest ecosystems</a>
Precipitation Chemistry			<a href="#">Sonnblick Observatory - High altitude research station</a>			
Present Weather	<a href="#">Climate Monitoring ZAMG VAMES</a> <a href="#">Aerodrome Met stations in Austria</a>					
Pressure	<a href="#">Climate Monitoring ZAMG HISTALP</a>	<a href="#">Radiosonde ZAMG</a>	<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>			
Radiation Longwave	<a href="#">Solar and terrestrial radiation monitoring networks (TAWES, ARAD)</a> <a href="#">BSRN – Baseline Surface Radiation Network</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Tuxer Alps</a>		
Radiation Shortwave	<a href="#">BSRN – Baseline Surface Radiation Network</a>			<a href="#">Tuxer Alps</a>		
Radioactivity			<a href="#">Sonnblick Observatory - High altitude research station</a>			
River Discharge				<a href="#">Hydrological Service of Austria (eHYD)</a> <a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>		
Runway Visual Range	<a href="#">VAMES</a>					

Parameter	Atmospheric Observation – Surface	Atmospheric Observation – Upper Air	Atmospheric Observation - Composition	Terrestrial Observations – Hydrosphere	Terrestrial Observations - Cryosphere	Terrestrial Observations - Biosphere
Snow Chemistry			<a href="#">Sonnblick Observatory - High altitude research station</a>			
Snow Depth	<a href="#">Climate Monitoring ZAMG</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Hydrological Service of Austria (eHYD)</a> <a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>	<a href="#">SNOW</a> <a href="#">ARGE LWD</a>	
Snow Ice Content					<a href="#">ARGE LWD</a>	
Snow Liquid Water Content					<a href="#">ARGE LWD</a>	
Snow Surface Temperature				<a href="#">Tuxer Alps</a>	<a href="#">ARGE LWD</a>	
Snow Temperature				<a href="#">Tuxer Alps</a>	<a href="#">SNOW</a> <a href="#">ARGE LWD</a>	
Snow Water Equivalent				<a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>	<a href="#">SNOW</a> <a href="#">ARGE LWD</a>	
Soil Moisture				<a href="#">ISMN</a> <a href="#">ASCAT</a>		<a href="#">Monitoring hydrological data of forest ecosystems</a>
Soil Properties				<a href="#">ISMN</a>		
Soil Temperature				<a href="#">Tuxer Alps</a> <a href="#">ISMN</a>		<a href="#">Monitoring hydrological data of forest ecosystems</a>
Spectral UV Irradiance	<a href="#">UV Radiation</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>			
Sunshine Duration	<a href="#">Climate Monitoring ZAMG</a> <a href="#">Sunshine duration – Measurements Austria</a> <a href="#">HISTALP</a>		<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>			
Surface Radiation Budget			<a href="#">Air quality monitoring network</a>			
Total Column Ozone			<a href="#">Stratospheric Ozone</a>			



Parameter	Atmospheric Observation – Surface	Atmospheric Observation – Upper Air	Atmospheric Observation - Composition	Terrestrial Observations – Hydrosphere	Terrestrial Observations - Cryosphere	Terrestrial Observations - Biosphere
			<a href="#">Sonnblick Observatory - High altitude research station</a>			
Trace Gases, selected Reactive Gases			<a href="#">Sonnblick Observatory - High altitude research station</a> <a href="#">Air quality monitoring network</a>			
Tree- specific Parameters (e.g. Tree Species, forest structure, Tree Diameter and height)						<a href="#">National Forest Inventory of Austria</a>
UV-B			<a href="#">Sonnblick Observatory - High altitude research station</a>			
Vertical Ozone Profiles			<a href="#">Stratospheric Ozone</a>			
Visibility	<a href="#">Climate Monitoring ZAMG</a> <a href="#">VAMES</a>		<a href="#">Sonnblick Observatory - High altitude research station</a>			
Water Level				<a href="#">Hydrological Service of Austria (eHYD)</a>		
Wind Direction	<a href="#">Climate Monitoring ZAMG</a> <a href="#">VAMES</a> <a href="#">Aerodrome Met stations in Austria</a>	<a href="#">Radiosonde ZAMG</a> <a href="#">Radiosonde AUSTRO CONTROL</a>	<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>	<a href="#">ARGE LWD</a>	<a href="#">Monitoring hydrological data of forest ecosystems</a>
Wind Speed	<a href="#">Climate Monitoring ZAMG</a> <a href="#">VAMES</a> <a href="#">Aerodrome Met stations in Austria</a>	<a href="#">Radiosonde ZAMG</a> <a href="#">Radiosonde AUSTRO CONTROL</a>	<a href="#">Air quality monitoring network</a> <a href="#">Sonnblick Observatory - High altitude research station</a>	<a href="#">Tuxer Alps</a> <a href="#">Torrent Research Areas</a>	<a href="#">ARGE LWD</a>	<a href="#">Monitoring hydrological data of forest ecosystems</a>

# Foreword

---

## Local Observations for Global Understanding

The ultimate success of the Global Climate Observing System, GCOS, depends on effective coordination at the national level of the contributions of Member countries to the WMO Integrated Global Observing Systems (WIGOS), the IOC-led and co-sponsored Global Ocean Observing System (GOOS), the coordination of the various and very diverse terrestrial observing systems, and the many other in situ and space-based observing systems providing climate-related observation data.

The need for an effectively operating GCOS has recently assumed even greater importance with the Paris Agreement<sup>1</sup>, which was adopted by the 21st Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015 which addresses global efforts to limit climate change. Its central aim is to strengthen the global response to the threat of climate change by keeping the global temperature rise until the end of this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit it to 1.5 degrees Celsius. This is, however, not possible without a thorough and reliable systematic observations of the climate system.

The mechanism to address these observation needs is GCOS. Established in 1992 and co-sponsored by the World Meteorological Organization (WMO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU), GCOS promotes standardized, systematic and sustained climate observations in order to improve the understanding of our climate system and enhance climate services. One of GCOS most prominent tools to promote climate observations are the Essential Climate Variables (ECVs), a collection of currently 54 parameters that serve as a guideline for operators of climate observation systems.

GCOS guides climate observing systems through regular implementation plans. The recent plan was published in 2016<sup>2</sup> and responds to the needs identified in the GCOS status report from 2015<sup>3</sup> but also to the ambitious goals and expectations of the Paris Agreement. This 2016 plan includes many actions to improve the observing networks that will help to improve and adapt observations networks to the increasing needs of the climate community. In order to reach this goal, the 22nd COP in Marrakesh in 2016 invited “United Nations agencies and international organizations to support the full implementation of the [GCOS] implementation plan, as appropriate”.

This recognition and support by the United Nations and its members to address the big challenges laid out in the Paris agreement holds for all climate observing networks of which the GCOS consists.

The responsibility for GCOS implementation and operation at the national level in individual WMO, IOC, UNEP, and ICSU Member countries is thus usually distributed across many departments and agencies rather than being focused solely in a single agency, such as the National Meteorological Service (NMS). It is therefore useful, in order to ensure effective coordination across the GCOS contributing organizations at the national level and to maintain a coordinated overall channel of communication with the GCOS Secretariat in Geneva, that there be a jointly designated ‘GCOS National Coordinator’ in each country with responsibility for as many as possible of the following functions.

---

1 "Paris Agreement". United Nations Treaty Collection. 8 July 2016: [https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg\\_no=XXVII-7-d&chapter=27&clang=\\_en](https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en)

2 The Global Observing System for Climate: Implementation Needs. GCOS-200 (GOOS-214). Pub WMO, Geneva, 2016. [https://library.wmo.int/opac/index.php?lvl=notice\\_display&id=19838](https://library.wmo.int/opac/index.php?lvl=notice_display&id=19838).

3 The Global Observing System for Climate: Status of the Global Observing System for Climate. GCOS-195. Pub WMO, Geneva, 2015.

Many countries have appointed GCOS National Coordinators and National Committees that are able to cross-manage the observation requirements of the atmospheric, ocean and terrestrial domains. Many countries still need to establish such national coordination mechanisms.

I would like to thank Austria and the Zentralanstalt für Meteorologie und Geodynamik, ZAMG, for nominating in 2017 an Austrian GCOS Coordinator, Ms Silke Adler, whose efforts in facilitating climate observations will certainly serve as inspiration and motivation for all national experts in climate research and observation to prove that it will need “Local observations for Global Understanding” of our changing Earth`s climate.

Dr. Carolin Richter  
Director of the GCOS Secretariat,  
World Meteorological Organization

2017

## Foreword

---

Policy makers have to face changing climate conditions and their possible impact on various aspects of life. Long-term series of climate measurements are essential for our knowledge of the interactions between the climate, ecosystems and human activities. In Austria, we can count on long-standing meteorological data collections, the longest starting in 1767 at Kremsmünster, which builds the basis for research on climate change. Not only temporal, but also spatial continuity is the deciding factor for successful climate monitoring. Therefore supporting and promoting monitoring networks on an international level is a major task when dealing with climate change.

The Global Climate Observing System (GCOS) of the World Meteorological Organization (WMO) is such an effort. It was founded to identify and coordinate monitoring networks worldwide. It also supports countries in setting up monitoring networks especially when public funding is poor.

Although in Europe public funding of monitoring networks is relatively high, even in Austria important initiatives like glacier or permafrost monitoring are partly depending on third party funding. This creates not only financial uncertainties, but also possible discontinuations of valuable long time series.

This report is the result of the effort, taken on by Zentralanstalt für Meteorologie und Geodynamik (ZAMG) in its role as Austria's national GCOS coordinator, to provide an overview of various programs for collecting the main climate variables in Austria. The report may help to facilitate the access and interdisciplinary use of this data.

We want to thank all national partner institutions and organizations for their productive collaboration on the Austrian GCOS Report and the readers for their interest.

Dr. Michael Staudinger  
Director of the Central Institute for Meteorology and Geodynamics



## Introduction

---

Austria's landscape consists of high mountains and valleys in the west and lowlands in the eastern part of the country. While this composition may be perceived as quite idyllic, it poses a major challenge when measuring meteorological parameters and monitoring long term changes of the climate. For example, when observing meteorological parameters under the extreme conditions of an Alpine summit, one will be faced with higher demands to the instruments in use.

In Austria several institutions own observation networks designed for their specific needs. These networks build the fundamental basis to understand the impact of climate change.

Various aspects of the change need to be observed, covering rockslide due to melting permafrost as well as woods or plants facing infestation with vermin.

These changes and modifications in our environment make it increasingly important to document the changes and exchange experiences with other countries.

Global Climate Observing System (GCOS) is a Co-sponsored Program of the World Meteorological Organisation (WMO) for collecting and providing climate monitoring data records for improved management of the impacts and consequences of climate variability and current and future climate change. (<https://public.wmo.int/en/programmes/global-climate-observing-system>).

For a global climate monitoring system, national coordination is an essential factor. Therefore, in 2012 a national coordination GCOS office was set up in Austria (Austrian GCOS Secretariat) located at the national weather service, the Zentralanstalt für Meteorologie und Geodynamik (ZAMG). Periodic meetings have been established and attended by several institutions.

This Report is an overview of climate monitoring in Austria in collaboration with governmental institutes, universities and alpine organisations. The first part gives short introductions to the contributing institutes. The second part is structured into two climate monitoring domains, the atmospheric climate observing system and the terrestrial climate observing system. All institutions present their climate observation network and measurement methods. An information sheet summarizes where the data records can be found and lists the contact person appointed by the institution.

This document is a record of climate monitoring in Austria in accordance with the Implementation Plan of the WMO Global Climate Observing System (GCOS).

More information about the impact of climate change in Austria can be found in the Austrian Assessment Report 2014 - AAR14 which is based on the IPCC structure and process. In this extensive work, more than 200 scientists depict the state of knowledge on climate change in Austria and the impacts, mitigation and adaptation strategies, as well as the associated known political, economic and social issues. (<https://ccca.ac.at/wissenstransfer/apcc>)

# Contributing Institutes

---



<https://www.alpenverein.at/portal/index.php>

The monitoring of glacier length variations in Austria is traditionally organized and carried out by the Austrian Alpine Association (Österreichischer Alpenverein). This monitoring started as early as 1891 and is currently carried out at about 100 glaciers by research institutions or private persons who are responsible for defined mountain groups or regions. At a limited number of glaciers additional monitoring on surface velocities and height variations takes place. Data is collected by responsible persons appointed by the association (currently: A. Kellerer-Pirklbauer and Gerhard K. Lieb) and compiled to an annual report which is published in the association's journal "Bergauf" and in the internet. The association's special interest in glacier (and permafrost) variations is due to the fact that its network of marked trails in the Alps is prone to potentially hazardous processes triggered by these changes.



**ARGE LWD**

<http://www.lawinen.at/>

The ARGE LWD is an informal consortium linking all regional avalanche warning services in Austria. The ARGE LWD includes the avalanche warning services of the Provinces Vorarlberg, Tyrol, Salzburg, Carinthia, Styria, Upper and Lower Austria. Most avalanche warning services were founded in the mid-1960s and provide since the early days public avalanche forecasting or warning products and safety advisories. The most prominent product is the avalanche bulletin, which is issued on a daily basis during winter season by the regional avalanche forecasting centres for their Province. In order to provide high-quality avalanche danger assessments throughout the warning products, the various regional Avalanche Warning Services established and continuously maintain an intensive network of observers and automated measurements. In total, the consortium obtains snow measurements from 186 automated weather stations, which represents one of the densest snow and weather station networks in mountainous terrain worldwide. ARGE LWD's experts represent Austria in numerous international organizations and associations such as e.g. the EAWS Technical Advisory Board and ISSW Steering Committee.



<https://www.austrocontrol.at/>

The "AUSTRO CONTROL GMBH" was founded in 1994 as a privatized successor organization of the former "Bundesamt für Zivilluftfahrt" which had been founded in 1955. AUSTRO CONTROL is an air navigation service provider primarily responsible for Austria's air traffic control and therefore one part of it is the aviation meteorological department. AUSTRO CONTROL is an institution affiliated to the Federal Ministry of Traffic, Innovation and Technology (BMVIT). Until a new headquarter building is built in Schnirchgasse 11 the institution is temporary headquartered at Wagramer Straße 19 in Vienna and maintains air traffic control towers at Wien Schwechat, Linz, Salzburg, Innsbruck, Graz and



Klagenfurt and an air traffic control centre at Wien Schnirchgasse. The meteorological operational service is located at each of the towers and the MET department with about 10 employees is located in Wagramer Straße. About 50 employees in shift work provide aviation meteorological reports, forecasts and warnings. Beside the observations at the six Austrian international airports AUSTRO CONTROL operates in close cooperation with ZAMG the full automatic VAMES AUTOMETAR network with 50 stations. AUSTRO CONTROL's experts represent Austria in numerous international organizations at ICAO.



## Bundesforschungszentrum für Wald

<https://www.bfw.gv.at/>

The Austrian Research Centre for Forests (BFW) is a multidisciplinary research and training institution and holds the legal status of an institution under public law. The BFW supports the economic, ecological and socially sustainable development of the society and its environment through the preparation of scientific guidelines and the dissemination of knowledge concerning the multi-functional utilisation of natural resources. In pursuance of research, monitoring and knowledge transfer the BFW focuses its work on the strategic and thematic fields of forest management, forest and climate, bioenergy, biodiversity and natural hazards. The BFW is organized in six Research Departments, two Forest Training Centres, and several internal service units. Currently the BFW employs approximately 280 people of which about 120 are researchers. At the European level, the BFW and its Departments provide leadership in fields of forest inventory, harmonization and monitoring issues, forest growth modelling and soil carbon and nitrogen cycling and modelling with a special focus on soil ecology.



## University of Natural Resources and Life Sciences

<https://boku.ac.at/en/>

The University of Natural Resources and Life Sciences or BOKU, Vienna was founded in 1872. The first study programmes offered were Agricultural-, Forestry studies and Environmental Engineering. Today BOKU, sometimes called "Alma Mater Viridis", is a modern, international University of Life Sciences with 9 Bachelor and 25 Master programmes for more than 10,000 students. BOKU perceives itself as a teaching and research centre for renewable resources, which are necessary for human life. It is BOKU's objective to help make a considerable contribution to the conservation and protection of resources for future generations by providing diversity in its fields of study. Connecting natural sciences, engineering and economic sciences, we wish to increase knowledge of the ecologically and economically sustainable use of natural resources, to provide a harmoniously cultivated landscape. We at BOKU commit ourselves to international performance in research and teaching, cooperation on regional, national and international levels, and to receptiveness to new developments.



<http://www.enveo.at/>

ENVEO (Environmental Earth Observation) IT GmbH, Innsbruck, is an engineering company founded in 2001 with main business activities in the field of remote sensing research and services in climate monitoring, hydrology, meteorology, and cryospheric studies. The scope of activities and expertise comprises the development of techniques for remote sensing data analysis and satellite data



exploitation, including product generation and services for snow and glacier monitoring, hydrology and water management, polar research, and geo-hazard monitoring. From the beginning ENVEO has also contributed to the development of concepts and techniques for advanced satellite systems in environmental monitoring. Climate related products generated from satellite data within ESA and EC contracts, made available to the public, include time series of snow cover extent with global and regional coverage, regional maps of glacier area extent and surface velocity, and maps of ice motion covering the Greenland and Antarctic ice sheets.



---

<https://ehyd.gv.at/>

The Division 1/3 – Water Balance (Hydrographical Central Office) is part of the Federal Ministry of Agriculture, Regions and Tourism (BMLRT <http://www.bmlrt.gv.at>) and coordinates the work of the Hydrographical Services in the nine provincial governments. The Hydrographical Service in Austria operates a hydrometrical network for the quantification of the water cycle in Austria. The network consists of about 800 discharge, 900 precipitation and 3800 groundwater stations. Acquisition, processing and controlling of hydrological data is done consistently by the hydrological divisions in the nine provincial governments.

The results of the investigations on the water cycle are published currently in the Austrian Hydrographical Yearbook. This yearbook and hydrological data are available in the internet, published at <https://wasser.umweltbundesamt.at/hydjb> and <http://ehyd.gv.at>.



---

<https://www.oeaw.ac.at/>

The Institute for Interdisciplinary Mountain Research of the Austrian Academy of Sciences is investigating the effects of global change on mountain regions. Climate change and globalization in terms of the relations of humans with the environment in cultural landscapes, mountain cities and in protected mountain areas are the subject of disciplinary, but also inter- and transdisciplinary research. The disciplinary research in cryospheric sciences focusses on Alpine sites and on process studies which are often based on long time series and are aiming at developing and validating tools and methods for application to the world's mountain glaciers.



---

<https://www.burgenland.at/themen/umwelt/luftguete/>

The Air Quality Network of Burgenland is a part of the department for natural reserve at the government of Burgenland and is located in Eisenstadt. The main task is to measure air pollution in Burgenland. The Basis for these measurements is the Austrian law for ambient air quality „Immissionsschutzgesetz – Luft“ and the „Ozongesetz“. Therefore the main aim is the control of the permanent protection of human health, animal and plant life, reduction of immissions and preservation of best air quality. The Air Quality Network of Burgenland started in 1994 and only for measure ozone and nitrogen dioxide and meteorological data at two measuring points. Since then the

network was increased to three fixed stations and three mobile ones, which are now operated by 3 employees. Data are collected automatically throughout the day and year. The monitoring stations are located in urban agglomerations and also in rural regions. The collected data are freely available for both private and public institutions.

## LAND KÄRNTEN **Amt der Kärntner Landesregierung**

<https://www.ktn.gv.at/Themen-AZ/Uebersicht?thema=11>

Meteorological measurements within the Provincial Government of Carinthia (Amt der Kärntner Landesregierung) are performed by the Department 8 – Environment, Water and Nature Protection, headquartered in Klagenfurt am Wörthersee, Flatschacher Straße 70. With its more than 400 employees the department is responsible for the protection of soil, water and air in the province of Carinthia. The spectrum of the department is broadly diversified with the areas of waste management and environmental remediation, energy management and grants, water rights, water management, hydrography, lakes research, climate protection and adaptation, sustainability, air quality improvement, geology and soil protection, strategic environmental assessment, nature protection, environmental control, acoustic and electrical engineering, safety and process engineering, radiation protection, shipping and motor and air traffic. Through the use of synergies of all these areas the department is the main contact point for all matters relating to environment, water, nature and energy in Carinthia.



### **NUMBIS - NÖ Luftgütemessnetz**

<https://www.noel.gv.at/luft>

The NÖ Luftgütemessnetz is affiliated to the Amt der NÖ Landesregierung and is headquartered in St. Pölten, Landhausplatz 1. The main task of the monitoring network is the execution of the “Immissionsschutzgesetz Luft” (law for ambient air quality). Therefore the main aim of the institution is the control of the permanent protection of human health, animal and plant life, reductions of immissions and preservation of best air quality.

The air quality network of Lower Austria started in 1984 with monitoring air quality. Since then a network of 42 fixed stations and 4 mobile stations has been built up, which is now operated by six employees. Data are collected automatically throughout the day and year. The monitoring stations are located in urban agglomerations, near hotspots like motorways and industries and also in rural regions. Because of a close cooperation with the Environment Agency Austria (Umweltbundesamt - UBA) concerning the quality management system the measurements are fully comparable. The collected data are freely available for both private and public institutions.



### **LUIS – Steiermärkisches Luftgütemessnetz**

<https://www.umwelt.steiermark.at/>

The Styrian Air Quality Network is part of the regional government of Styria/Austria. The main task of the monitoring network are measurements of ambient air quality due to the EU air Quality Directive (2008/50/EC) and the Austrian law for ambient air quality “Immissionsschutzgesetz Luft”. Therefore the main aim of the institution is the control of the permanent protection of human health, animal and plant life, reductions of immissions and preservation of best air quality.

The air quality network of Styria started in the late 1970s with measurement of SO<sub>2</sub> at industrial hot spots. Since 1989 all data were stored in our Air Quality Database. Now a network of 38 fixed stations and 3 mobile stations has been built up, which is currently operated by five employees. The monitoring stations are located in urban agglomerations, near traffic routes and industrial sites but also in rural regions. Because of a close cooperation with the Environment Agency Austria (Umweltbundesamt - UBA) concerning the quality management system the air quality measurements are fully comparable. The collected data are freely available for both private and public institutions.



## Oberösterreichisches Luftmessnetz

<https://www.land-oberoesterreich.gv.at/657.htm>

The Upper Austrian air-measuring network belongs to the office of the Upper Austrian government and is headquartered in Linz, Goethestraße 86. The main task of the monitoring network is the execution of the “Immissionsschutzgesetz - Luft” (law for ambient air quality). Therefore the main aim of the institution is the control of the permanent protection of human health, animal and plant life, reductions of immissions and preservation of best air quality.

The air quality network of Upper Austria started in 1977 with monitoring air quality. Since then a network of 15 fixed stations and about 4 mobile stations has been built up, which is now operated by ten employees. Data of the main pollutants are collected automatically throughout the day and year. The connected calibration laboratory is a European reference laboratory in the Aquila network.

For other pollutants samples are collected and analysed in our laboratory. The monitoring stations are located in urban agglomerations, near hotspots like motorways and industries and also in rural regions. The collected data are freely available for both private and public institutions.



## Air Quality Monitoring Network

<https://www.salzburg.gv.at/themen/umwelt/luft>

The air-measuring network of Salzburg as a part of the environmental department belongs to the local government of Salzburg and is headquartered in the City of Salzburg, Michael-Pacher-Straße 36. The main task of the monitoring network is the execution of the “Immissionsschutzgesetz-Luft” and the “Ozongesetz” (law for ambient air quality). Therefore the main aim of the institution is the control of the permanent protection of human health, animal and plant life, reductions of immissions and preservation of best air quality.

The air quality network of Salzburg started in 1978 with monitoring air quality. Since then a network of 13 fixed stations and about 3 mobile stations has been built up. Data of the main pollutants are collected automatically throughout the day and year. The connected calibration laboratory ensures the high quality of the measured data and is supplemented with the standards of the Environment Agency Austria (UBA).

All data are published daily, monthly and yearly in reports and can be accessed from the webpage.



## Abteilung Waldschutz/Fachbereich Luftgüte

<https://www.tirol.gv.at/umwelt/luftqualitaet>

The Tyrolean air-quality-monitoring network is affiliated to the Amt der Tiroler Landesregierung and is headquartered in Innsbruck Bürgerstraße 36 and Langer Weg 27. The main task of the monitoring

network is the execution of the “Immissionsschutzgesetz-Luft” and “Ozongesetz” (law for ambient air quality). Therefore the main aim of the institution is the control of the permanent protection of human health, animal and plant life, reductions of immissions and preservation of best air quality.

The air quality network of Tyrol started in 1973 with monitoring air quality. Since then a network of at the moment 19 fixed stations has been built up, which is now operated by 7 employees. Data are collected automatically throughout the day and year. The monitoring stations are located in urban agglomerations, near hotspots like motorways and industries and also in rural regions. Because of a close cooperation with the Environment Agency Austria (Umweltbundesamt - UBA) concerning the quality management system the measurements are fully comparable. The collected data are freely available for both private users and public institutions.



<https://www.tugraz.at/home/>

The Graz University of Technology (German: Technische Universität Graz, short TU Graz) is one of five universities in Styria, Austria. It was founded in 1811 by Archduke John of Austria and currently comprises seven faculties. The university is a public university. It offers 18 bachelor and 33 master study programmes (of which 14 are in English) across all technology and natural science disciplines. Doctoral training is organised in 14 English-speaking doctoral schools. The university has more than 13,000 students, and approximately 2,000 students graduate every year. Science study programmes are offered in the framework of NAWI Graz together with the University of Graz. The university has some 3,300 staff. Research areas are combined in five fields of expertise. The university is one of the universities with the highest third-party funding in Austria. In the competence centre programme COMET of the Austrian Research Promotion Agency, the university is the most strongly represented Austrian university. The university information system CAMPUSonline, which was developed at the university, is used by the majority of Austrian universities as well as by several other universities in the German-speaking area. Student teams from the university successfully participate in international student competitions in a variety of disciplines. The TU Graz, the Montanuniversität Leoben and the TU Wien form the network Austrian Universities of Technology (TU Austria) with approximately 47,000 students and 9,000 staff.



<https://mrs.geo.tuwien.ac.at/>  
<https://www.tuwien.at/>

The Vienna University of Technology (TU Wien) was founded in 1815 as „k. k. polytechnisches Institut“, making it the first University of Technology of today’s German-speaking area. TU Wien staff comprises about 140 professors, 3300 scientific staff and 1300 non-scientific staff. Over 28,000 students are enrolled. With its eight faculties – mathematics and geo-information, physics, technical chemistry, informatics, civil engineering, architecture and regional planning, mechanical engineering and business science, electrical engineering and information technology – TU Wien covers the classic engineering disciplines.

The Remote Sensing unit of the Department of Geodesy and GeoInformation (GEO, Faculty of Mathematics and GeoInformation) is one of the leading research institutes in Europe in global monitoring of soil moisture and other land-surface variables (water surfaces, wetlands, freeze/thaw status) by microwave remote sensing. Many of the algorithms and products developed by the unit have been transferred into operational data services, including Copernicus Global Land and Climate Change Services, and EUMETSAT’s soil moisture services. The world’s largest database of global in situ

soil moisture observations, the International Soil Moisture Network (ISMN), has been developed and operated by the GEO Remote Sensing research group since 2010.



<https://www.umweltbundesamt.at/>

With more than 500 staff members from 55 scientific disciplines, the Environment Agency Austria is the largest organisation of experts in the environment sector in Austria and a leading adviser in environmental matters. The Environment Agency builds bridges between the economy, science and politics at national and international level and develops perspectives on the sustainable development of society.

The Environment Agency Austria has a demonstrable track record of successful projects in more than 60 countries – from the new EU Member States to the Western Balkans, the Middle East, the Maghreb countries and Asia. In its capacity as adviser the Environment Agency Austria advises UN and EU institutions and is active as a partner in more than 200 national, European and international networks, bodies, and working groups.



**University of Graz**

<https://www.uni-graz.at/de/>

The University of Graz was founded in 1585 and is therefore Austria's second oldest university. Many excellent scientists, amongst them six Nobel laureates, have taught and researched at this university. With some 32,500 students and 4,300 employees this university is one of the largest in the country. The university consists of 6 faculties with a total number of 76 institutes and department. In particular one department of the University of Graz carries out research in the field of glaciology, namely the Department of Geography and Regional Science. This department focuses on a strong cooperation with a variety of national and international partners in the field of environmental issues including glaciers and permafrost, sustainable development and educational matters. In the field of glaciology several scientists at this department carry out field, remote sensing and modelling studies at different glacier and permafrost areas in the Austrian Alps but also the high Arctic.



**University of Innsbruck**

<https://www.uibk.ac.at/>

Founded in 1669, the University of Innsbruck looks back to a long and variable history. It is currently the largest research and education institution in western Austria with more than 28,000 students and 4,500 staff. The 16 different faculties include social and natural sciences, economy, law and architecture. The research focus 'Alpine space – man and environment' is unique in Austria. This is based on a long tradition in mountain research at the University. The focus of the Research Centre 'Climate - Cryosphere and Atmosphere' is on the interactions between climate and cryosphere as well as any scientific research within any of these disciplines. The Alps and particularly our field sites in the "backyard" of the Innsbruck University (e.g. Hintereisferner) are an ideal laboratory for research, from which universal climate-relevant aspects of surface-atmosphere exchange in complex terrain can be inferred and transferred to other mountain ranges worldwide.

The University of Salzburg is proud of its long history in glaciology and high mountain research. Today the LTER site Oberes Stubachtal is a long-range research site with a main focus on the measurement of glacier front variation and annual mass balance, going along with water budget estimations within the catchment area of the lake Weißsee. The research site, including the Stubacher Sonnblickkees (SSK) is located in the Hohe Tauern Range (Eastern Alps) in the south of Salzburg Province. The mass balance record was the first one established in the Hohe Tauern region and is one of the two dozen longest series worldwide. For more than 20 years the Interfaculty Department of Geoinformatics (Z\_GIS) has supported the research activities and monitoring programs at Sonnblickkees in many ways: Monitoring glaciers with various data capture and photogrammetric methods as well as geospatial analysis workflows are the key methods.

Vienna's air quality monitoring network is affiliated to the "Amt der Wiener Landesregierung" and is headquartered in Vienna, Dresdnerstraße 45. The main task of the monitoring network is the execution of the "Immissionsschutzgesetz Luft" (act for ambient air quality). Therefore, the main aim of the institution is to control the permanent protection of human and animal health and plant life, reductions of immissions and preservation of best air quality.

Vienna's Air Monitoring Network is a real-time system to primarily provide information on current values of air components (sulfur dioxide, nitrogen dioxide, carbon monoxide, ground-level ozone and particulate matter). Thus, the Environmental Protection in Vienna (Municipal Department 22) can inform and warn the population about the exceedance of thresholds. The evaluation of measures concerning the reduction of the amount of air pollutants is accomplished with long-term datasets. In addition to the acquisition of air pollutant values, meteorological parameters are also measured (wind direction, wind velocity, air temperature, air pressure, sunshine duration, precipitation). All datasets are based on half-hourly average values. The longest series extend back to 1986. Vienna's Air Quality Monitoring Network consists of 17 stationary measurement stations. The monitoring stations are located at roadside, in the urban background, in industrial zones and in the rural fringes of the city.

Quality control of the data is done by the data providers of the particular federate states of Austria. Because of a close cooperation with the Environment Agency Austria (Umweltbundesamt - UBA) concerning the quality management system the measurements are fully comparable. The collected data are freely available for both private users and public institutions.



Ambient air quality monitoring has been carried out in Vorarlberg since the 1970s. Initially, classical air pollutants like sulfur dioxide and carbon monoxide were our main concern. At the end of the 1980s the ozone problem was recognized and remains to this day, a central theme. Our interests further include a particular concern for traffic caused air pollution by nitrogen dioxides, particulate matter, carbon monoxide and benzene. Together with results from meteorological investigations, air quality data provide the essential basis for developing measures to maintain clean air. Data on ambient air

concentrations are recorded at stationary and mobile measuring sites and analysed in the air-quality-monitoring information-centre of the Environmental Institute.

Activities:

- operating the ambient air-quality monitoring network and continuous monitoring and assessment of air-quality
- problem oriented air-quality investigations
- calculation of the dispersion of air pollutants
- determining the causes and consequences of air pollution
- documenting and publishing air quality data
- producing air quality assessment reports.

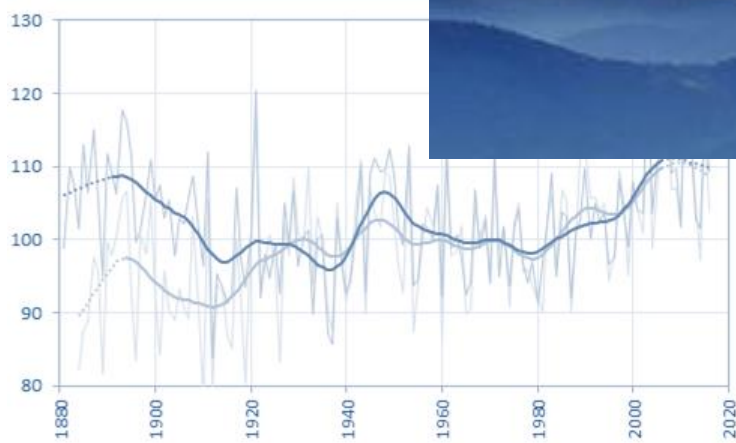


**Zentralanstalt für Meteorologie und Geodynamik**

<https://www.zamg.ac.at/cms/de/aktuell>

ZAMG as the Austrian National Weather and Geophysical Service is an institution affiliated to the Federal Ministry of Science, Research and Economy (BWF). ZAMG with its head office in Vienna maintains customer service centres in Graz, Innsbruck, Klagenfurt and Salzburg. Its nearly 300 employees provide weather forecasts and warnings, conduct meteorological, climatological and geophysical research, perform seismological measurements, and serve as environmental and climatological consultants. Founded in 1851, ZAMG operates a meteorological and a seismic monitoring network as well as the Conrad Observatory in Lower Austria, and the Sonnblick Observatory in Salzburg. ZAMG's experts represent Austria in numerous international organizations and associations such as WMO, ECMWF, and GEO. The leading meteorological institution in Austria, ZAMG, offers its services to clients such as public and private television and radio stations and newspapers as well as to insurance companies, energy providers, road services, construction companies and municipal authorities.





# Atmospheric Observations

Surface



## Climate Monitoring ZAMG

---

*Silke Adler (ZAMG)*

The Zentralanstalt für Meteorologie und Geodynamik (ZAMG) offers meteorological data from 199 semi-automatic weather stations (TAWES), 61 full automatic weather stations (VAMES) in cooperation with Austro Control (ACG) and about 164 climate stations, which additionally provide observer-based meteorological information.

The longest measurement period of climate data can be found in Kremsmünster (since 1767), in Vienna (since 1775) and in Innsbruck (since 1777). From about 20 observing stations in 1852 the meteorological service rose to more than 200 observing stations in 1896. Observations of the most important meteorological parameters such as temperature, pressure, precipitation and humidity were recorded daily by observers - initially at 07, 14 and 21 local mean time (LMT).

During the annexation of Austria the climate observation archive had been moved to the Reichswetterdienst in Berlin, where most of the hard-copies had been destroyed during World War II. Due to this break most climate observations in Austria do not start before 1948. Only a few data duplicates could be retained at ZAMG, building now the basis for long-term studies in Austria (Vienna, Salzburg, Graz, Innsbruck, Sonnblick). In 1980 the observing weather stations became semi-automatic weather stations (TAWES) and climate stations.

The semiautomatic weather stations (TAWES) take measurements of air temperature, wind speed, wind direction, pressure and relative humidity and transmit the data with a rate of 10 minutes. Information on precipitation is crucial for several applications and is therefore sent every minute. After thorough quality checks and corrections the measurement and observation data is stored at ZAMG's climate database.

Observations at the 164 climate stations are made three times a day, at 06 UTC, at 12 UTC and at 18 UTC (before 1972 at 07, 14 and 21 LMT). They include the current weather condition and development, (e.g. type of cloud, lower cloud limit, visibility, type of precipitation) which cannot be detected satisfactorily by an automatic sensor. Historically these daily records have been transmitted to ZAMG or the responsible regional office once a month by mail in the form of a climate sheet. At ZAMG these climate records were archived and entered into a database since 1984. Since 2012 a direct input of the observation to the database is possible using an online tool called KSE (Klima-Synop-Eingabe). This allows immediate access and quality control of the data.

The meteorological network also includes SYNOP stations, most of them are semiautomatic weather stations (TAWES) which reports hourly or once a day. At the synoptically main time 06 UTC and 18 UTC next to the automatic measurements of the TAWES stations about 45 additional observations according to WMO specifications are made by observers or supervisors.

The data are transmitted via the Global Telecommunication System (GTS, [https://www.wmo.int/pages/prog/www/TEM/GTS/index\\_en.html](https://www.wmo.int/pages/prog/www/TEM/GTS/index_en.html)). The data set of these SYNOP stations can be found in the WMO Information System (WIS) Program of the World Meteorological Organisation (WMO).

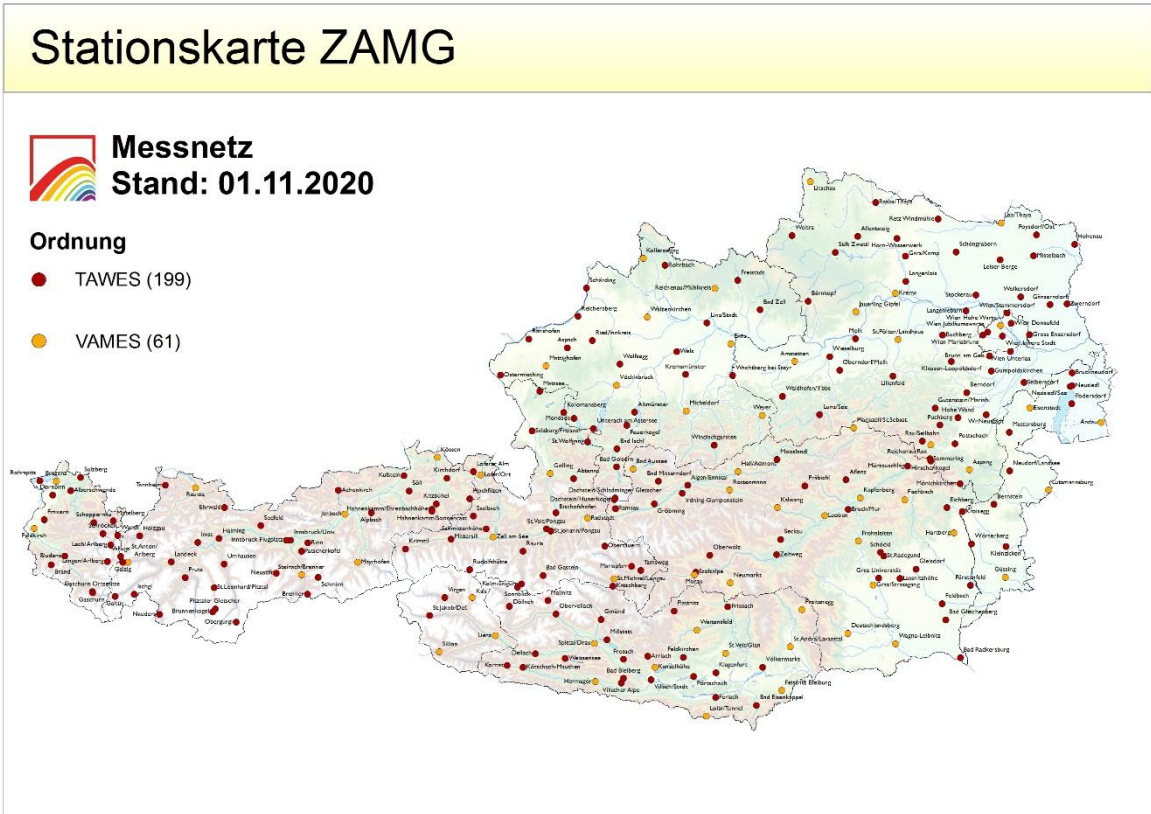


Figure 1 TAWES and VAMES stations of Austria.

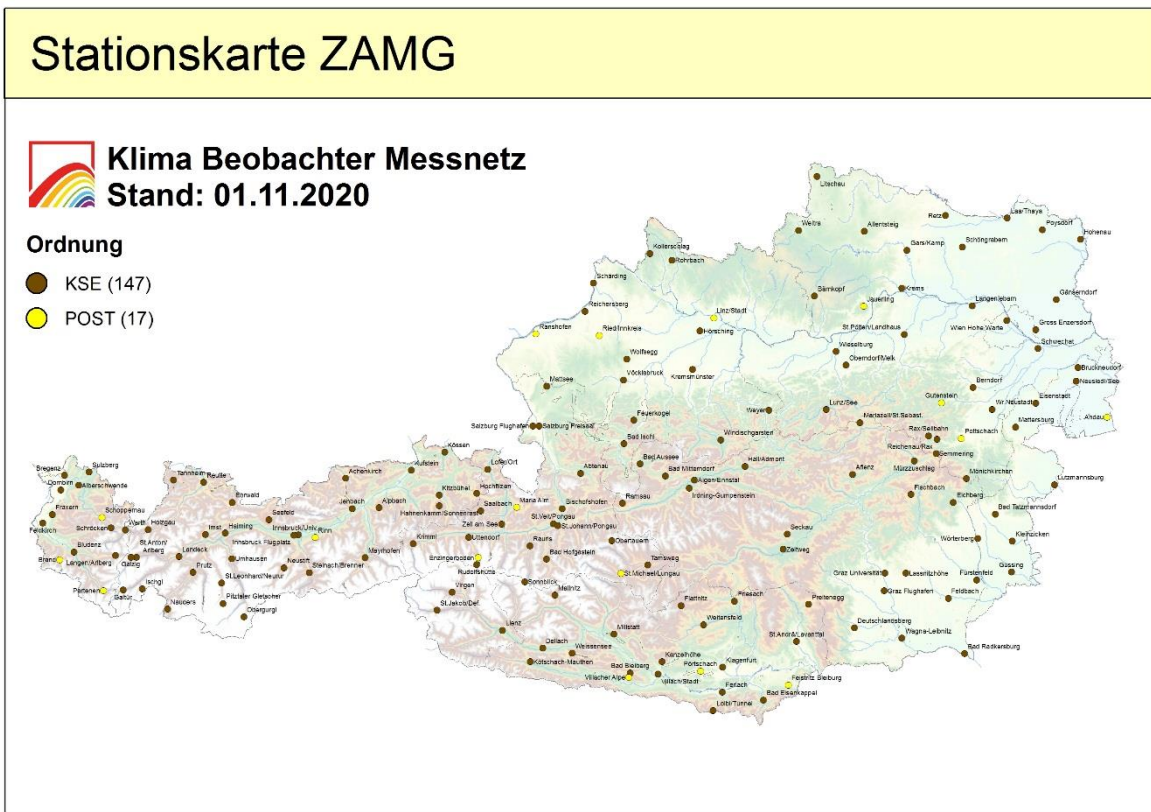


Figure 2 Manual observing stations of Austria.

Essential Climate Variables - Atmospheric Observations - Surface

<b>Parameter measured/observed</b>	air temperature, wind, relative humidity, pressure, clouds, sunshine duration, precipitation, global radiation visibility, present weather, cloud base, cloud amount, snow depth, new snow depth
<b>Starting date</b>	01.03.1767 Kremsmünster
<b>Temporal Resolution</b>	air temperature, wind speed, wind direction, relative humidity, sunshine duration, global radiation, pressure: 10-minute data. precipitation: 1-minute-data data are also available hourly, daily or monthly
<b>Observational Network</b>	Austrian TAWES network, about 260 stations
<b>Stations</b>	20 essential stations and 96 additional stations located throughout Austria (9.53 - 17.16 deg E, 46.37 - 49.02 deg N)
<b>Data Portal</b>	ZAMG: <a href="https://www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch">https://www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch</a> WIGOS: <a href="https://www.wmo.int/pages/prog/www/wigos/index_en.html">https://www.wmo.int/pages/prog/www/wigos/index_en.html</a> Part of WIGOS are: OSCAR: <a href="https://www.wmo-sat.info/oscar/">https://www.wmo-sat.info/oscar/</a> WIS: <a href="https://gisc.dwd.de/wisportal/#PortalHomePlace:PortalHome">https://gisc.dwd.de/wisportal/#PortalHomePlace:PortalHome</a> WDQMS: <a href="https://wdqms.wmo.int/">https://wdqms.wmo.int/</a>
<b>Supervising Organization</b>	ZAMG
<b>National and/or international Networks or Programs</b>	WIGOS (WMO Integrated Global Observing System) WIS / OSCAR /WDQMS (WMO Information System / Observation Systems Capability Analysis and Review Tool / WIGOS Data Quality Monitoring System) GCOS (Global Climate Observing System) EGOS (Evolution of Global Observing System)
<b>Data Submission</b>	data contribution according to WMO specifications
<b>Licenses</b>	general ZAMG data conditions, essential stations: CC-BY 3.0 AT
<b>Use Limitation</b>	no limitation but fee depending on usage conditions
<b>Data Format</b>	data download as ASCII File, PDF-File, HTML-File
<b>Data Access</b>	open access daily and monthly data: <a href="https://www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch">www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch</a>

	access by registration is also available
<b>Data Quality</b>	quality control is done by ZAMG / Division for Data, Methods, Modelling / Section Quality Control System
<b>Performance Monitoring</b>	Continuously supervised by ZAMG.
<b>Publications</b>	Once a year the year book is produced and made public on ZAMG Homepage: <a href="http://www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch">www.zamg.ac.at/cms/de/klima/klimauebersichten/jahrbuch</a>
<b>Contact (National correspondent, focal point)</b>	Focal Point: GCOS: Silke Adler, <a href="mailto:silke.adler@zamg.ac.at">silke.adler@zamg.ac.at</a> WIGOS: Lipa Wolfgang, <a href="mailto:wolfgang.lipa@zamg.ac.at">wolfgang.lipa@zamg.ac.at</a> WDQMS: Paul Anita, <a href="mailto:anita.paul@zamg.ac.at">anita.paul@zamg.ac.at</a> WIS: Paul Anita, <a href="mailto:anita.paul@zamg.ac.at">anita.paul@zamg.ac.at</a> Pichler Michael, <a href="mailto:Michael.Pichler@astrocontrol.at">Michael.Pichler@astrocontrol.at</a> OSCAR: Silke Adler, <a href="mailto:silke.adler@zamg.ac.at">silke.adler@zamg.ac.at</a> EGOS-IP: Lipa Wolfgang, <a href="mailto:wolfgang.lipa@zamg.ac.at">wolfgang.lipa@zamg.ac.at</a>  TAWES: <a href="mailto:roland.potzmann@zamg.ac.at">roland.potzmann@zamg.ac.at</a> <a href="mailto:dpru@zamg.ac.at">dpru@zamg.ac.at</a>
<b>Remarks</b>	

## VAMES

*Gregor Mitternast (ACG)*

VAMES (Voll\_Automatisches\_Meteorologisches\_Erfassungs\_System) has been established as an aviation weather observation network within Austria. It is a very successful cooperation project between the national weather service ZAMG and the aviation weather service which is a department of the air traffic services AUSTRO CONTROL. Based on the existing TAWES network from ZAMG with about 260 stations, 50 stations along valley flight tracks which are used by general aviation have been chosen to extend them with visibility/present weather detection sensors (VAISALA PWD22) and ceilometers with cloud coverage algorithm (VAISALA CL31). The extension began in 2011 with 10 stations per year and has been completed at the end of 2016. The performance of the availability lies at more than 98%. Raw data are collected by ZAMG and delivered to AUSTRO CONTROL where AUTOMETARs in the WMO No. 306 METAR format are produced after the information of a so called convection module (TS, VCTS and CB) has been integrated. AUTOMETARs are disseminated within Austria and Germany continuously every 10 minutes and used e.g. for GAFOR preparation and for aviation meteorological briefings.

Quality control is done by ZAMG with data monitoring software and by AUSTRO CONTROL in form of continuously supervising by the operational service at the meteorological watch office in Wien Schwechat.

Content of the AUTOMETAR reports:

- Wind speed (TAWES sensor)
- Wind direction (TAWES sensor)
- Meteorological visibility from VAISALA PWD 22
- Present weather:



- from VAISALA PWD 22
- TS and VCTS information from convection module (generated product of lightning and weather radar information)
- Height of cloud base from VAISALA CL31
- Cloud amount by algorithm from VAISALA CL31
- Type of cloud in case of CB from convection module (generated product of lightning and weather radar information)
- Temperature at 2 m above ground (TAWES sensor)
- Dew point (TAWES sensor)

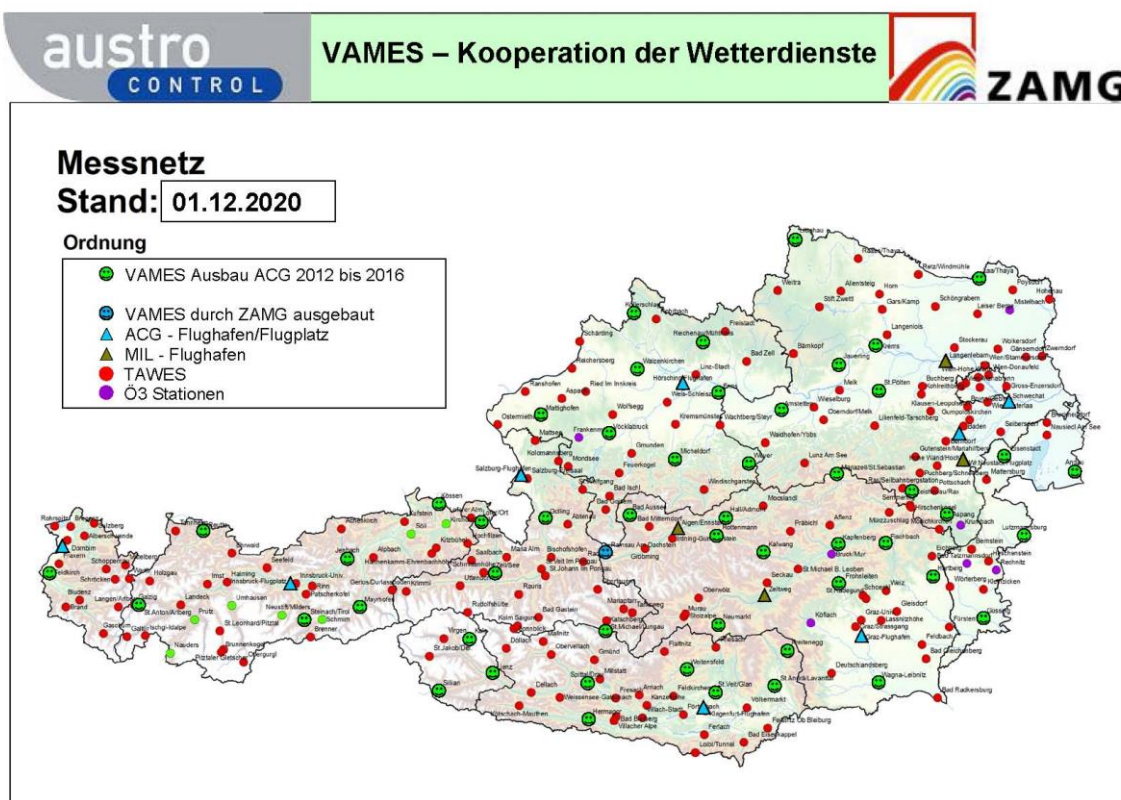


Figure 3 VAMES Stations.

List of stations:

- |                     |                              |
|---------------------|------------------------------|
| 11070 Krems         | 11220 Neumarkt               |
| 11171 Mariazell     | 11225 Weitensfeld            |
| 11188 Aspang        | 11237 St.Veit an der Glan    |
| 11335 Laa/Thaya     | 11259 Hermagor               |
| 11380 Reichenau/Rax | 11272 Spittal an der Drau    |
| 11389 St.Pölten     | 11007 Kollerschlag           |
| 11393 Lutzmannsburg | 11021 Litschau               |
| 11395 Andau         | 11050 Reichenau im Mühlkreis |
| 11190 Eisenstadt    | 11105 Feldkirch              |
| 11024 Jauerling     | 11131 Kössen                 |
| 11063 Rottenmann    | 11311 St.Anton am Arlberg    |
| 11167 Hall/Admont   | 11314 Reutte                 |

11173 Fischbach	11325 Jenbach
11198 Güssing	11329 Steinach in Tirol
11249 Frohnleiten	11330 Mayrhofen
11296 Leibnitz	11002 Enns
11229 St.Andrä/Lavanttal	11049 Mattighofen
11362 Kalwang	11056 Vöcklabruck
11370 Kapfenberg	11058 Waizenkirchen
11390 Hartberg	11140 Lofer
11018 Amstetten	11144 Zell am See
11200 Kals	11148 St.Michael im Lungau
11201 Sillian	11341 Weyer
11204 Lienz	11347 Micheldorf
11214 Preitenegg	11356 Bad Aussee
11371 Golling	

---

### Essential Climate Variables - Atmospheric Observations - Surface

---

<b>Parameter measured/observed</b>	wind, visibility, present weather, cloud base, cloud amount (according ICAO 1-3-5), temperature, dew point are used to prepare AUTOMETARs
<b>Starting date</b>	Cooperation between AUSTRO CONTROL and ZAMG was started on 9th November 2011.
<b>Temporal Resolution</b>	10-minute data
<b>Observational Network</b>	Austrian TAWES network
<b>Stations</b>	50 stations as part of the TAWES network
<b>Data Portal</b>	AUTOMETARs are officially disseminated by AUSTRO CONTROL within Austria and Germany
<b>Supervising Organization</b>	Depends on the type of sensor: AUSTRO CONTROL: visibility, present weather and cloud information ZAMG: all other TAWES sensors
<b>National and/or international Networks or Programs</b>	TAWES
<b>Data Submission</b>	update every 10 minutes, 24 h a day
<b>Licenses</b>	AUTOMETARs are disseminated free of charge
<b>Use Limitation</b>	For use in Aviation Meteorology only
<b>Data Format</b>	METAR (according WMO No. 306)

<b>Data Access</b>	Access by registration with pilot license
<b>Data Quality</b>	Quality control is done by AUSTRO CONTROL and ZAMG
<b>Performance Monitoring</b>	Continuously supervised by AUSTRO CONTROL and ZAMG.
<b>Publications</b>	No publications available
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:Met-info@austrocontrol.at">Met-info@austrocontrol.at</a>
<b>Remarks</b>	

## Aerodrome Met stations in Austria

*Gregor Mitternast (ACG)*

Aerodrome meteorological stations at Austrian international aerodromes have been established in 1955 with the foundation of the Bundesamt für Zivilluftfahrt called AUSTRO CONTROL since 1994. According to the established air space classes within Austria it is necessary to operate with air traffic controllers (ATCOs) at the international aerodromes Wien (LOWW), Linz (LOWL), Salzburg (LOWS), Innsbruck (LOWI), Graz (LOWG) and Klagenfurt (LOWK).

Following the international standards and recommendations of ICAO, it is required that each provide meteorological observations and standardized reports in the MET REPORT, SPECIAL and METAR format. SYNOPSIS are prepared at all of these stations hourly and climatological observations are made three times per day semi-manually at Wien (LOWW), Linz (LOWL), Salzburg (LOWS) and Graz (LOWG).

Quality control of SYNOPSIS is done by ZAMG with data monitoring software, while aviation meteorological reports are handled by AUSTRO CONTROL in the form of continuously supervising by the operational service at the meteorological office in Wien Schwechat.

Measured parameters at each station are:

- Wind speed
- Wind direction
- Prevailing visibility
- Visibility runway specific
- Runway Visual Range
- Present weather
- Height of cloud base
- Cloud amount
- Temperature at 2 m and 5 cm above ground
- Dew point
- Air pressure QNH
- Sunshine duration
- Snow depth

Routinely aerodrome relevant evaluations are prepared e.g. as frequencies of the occurrence of RVR and/or height of the base of the lowest cloud layer of BKN or OVC extent below specified values at specific times – see figure 4.

## AERODROME CLIMATOLOGICAL SUMMARY LOWW / MODEL A1



LAT / LONG: 48.11 N / 16.57 E      ELEVATION: 183M      RUNWAY: 16/34  
 PERIOD OF RECORD: 2004 - 2016      PERIOD: DECEMBER 01 - 31  
 TOTAL NUMBER OF OBSERVATIONS: 18844

FREQUENCIES (PER CENT) OF THE OCCURENCE OF RUNWAY VISUAL RANGE (IN METRES) AND/OR HEIGHT OF THE BASE OF THE LOWEST CLOUD LAYER (IN METRES) OF BKN OR OVC EXTENT BELOW SPECIFIED VALUES AT SPECIFIC TIMES						
TIME (UTC)	RVR/Hs					#OBS.
	<50	<200	<350	<550	<1500	
	-	-	<30 (100 ft)	<60 (200 ft)	<90 (300 ft)	
0000			0.5	9.4	13.2	393
0030			0.5	9.2	13.3	391
0100			0.5	9.7	12.8	391
0130			0.5	9.2	13.8	391
0200			0.5	10.3	13.8	390
0230			0.5	10	15.1	391
0300			0.5	10.4	15.3	393
0330			0.5	10.4	14.8	393
0400			0.8	9.7	14.8	393
0430			0.3	11.2	15.5	393
0500			0.5	11	15.3	392
0530			1.3	11	15.6	392
0600			2	11	16.1	392
0630			1.5	11.7	16.8	393
0700			2.3	11	16.9	391
0730		0.3	2	10.5	16.1	392
0800			2.5	11.2	16.5	393
0830			2.8	10.2	15.7	394
0900			2.3	9.9	15.5	394
0930			1.3	9.7	14.8	393
1000			1.3	8.7	14	393
1030			1.3	7.6	13.2	395
1100		0.3	1	6.3	11.9	396
1130			1.3	5.8	10.4	396
1200			0.8	5.6	9.1	394
1230			0.5	5.1	8.4	394
1300			0.5	5.1	7.4	393
1330			0.8	4.9	7.2	391
1400			0.8	4.3	7.7	392
1430			0.5	4.6	7.6	393
1500			0.5	5.6	7.9	394
1530			0.8	5.6	7.4	392
1600			0.8	5.3	8.7	393
1630			0.5	6.4	9.2	391
1700			0.5	6.6	8.9	392
1730			0.3	6.4	9	391
1800			0.3	6.6	8.9	392
1830				7.1	10.4	393
1900			0.3	6.9	10.2	394
1930			0.5	5.9	9.9	393
2000			0.5	6.6	10.2	393
2030			0.5	7.4	11.5	391
2100			0.5	8	11.3	389
2130			0.5	8.9	11.5	393
2200			0.8	8.4	10.7	393
2230			0.3	8.1	11.5	393
2300			0.5	8.7	12.2	392
2330			0.8	8.7	13.2	393
TOTAL		0	0.9	8.2	12.1	18844

Figure 4 Aerodrome Climatological Summary.



**Essential Climate Variables - Atmospheric Observations - Surface**

<b>Parameter measured/observed</b>	wind, visibility, RVR (Runway Visual Range), present weather, cloud base, cloud amount (according ICAO 1-3-5), temperature, dew point, QNH are used to prepare MET REPORT, SPECIAL, METAR and SYNOP
<b>Starting date</b>	since 1955
<b>Temporal Resolution</b>	Depending on the sensors between 1 to 10-minute data
<b>Observational Network</b>	AUSTRO CONTROL internal MEDAS and external via GTS (Global Telecommunication System)
<b>Stations</b>	6 stations at the Austrian international aerodromes
<b>Data Portal</b>	MET REPORT and SPECIAL are disseminated nationally to air traffic service units. METAR and SYNOP are disseminated internationally via GTS (Global Telecommunication System)
<b>Supervising Organization</b>	AUSTRO CONTROL
<b>National and/or international Networks or Programs</b>	MEDAS
<b>Data Submission</b>	Update every 30 minutes or depending on weather situation
<b>Licenses</b>	Free of charge for aviation use
<b>Use Limitation</b>	For use in Aviation Meteorology only
<b>Data Format</b>	MET REPORT, SPECIAL (according ICAO Annex 3) METAR, SYNOP (according WMO No. 306)
<b>Data Access</b>	METAR: Access by registration with pilot license or via VOLMET Austria MET REPORT, SPECIAL access for pilots via ATIS
<b>Data Quality</b>	Quality control is done by AUSTRO CONTROL
<b>Performance Monitoring</b>	Continuously supervised by AUSTRO CONTROL
<b>Publications</b>	No publications available
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:Met-info@austrocontrol.at">Met-info@austrocontrol.at</a>
<b>Remarks</b>	

## Sunshine duration - Measurements Austria

Marc Olefs (ZAMG)

The earliest regular measurements of sunshine duration (SSD) in Austria date back to the 1880s. The longest SSD time-series are recorded at stations Bad Ischl, Wien, Kremsmünster, Klagenfurt, Villacher Alpe and Sonnblick (since 1880, 1881, 1884, 1884, 1884 and 1887 respectively). Until the 1980s, SSD was recorded using a Campbell-Stokes sunshine recorder (CS; using the burn method). Starting with the introduction of the semi-automatic TAWES measurement network in 1981, CS was successively replaced by an automated sensor: the Haenni Luft Solar 111b, using the contrast method. Today, sunshine duration is measured at all 250 TAWES stations.

Figure 6 shows the time-series of sunshine duration since the late 19th century in the Alpine lowlands and summit regions using homogenized long-term measurements of the ZAMG project HISTALP (see page 43)



Figure 5 The Campbell-Stokes sunshine recorder at station Sonnblick.

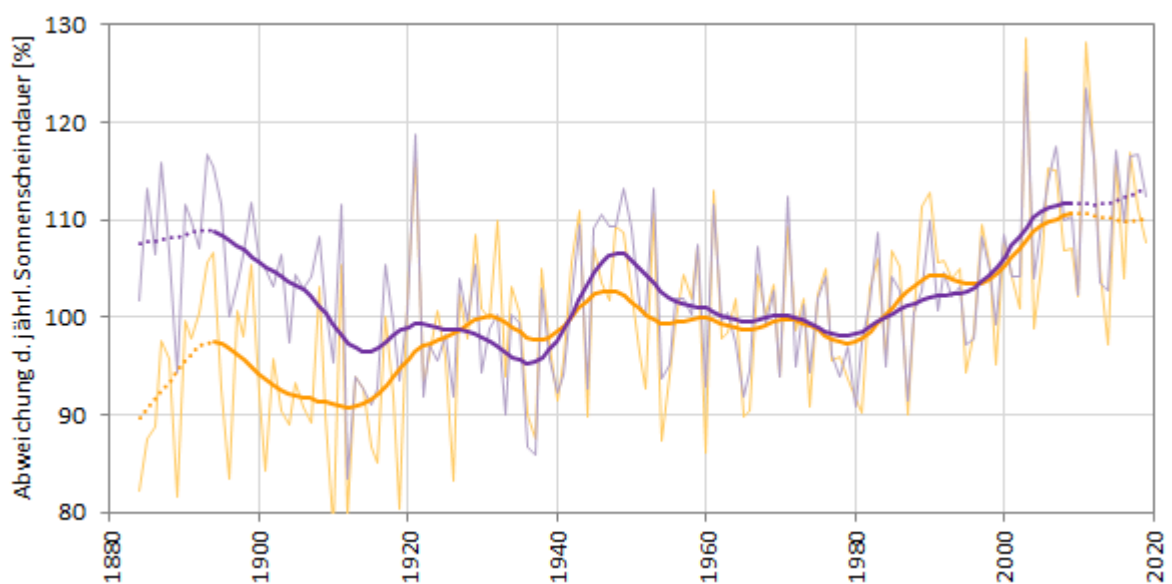


Figure 6 Time-series of annual sunshine duration anomalies in the Alpine lowlands (1881-2016, magenta) and summit regions (1884-2016; orange).

## Essential Climate Variables - Atmospheric Observations - Surface

Parameter measured/observed	sunshine duration
Starting date	1880 (first station in Bad Ischl)
Temporal Resolution	Daily sums until around 1981 10-minute-averages since around 1981
Observational Network	Austrian TAWES network
Stations	about 250 TAWES stations
Data Portal	TAWES: <a href="mailto:klima@zamg.ac.at">klima@zamg.ac.at</a>
Supervising Organization	ZAMG
National and/or international Networks or Programs	HISTALP project ( <a href="http://www.zamg.ac.at/histalp">www.zamg.ac.at/histalp</a> )
Data Submission	TAWES: 10-min since around 1981
Licenses	general ZAMG data conditions
Use Limitation	no limitation but fee depending on usage conditions
Data Format	time-series in ZAMG data base
Data Access	restricted access, contact: <a href="mailto:klima@zamg.ac.at">klima@zamg.ac.at</a>
Data Quality	Quality control is done by ZAMG / Division for Data, Methods, Modelling / Section Quality Control System
Performance Monitoring	Performance monitoring is done by ZAMG
Publications	
Contact (National correspondent, focal point)	TAWES: <a href="mailto:roland.potzmann@zamg.ac.at">roland.potzmann@zamg.ac.at</a> HISTALP: Barbara Chimani, <a href="mailto:Barbara.chimani@zamg.ac.at">Barbara.chimani@zamg.ac.at</a>
Remarks	

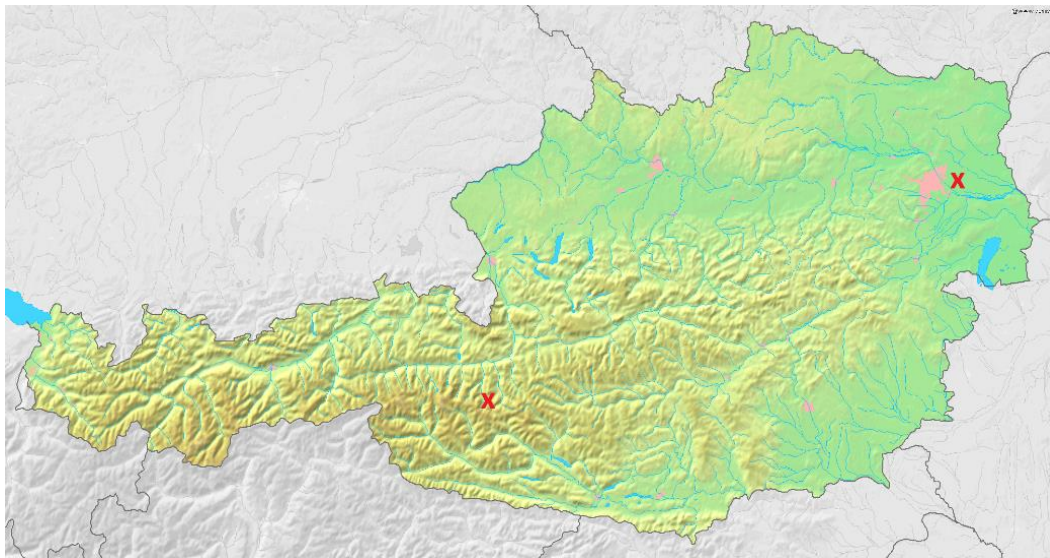
## UV Radiation

Stana Simic (BOKU)

Only about 5 % of the solar radiation reaching the earth's surface is in the ultraviolet spectrum. Although it's only a small portion, UV radiation has great impacts on the biosphere. Solar radiation with wavelengths shorter than 290 nm is entirely blocked by the Earth's ozone layer, whereas UV radiation with longer wavelengths is only partially absorbed. But it is this small portion in the UV-B range (290-315 nm) which is of great significance since it causes various chemical and physical reactions on molecular structures like life forms. While human exposure to UV radiation is very important and does have beneficial effects, it is a major risk factor for the development of skin cancer.

### Measurements of UV Radiation in Austria

UV radiation is monitored at two stations in Austria: Hoher Sonnblick and Groß-Enzersdorf (see figure 7). The measurements have been carried out since 1994 and 1998 respectively by the Institute of Meteorology of the "University of Natural Resources and Life Sciences" (BOKU) and are financed by the "Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management" (BMLFUW). The datasets meet the high quality-standards of the "Network for the Detection of Atmospheric Composition Change" (NDACC) and are among the longest of all of Europe. Instrument comparisons and the dataset of previous years confirm that a high quality was reached. The gathered data help to better understand radiation transfer processes and ground insolation of UV radiation.



**Figure 7** UV measurement sites in Austria: Groß-Enzersdorf (top-right) near the large city Vienna in a lowland basin at 156 m and Hoher Sonnblick (bottom-left) on a mountain peak at 3106 m elevation.

The knowledge of spectral UV-B irradiance and its dependence on various parameters is crucial to quantify and understand the consequences of increasing UV-B radiation. Evaluation of radiation transfer modelling, determination of a UV climatology and calculation of long-term UV-B trends all require exact measurements of spectral UV irradiance.

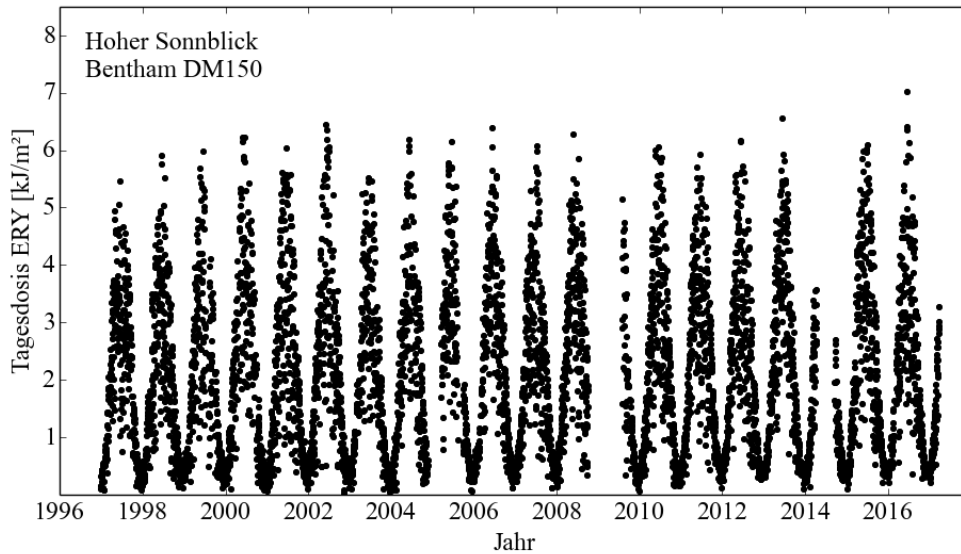


Figure 8 Daily sums of erythemally weighted UV irradiance measured at Hoher Sonnblick.

## The Austrian UV-B Measurement Network

It is known that exposure to UV radiation has beneficial as well as detrimental effects on the human body. While it is absolutely crucial for endogenous vitamin D photosynthesis, overexposure can acutely lead to sunburn and chronically induce skin cancer development. Therefore it is a high priority to provide the public with high-quality UV measurement data. The Austrian UV-B measurement Network is financed by the "Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management" (BMLFUW) and was established in 1998. Since 1999 it consists of 13 stations, equipped with UV biometers, spread throughout Austria. The Section for Biomedical Physics (<https://www.i-med.ac.at/dpmp/bmp/>) at the Medical University of Innsbruck and the CMS Ing. Dr. Schreder Company together maintain the UV-B measurement grid continuously. The UV index data is continuously published in 10-minute intervals at <http://www.uv-index.at>.



Figure 9 The Benthams spectrophotometer at sunset at the High Alpine Observatory Hoher Sonnblick (3106 m).

Essential Climate Variables - Atmospheric Observations - Surface

<b>Parameter measured/observed</b>	spectral UV irradiance
<b>Starting date</b>	01.01.1997
<b>Temporal Resolution</b>	10-minute intervals for UV biometer data 30-minute intervals for spectral UV radiation
<b>Observational Network</b>	Two spectrophotometers and two UV biometers
<b>Stations</b>	Two spectrophotometers and two UV biometers, one of each located in Groß-Enzersdorf, near Vienna and the high Alpine observatory Hoher Sonnblick (3106 m)
<b>Data Portal</b>	UV-B data: <a href="http://www2.i-med.ac.at/uv-index/de/graphs_hoehe_eu_de.html">http://www2.i-med.ac.at/uv-index/de/graphs_hoehe_eu_de.html</a> Spectral UV radiation data: NDACC
<b>Supervising Organization</b>	BOKU, BMLFUW
<b>National and/or international Networks or Programs</b>	NDACC (international Network for the Detection of Atmospheric Composition Change)
<b>Data Submission</b>	Via FTP to a Server located at BOKU
<b>Licenses</b>	general BOKU data conditions
<b>Use Limitation</b>	For research only
<b>Data Format</b>	ASCII
<b>Data Access</b>	Downloadable data at NDACC data centre
<b>Data Quality</b>	Data quality control is done by NDACC and is a very high standard
<b>Performance Monitoring</b>	The instruments and data availability are supervised by the work group „UV Radiation and Ozone“ at the Institute of Meteorology at University of Natural Resources and Life Sciences, Vienna (BOKU).
<b>Publications</b>	Annual publications at NDACC newsletter Further publications are listed here: <a href="http://www.wau.boku.ac.at/en/met/forschungsthemen/atmosphaerische-strahlung/forschungsbereich-uv-strahlung-und-gesamtozon/publikationen/">www.wau.boku.ac.at/en/met/forschungsthemen/atmosphaerische-strahlung/forschungsbereich-uv-strahlung-und-gesamtozon/publikationen/</a>
<b>Contact (National correspondent, focal point)</b>	Dr. Stana Simic BOKU Wien, Institut für Meteorologie, Department für Wasser-Atmosphäre-Umwelt Gregor-Mendel-Straße 33, 1180 Wien Telefon: (+43) (0)1 47654-81430, <a href="https://boku.ac.at/wau/met">https://boku.ac.at/wau/met</a>
<b>Remarks</b>	



## Solar and terrestrial radiation monitoring networks (TAWES, ARAD)

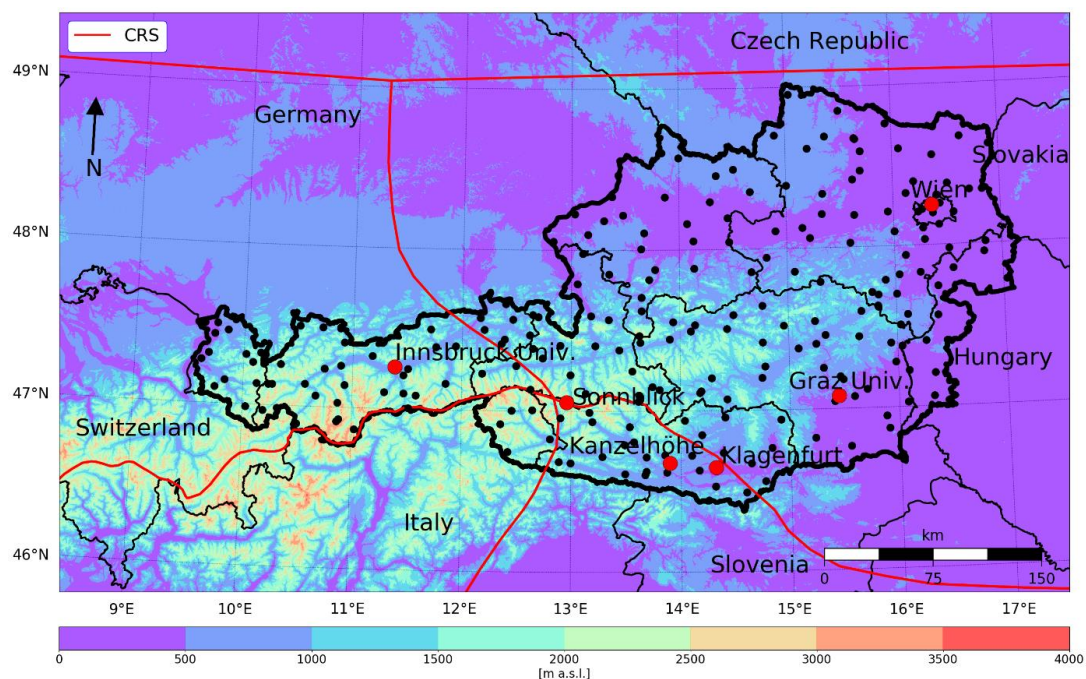
Marc Olefs (ZAMG)

10-minute average values of global radiation are currently measured at 246 TAWES stations of ZAMG using a Schenk Star Pyranometer (black dots in figure 10). Beside this routine measurement network, ZAMG and Austrian University partners operate a high accuracy radiation measurement network (ARAD; red dots in figure 10). ARAD (“Austrian Radiation”) is a long term measurement project for solar radiation and thermal radiation of the atmosphere in Austria. Currently, the temporal and spatial variations of the radiative components (global, direct and diffuse incoming solar radiation and incoming longwave radiation) are recorded at six sites (Vienna, Sonnblick, Graz, Innsbruck, Kanzelhöhe, Klagenfurt) using very high quality instruments.

ARAD is a scientific research project lead by the ZAMG in collaboration with the University of Innsbruck, the Karl-Franzens-University Graz and the University of Natural Resources and Life Sciences (BOKU) in Vienna. ARAD provides very accurate data of the temporal and spatial changes of the radiation components of the sun and atmosphere. Besides a continuous survey of our climate, these data can also be used to verify and improve regional climate models and weather forecasting models. More information can be found at [zamg.ac.at/strahlung](http://zamg.ac.at/strahlung).

### Integration in international networks

Since 2013 the ARAD Station Sonnblick is part of the baseline surface radiation measurement network BSRN (see separate chapter). Data of the TAWES Stations Grossenzersdorf, Salzburg/Freisaal, Bregenz, Innsbruck/Flughafen, Sonnblick (ARAD Station), Klagenfurt/Flughafen, Graz/Universität and Wien Hohe Warte is regularly transmitted to the World Radiation Data Center (WRDC) in St. Petersburg. BSRN and ARAD measurements are used at the European Centre for Medium Range Weather Forecasts (ECMWF) to evaluate forecasts of downward fluxes of shortwave and longwave radiation.



**Figure 10:** Topographic map (colour-coded elevations) with ARAD stations (red points), TAWES stations measuring GLO (black points) and the coarse resolution subregions (CRSs) defined as regions with common climatic variability.

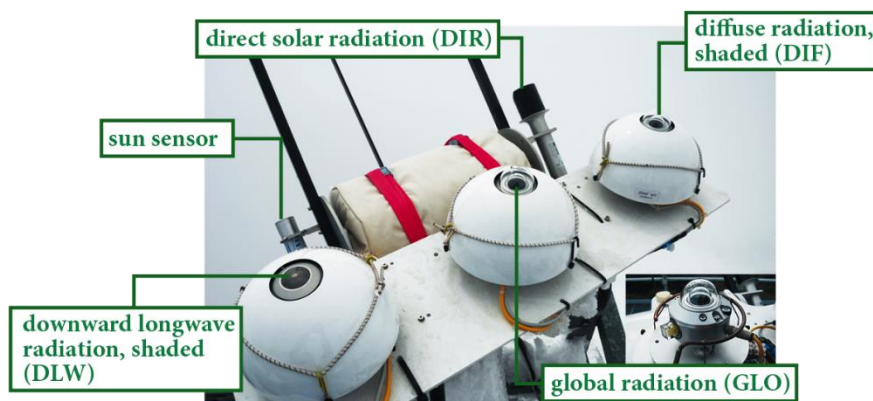


Figure 11: Typical ARAD station: suntracker with different radiation sensors. The picture in the lower right corner shows a pyranometer without radiation shield exposing the heating and ventilation system (PMOD-VHS).

## ZAMG ARAD Partners



## Essential Climate Variables - Atmospheric Observations - Surface

<b>Parameter measured/observed</b>	ARAD Network: global radiation, diffuse radiation, direct solar radiation, longwave incoming radiation TAWES Network: global radiation
<b>Starting date</b>	1953 (first station Vienna Hohe Warte)
<b>Temporal Resolution</b>	ARAD Network: 1-min averages (based on 1 Hz sampling), min/max (1 Hz) TAWES Network: 10-min average values (based on 1-minute averages based on 0,1 Hz samplings)
<b>Observational Network</b>	TAWES, ARAD
<b>Stations</b>	TAWES: 241 stations; ARAD: 5 stations
<b>Data Portal</b>	TAWES: <a href="mailto:klima@zamg.ac.at">klima@zamg.ac.at</a> ; ARAD: <a href="http://www.zamg.ac.at/strahlung">www.zamg.ac.at/strahlung</a>
<b>Supervising Organization</b>	ZAMG
<b>National and/or international Networks or Programs</b>	The ARAD network is a collaborative effort of ZAMG together with the following national partners: University of Innsbruck, Graz and BOKU (see <a href="http://www.zamg.ac.at/strahlung">www.zamg.ac.at/strahlung</a> )  5 stations: ARAD (national), station Sonnblick: BSRN (international)
<b>Data Submission</b>	TAWES: 10-min, ARAD: 1-min, ZAMG internal data transfer



<b>Licenses</b>	TAWES: general ZAMG data conditions, ARAD: ZAMG and partner conditions
<b>Use Limitation</b>	TAWES, ARAD: no limitation but fee depending on usage conditions
<b>Data Format</b>	Time-series in ZAMG data base
<b>Data Access</b>	restricted access, contact: <a href="mailto:klima@zamg.ac.at">klima@zamg.ac.at</a>
<b>Data Quality</b>	TAWES: Quality control is done by ZAMG / Division for Data, Methods, Modelling / Section Quality Control System. ARAD: strict data quality management following BSRN guidelines <a href="http://www.zamg.ac.at/strahlung">www.zamg.ac.at/strahlung</a>
<b>Performance Monitoring</b>	ZAMG
<b>Publications</b>	Olefs, M., Baumgartner, D. J., Obleitner, F., Bichler, C., Foelsche, U., Pietsch, H., Rieder, H. E., Weihs, P., Geyer, F., Haiden, T., and Schöner, W.: The Austrian radiation monitoring network ARAD – best practice and added value, Atmos. Meas. Tech., 9, 1513-1531, doi:10.5194/amt-9-1513-2016, 2016.
<b>Contact (National correspondent, focal point)</b>	ARAD: Marc Olefs ( <a href="mailto:marc.olefs@zamg.ac.at">marc.olefs@zamg.ac.at</a> ) ZAMG: <a href="mailto:dpru@zamg.ac.at">dpru@zamg.ac.at</a>
<b>Remarks</b>	

## BSRN - Baseline Surface Radiation Network

*Marc Olefs (ZAMG)*

The Baseline Surface Radiation Network (BSRN) is the most prominent, worldwide observational ground-based network for surface radiation fluxes and was established in the early 1990s (Ohmura et al., 1998) by the World Climate Research Programme (WCRP). BSRN provides measurements with high accuracy and high temporal resolution, and comprises currently 48 sites in different climate regimes (König-Langlo et al., 2013; [bsrn.awi.de](http://bsrn.awi.de); figure 30 and figure 31). In Austria, the ARAD station Sonnblick (3106 m a.s.l.), is also included in the BSRN network (SON; since January 2013; <http://bsrn.awi.de/stations/listings.html>).

The objectives of BSRN are:

- monitor the background (least influenced by immediate human activities which are regionally concentrated) short-wave and long-wave radiative components and their changes with the best methods currently available
- provide data for the validation and evaluation of satellite-based estimates of the surface radiative fluxes and
- produce high-quality observational data for comparison to climate model (GCM) calculations and for the development of local regionally representative radiation climatologies.
- to serve as a baseline for national radiation monitoring networks (e.g. TAWES in Austria).

The sites are equipped with four broadband radiation sensors, which are suitable to BSRN requirements, mounted on a suntracker, for measurements of global (GLO), direct (DIR) and diffuse (DIF) solar radiation and downward longwave radiation (DLW). The suntracker allows correct tracking of the solar path, guarantees the continuous alignment of the pyrheliometer to record DIR and ensures continuous shading of the pyranometer for measurements of DIF and the pyrgeometer for measurements of DLW. All radiation sensors used within ARAD are state-of-the-art thermopile instruments with specifications well within the limits recommended and accepted by BSRN. Following the ISO 9060 classification, all pyranometers used within ARAD are secondary standard instruments and all pyrheliometers are first-class instruments.



Figure 12 Map of the BSRN stations (world).

Running, planned, and closed BSRN Stations, May 2017

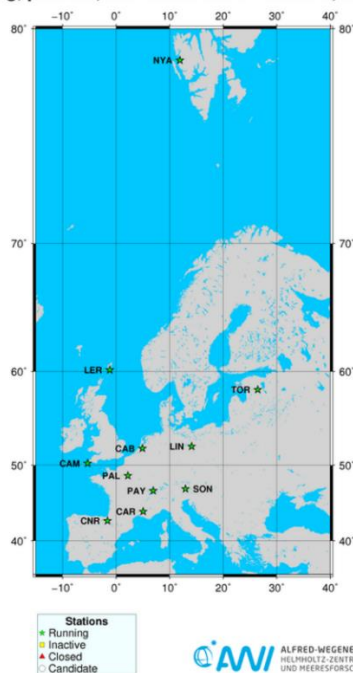


Figure 13: Map of the BSRN stations (Europe).

Essential Climate Variables – Atmospheric Observations - Surface

<b>Parameter measured/observed</b>	Shortwave solar radiation: global radiation, diffuse radiation, direct solar radiation. Longwave radiation: longwave incoming radiation
<b>Starting date</b>	1.1.2011
<b>Temporal Resolution</b>	1-Min averages (based on 1 Hz sampling), Min/Max (1 Hz)
<b>Observational Network</b>	BSRN
<b>Stations</b>	Sonnblick
<b>Data Portal</b>	<a href="http://bsrn.awi.de">bsrn.awi.de</a>
<b>Supervising Organization</b>	World Radiation Monitoring Center (WRMC – data management), GEWEX
<b>National and/or international Networks or Programs</b>	ARAD (national)
<b>Data Submission</b>	monthly, ftp
<b>Licenses</b>	Specific license details: <a href="http://bsrn.awi.de/data/data-retrieval-via-pangaea/">http://bsrn.awi.de/data/data-retrieval-via-pangaea/</a>
<b>Use limitation</b>	Data can be made available for bona fide research purposes at no cost.
<b>Data Format</b>	
<b>Data Access</b>	Free after acceptance of data release guidelines <a href="https://dataportals.pangaea.de/bsrn/">https://dataportals.pangaea.de/bsrn/</a>
<b>Data Quality</b>	Each station scientist is responsible for his station (strict BSRN quality standard/guidelines).
<b>Performance Monitoring</b>	ZAMG und WRMC (bsrn.awi.de)
<b>Publications</b>	Data are citable via PANGAEA (DOI). Driemel, A., Augustine, J., Behrens, K., Colle, S., Cox, C., Cuevas-Agulló, E., ... König-Langlo, G. (2018). Baseline Surface Radiation Network (BSRN): structure and data description (1992–2017). <i>Earth System Science Data</i> , 10(3), 1491–1501. <a href="https://doi.org/10.5194/essd-10-1491-2018">https://doi.org/10.5194/essd-10-1491-2018</a>
<b>Contact (National correspondent, focal point)</b>	Amelie Driemel ( <a href="mailto:amelie.driemel@awi.de">amelie.driemel@awi.de</a> ) – WRMC Marc Olefs ( <a href="mailto:marc.olefs@zamg.ac.at">marc.olefs@zamg.ac.at</a> ) - Station Scientist Sonnblick (SON)
<b>Remarks</b>	

## HISTALP - Homogenized monthly long-term climate dataset

Barbara Chimani (ZAMG)

HISTALP is an international dataset to provide information on the long-term climate evolution in the Alpine region. The dataset consists of monthly homogenised temperature, pressure, precipitation, sunshine and cloudiness records for about 150 stations located in the „Greater Alpine Region“ (GAR, 4-19 deg E, 43-49 deg N, 0-3500 m asl). The longest temperature and air pressure series extend back to 1760, precipitation to 1800, cloudiness to the 1840s and sunshine to the 1880s. Such long term datasets are essential to estimate the significance of current climate evolutions. But due to the length of those series they are subject to changes like improvements in the instrumentation, necessary relocations due to improved knowledge on e.g. impact of buildings or due to changes in the surrounding, changes in the observation times, etc. In order to get a realistic climate signal from those time series, those effects have to be removed. This process is called homogenisation.

Quality control of the data is done by the national data providers. Homogenisation of the time series is done afterwards to remove artificial “climate signals” that are solely caused by effects on the measurement like the relocation of the stations or changes in the instrumentation. Additionally, corrections for the early instrumental bias have been applied.

Homogenisation is redone in about 10 year cycles. Updates of the time series are done annually, depending on the availability of the data.

In addition to the stations data, gridded datasets of temperature and precipitation are available.

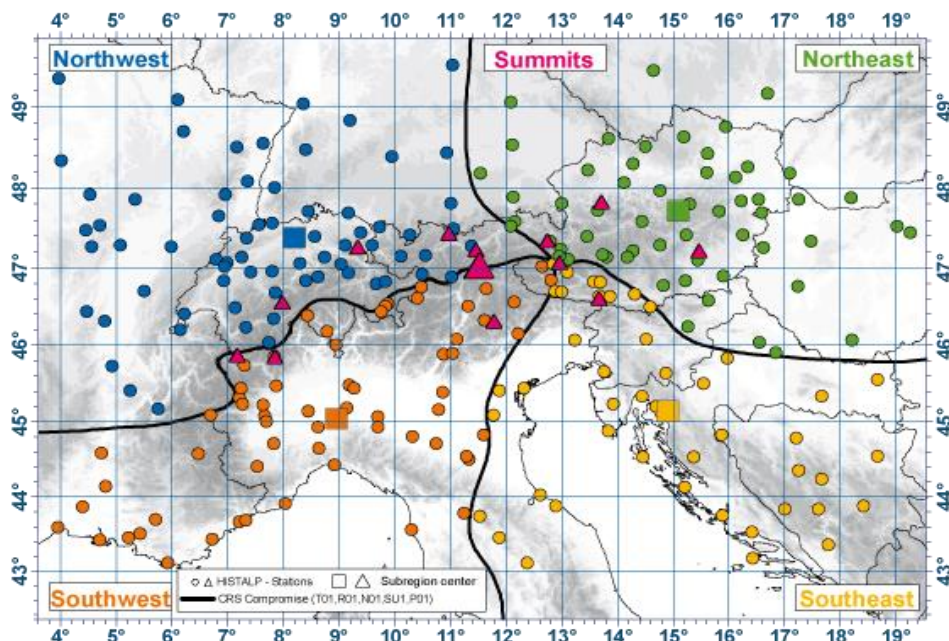


Figure 14 Network of HISTALP stations and regionalisation into different climate regions (colours). Small points and triangles represent the stations, big symbols the centre of the subregions. Triangles represent mountain stations. (Due to data restrictions data of France and Switzerland can not be downloaded via the HISTALP-data centre)

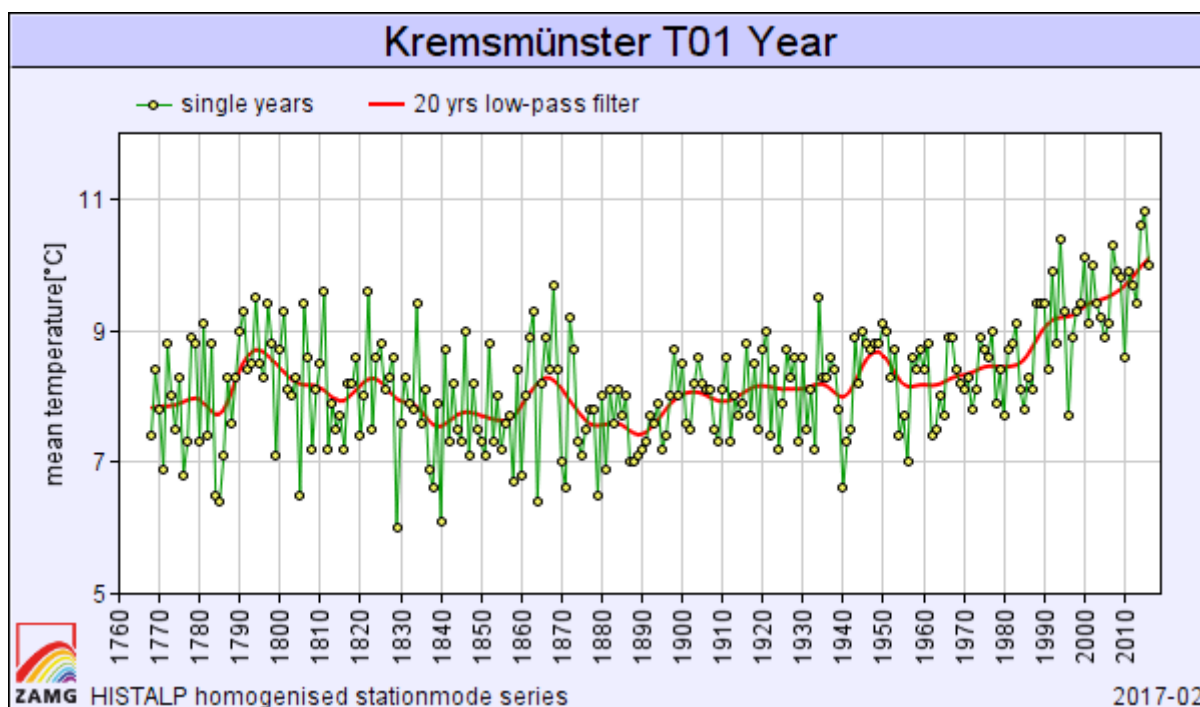


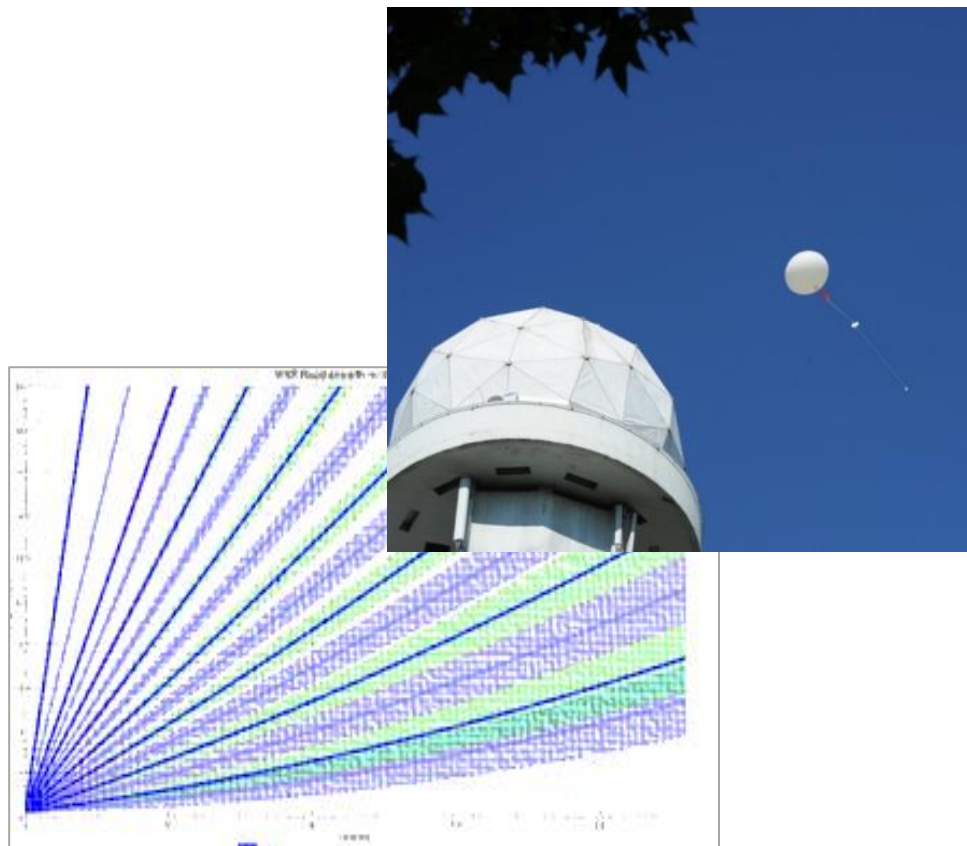
Figure 15 Homogenised time series of annual homogenised temperature of Kremsmünster (Austria).

## Essential Climate Variables - Atmospheric Observations - Surface

<b>Parameter measured/observed</b>	homogenized monthly data of temperature, precipitation, mean station level pressure and sunshine duration
<b>Starting date</b>	earliest time series in 1760
<b>Temporal Resolution</b>	monthly data
<b>Observational Network</b>	Long term time series of the Alpine region from the national observation networks of the participating countries
<b>Stations</b>	About 150 stations located in the Greater Alpine region (4-19 deg E, 43-49 deg N)
<b>Data Portal</b>	<a href="http://www.zamg.ac.at/histalp">www.zamg.ac.at/histalp</a> partly national data centre of the participating countries
<b>Supervising Organization</b>	ZAMG
<b>National and/or international Networks or Programs</b>	HISTALP

<b>Data Submission</b>	Most of the stations are updated once a year
<b>Licenses</b>	free of charge, provided the sources are acknowledged
<b>Use Limitation</b>	for non-profit research
<b>Data Format</b>	Download of the data as csv
<b>Data Access</b>	Download via the HISTALP-homepage ( <a href="http://www.zamg.ac.at/histalp">www.zamg.ac.at/histalp</a> ) Open access
<b>Data Quality</b>	Data quality control is done by the national data providers. The data is homogenized afterwards.
<b>Performance Monitoring</b>	Data availability is supervised by ZAMG, but depends on the national data providers.
<b>Publications</b>	Regular newsletters (3 times a year) on the long term climate evolution in Austria  Further publications on the dataset can be found on the HISTALP-webpage: <a href="http://www.zamg.ac.at/histalp">www.zamg.ac.at/histalp</a>
<b>Contact (National correspondent, focal point)</b>	Contact: <a href="mailto:histalp@zamg.ac.at">histalp@zamg.ac.at</a>
<b>Remarks</b>	





# Atmospheric Observations

Upper Air

## Radiosonde ZAMG

---

*Silke Adler (ZAMG), Roland Potzmann (ZAMG)*

Since 1952 radiosonde ascents have been carried out twice a day (0 UTC, 12 UTC) at the ZAMG. A probe is transported by a weather balloon to heights of 30 to almost 40 km. This probe continuously measures air temperature, humidity and air pressure and transmits the recorded data to the ground station with a radio signal in cycle only seconds long. From 1956, a radar was used to determine the position of the balloon, and since the end of the 1990s GPS has also been available for this purpose. The wind speed and wind direction are calculated from the change in the position between two (or more) time steps.

Despite new measurement methods being available, such as the installation of sensors on commercial aircraft (AMDAR), the radiosonde data remain an indispensable basis for weather models. Apart from the limited number of airports, too few AMDAR system data is available, especially during the night (0 UTC) due to take-off and landing prohibitions. Radiosonde data provide important information for the meteorologist for short-term forecasts and for the estimation of thunderstorm probability (stability of the atmospheric stratification). In winter the knowledge of the temperature and humidity profile helps to forecast fog.

The temporal homogeneity of this measuring system can only be ensured with a certain effort, which poses a problem when using it for monitoring climate (changes). While instruments for ground based measurements at a station are usually used over many years or even decades, radiosonde devices can only be used for one ascent. High demands are also placed on the sensors, which are intended to measure accurately over a temperature range of 40° C to -90° C and a pressure range of less than 5 hPa to 1000 hPa. Particularly at low pressure with simultaneous solar irradiation, the sensors will be heated up by the solar radiation and therefore the temperature is measured systematically too high compared to the actual air temperature. During the observation period of more than 50 years, various radiosonde models with different systematic measurement errors were used at the radio probe station in Vienna.

Modern radio probes show only slight systematic measurement errors and GCOS explicitly recommends the use of radio probes with very well-known measuring characteristics.



**Essential Climate Variables - Atmospheric Observations – Upper Air**

<b>Parameter measured/observed</b>	wind, temperature, dew point, pressure.
<b>Starting date</b>	1.1.1952
<b>Temporal Resolution</b>	2 RASO ascents per day
<b>Observational Network</b>	GUAN (Global Upper Air Network) RASO of ZAMG
<b>Stations</b>	11035 Wien Hohe Warte
<b>Data Portal</b>	ZAMG: <a href="mailto:drpu@zamg.ac.at">drpu@zamg.ac.at</a> , <a href="mailto:roland.potzmann@zamg.ac.at">roland.potzmann@zamg.ac.at</a> GUAN: <a href="https://www.ncdc.noaa.gov/gosic/global-climate-observing-system-gcos/development-gcos-networks/gcos-upper-air-network-guan-data-access">https://www.ncdc.noaa.gov/gosic/global-climate-observing-system-gcos/development-gcos-networks/gcos-upper-air-network-guan-data-access</a>
<b>Supervising Organization</b>	ZAMG
<b>National and/or international Networks or Programs</b>	GUAN (Global Upper Air Network)
<b>Data Submission</b>	GTS (Global Telecommunication System). Two times a day
<b>Licenses</b>	TEMP Data are disseminated free of charge
<b>Use Limitation</b>	no limitation but fee depending on usage conditions
<b>Data Format</b>	TEMP (according WMO No. 306) Bufr (since 2016)
<b>Data Access</b>	
<b>Data Quality</b>	Quality control is done by ZAMG / Division for Data, Methods, Modelling / Section Quality Control System
<b>Performance Monitoring</b>	Performance monitoring is done by ZAMG.
<b>Publications</b>	No publications available
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:drpu@zamg.ac.at">drpu@zamg.ac.at</a> , <a href="mailto:roland.potzmann@zamg.ac.at">roland.potzmann@zamg.ac.at</a>
<b>Remarks</b>	

## Radiosonde AUSTRO CONTROL

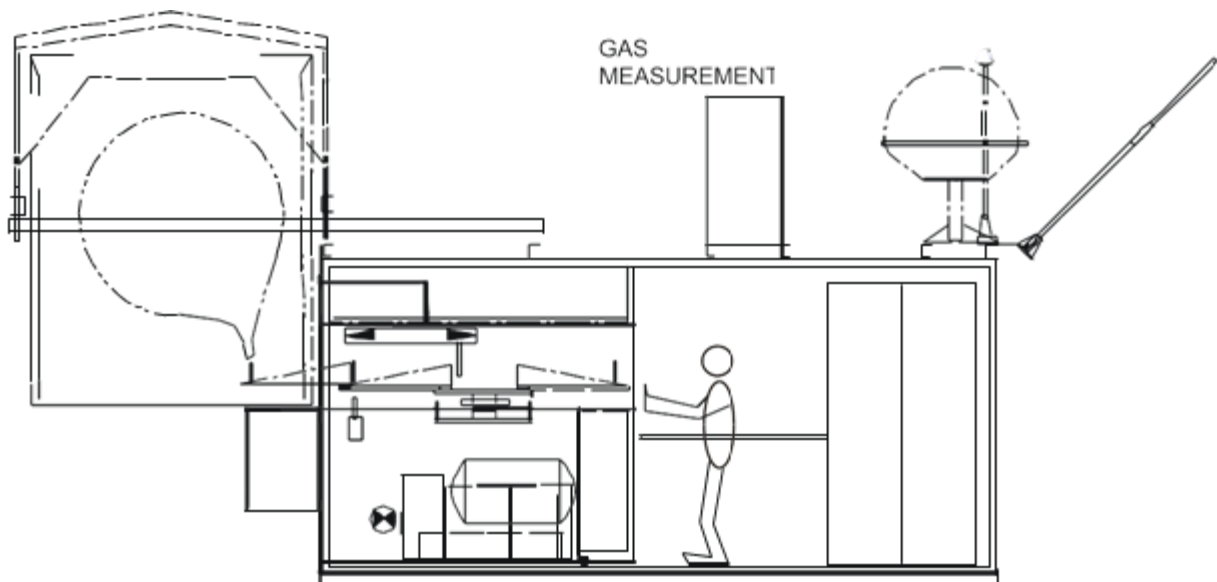
Gregor Mitternast (ACG)

Radiosoundings are made by AUSTRO CONTROL since 1994 after a government decision. They have to be made for military use with cost refund at the aerodromes in Linz (LOWL), Graz (LOWG) and Innsbruck (LOWI) once per day at published early morning times. Since 2016 all three stations are equipped with VAISALA AUTOSONDE AS14 systems which are full automatic operating systems each with maximum load of 24 radiosondes on a carousel launcher. VAISALA RS92 sondes are used with parachutes and TOTEX balloons filled with hydrogen.

Quality control is done by ZAMG with data monitoring software and by AUSTRO CONTROL in form of continuously supervising by the operational service at the meteorological watch office in Wien Schwechat.

Main components are:

- Sounding converting system SPS311
- Local workstation including sounding software
- Remote workstation
- Logic controller and support facility
- Balloon launcher
- Carousel and support facility for RS92 radiosondes
- Gas cassettes
- Periphery tools including GC25 and UPS
- Antennas (Telemetry, GPS und Navigationshilfe)
- RS92 Radiosondes with dry batteries)



**Essential Climate Variables - Atmospheric Observations – Upper Air**

<b>Parameter measured/observed</b>	wind, temperature, dew point
<b>Starting date</b>	Since 1994 after governmental decision AUSTRO CONTROL received order to take over the radiosoundings for military use at the aerodromes in Linz (LOWL), Graz (LOWG) and Innsbruck (LOWI).
<b>Temporal Resolution</b>	1 RASO ascent per day at each station
<b>Observational Network</b>	GTS (Global Telecommunication System)
<b>Stations</b>	3 stations at the aerodromes LOWL, LOWG, LOWI
<b>Data Portal</b>	GTS (Global Telecommunication System)
<b>Supervising Organization</b>	AUSTRO CONTROL
<b>National and/or international Networks or Programs</b>	National military network
<b>Data Submission</b>	Update once a day
<b>Licenses</b>	TEMP Data are disseminated free of charge
<b>Use Limitation</b>	For operational use in Military Aviation Meteorology
<b>Data Format</b>	TEMP (according WMO No. 306)
<b>Data Access</b>	Open access via international data bank
<b>Data Quality</b>	Quality control is done by AUSTRO CONTROL
<b>Performance Monitoring</b>	Continuously supervised by AUSTRO CONTROL.
<b>Publications</b>	No publications available
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:Met-info@austrocontrol.at">Met-info@austrocontrol.at</a>
<b>Remarks</b>	

## Austrian Weather Radar Network

Gregor Mitternast (ACG)

The operational weather radar network in Austria is operated by Austro Control for aeronautical purpose and consists of 4 stations (figures 16, 17), where 2 stations are situated at lower altitudes close to international airports and others are mountain sites above altitudes of 2000 m msl. All weather radars are manufactured by Enterprise Electronics Corporation (EEC) and operate at C band (5600-5650 MHz) fully polarized. The four weather radars have been renewed between 2010 and 2013. The new radar type is DWSR-5001C/SDP/CE (antenna pedestal mounted receiver) including 500 kW solid state modulator, EEC IQ2 signal processor, 4.2 m sandwich antenna and AFC 6 m stealth radome with hydrophobic coating. .

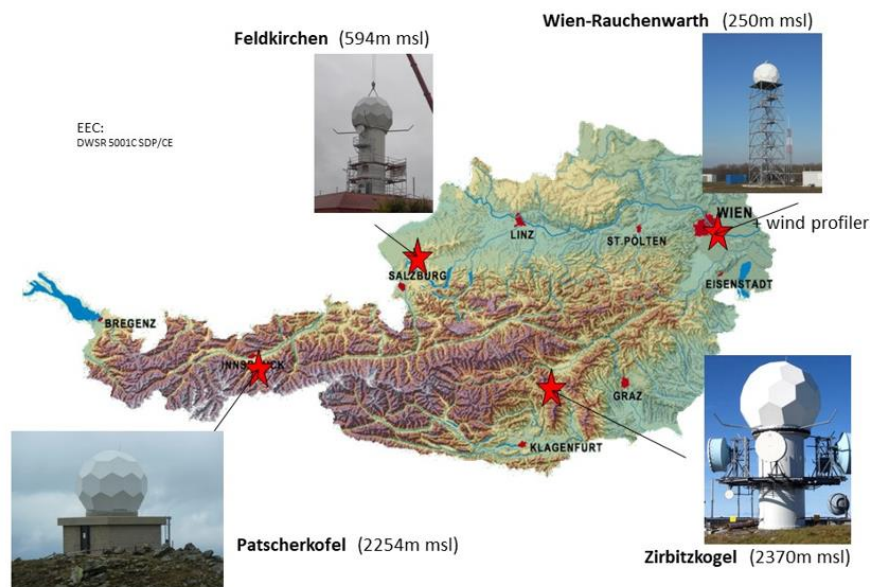


Figure 16 Austrian Weather Radar Network.

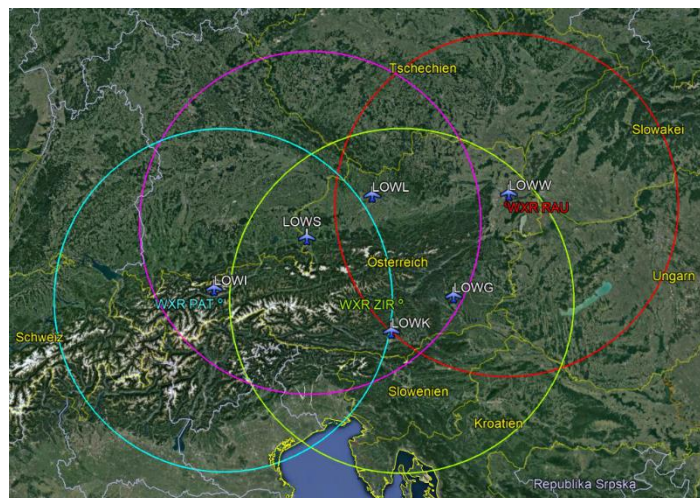
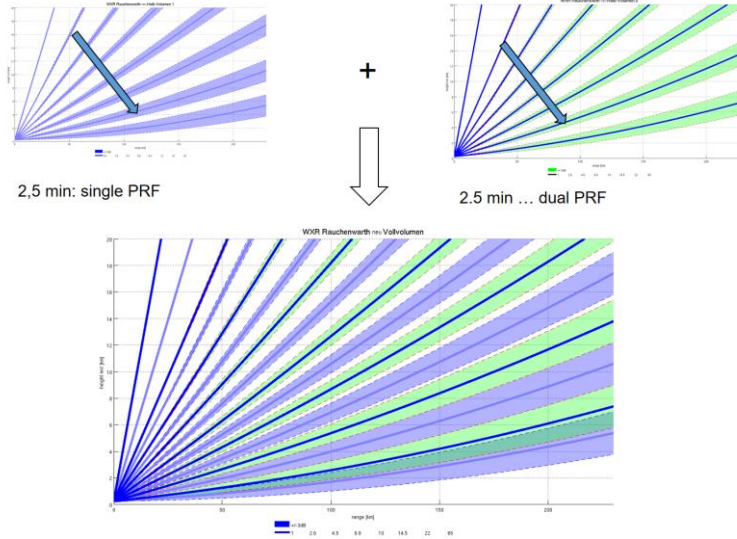


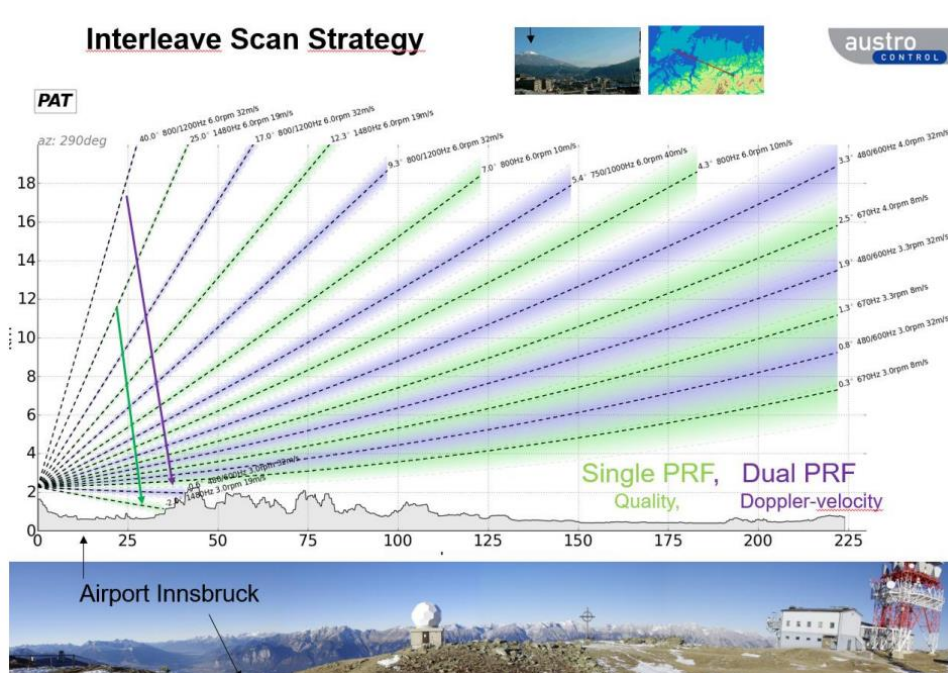
Figure 17 Weather radar data coverage using range of 224 km (cyan-Patscherkofel, magenta-Feldkirchen, red-Rauchenwarth, green-Zirbitzkogel).

The radars use two interleave scans (figure 18) with elevation angles from -2.0 to 65 degrees. Each half scan consists of 8 elevations (approx. duration of 2.5 min) by applying variable antenna rotation speeds. The latest two half scans are combined and updated every 2.5 min for Austrian composite production. Subsequent full volume scan covers 16 elevations, too. For each half scan the scan sequence is from top to bottom.



**Figure 18** Interleave scan strategy. Full volume scan consists of two half scans of different elevations (3dB beam width is colored in blue for half-scan 1 and green for half scan 2).

Vertically pointing bird bath scans for ZDR calibration are executed every 15 min. To increase the unambiguous Doppler velocity, dual PRF (pulse repetition frequency) sampling is applied on the second half scan (figure 19). Spatial resolution is approximately 0.9 degree azimuthal and 250 m in radial by using pulse width of 0.8  $\mu$ s. Cartesian composite products are created for 1 km resolution in 2.5 min resolution.



**Figure 19** Weather radar Patscherkofel interleave scan strategy and applied pulse repetition frequencies, antenna rotation speed and unambiguous Doppler velocity for each sweep.

Austrian weather radars collect following moments in simultaneous transmission and reception of horizontally and vertically polarized waves: radar reflectivity , Doppler velocity, spectral width, and the polarimetric moments as differential reflectivity, copolar cross-correlation coefficient and differential phase.

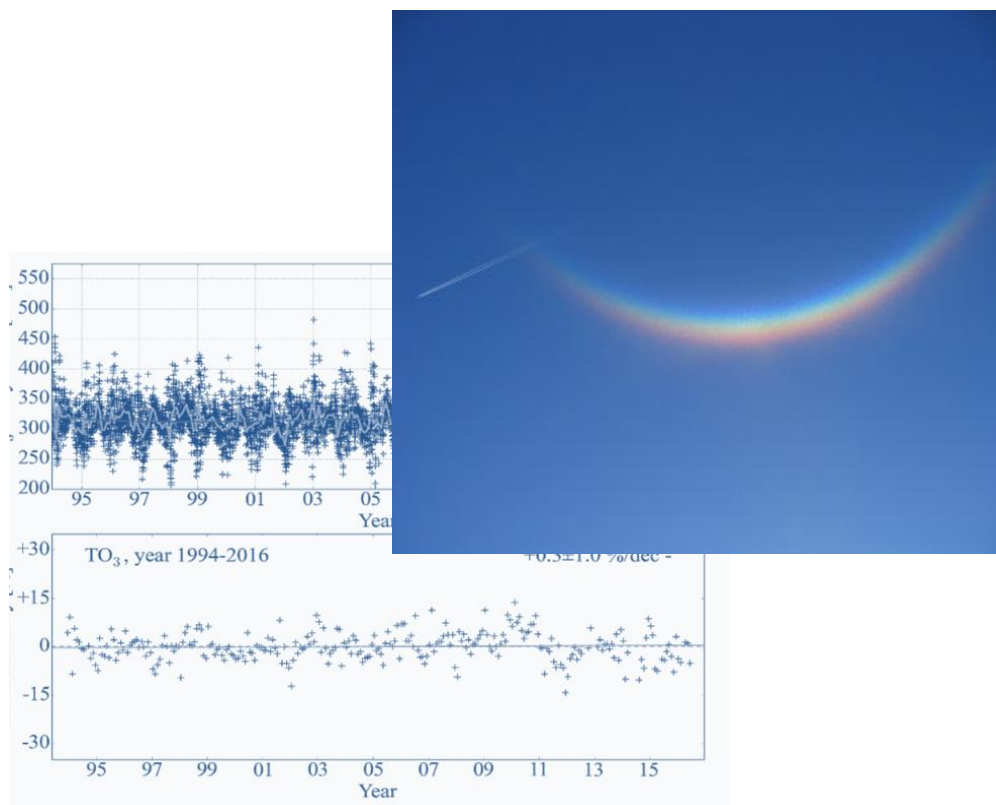
References:

[http://www.meteo.fr/cic/meetings/2012/ERAD/extended\\_abs/NET\\_166\\_ext\\_abs.pdf](http://www.meteo.fr/cic/meetings/2012/ERAD/extended_abs/NET_166_ext_abs.pdf)

[http://www.meteorologie.at/docs/OEGM\\_bulletin\\_2012\\_2.pdf](http://www.meteorologie.at/docs/OEGM_bulletin_2012_2.pdf)

[http://eumetnet.eu/wp-content/themes/aeron-child/observations-programme/current-activities/opera/database/OPERA\\_Database/index.html](http://eumetnet.eu/wp-content/themes/aeron-child/observations-programme/current-activities/opera/database/OPERA_Database/index.html)





# Atmospheric Observations

## Composition

## Stratospheric Ozone

---

*Stana Simic (BOKU)*

The major part of atmospheric ozone (about 90 %) is found in the stratosphere in heights of 15 to 55 km. The maximum concentration varies with latitude and season between heights of 20 and 25 km. Ozone has the ability to strongly absorb UV radiation. Therefore no radiation with wavelengths shorter than 290 nm (harmful UV-C radiation) reaches the Earth's surface and its lifeforms. Thus the ozone layer is an essential part for the wellbeing of life on Earth. Considering the heavy ozone depletion of the past decades it is of outermost importance to precisely and continuously monitor stratospheric ozone.

As scientists of the British Antarctic Survey (Farman et al, 1985) discovered the extremely low ozone values over Antarctica in 1985, anthropogenic Chlorofluorocarbons (CFCs) could be identified as the main cause. The following years a global depletion of ozone was found. These findings lead to the 1987 international Montreal Protocol to limit further emissions of CFCs. The protocol proved to be successful when research showed that the concentration of CFCs was decreasing since the mid-1990s.

### Measurements of Stratospheric Ozone in Austria

Total ozone column has continuously been measured at the High-Alpine Observatory Hoher Sonnblick since 1994 and is the only ozone measurement station in Austria. Measurements are carried out by the Institute of Meteorology of "University of Natural Resources and Life Sciences" (BOKU) and are financed by the "Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management" (BMLFUW). The data fulfils the high-quality standards of the "Network for the Detection of Atmospheric Composition Change" (NDACC). Ozone is measured with a Brewer MkIV spectrophotometer which is maintained regularly by the Institute of Meteorology at BOKU.

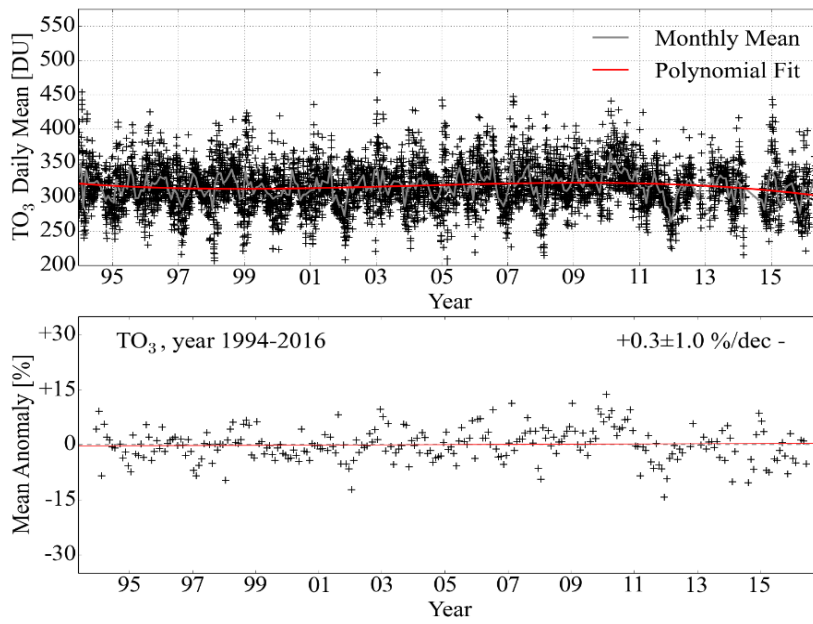
### Total Ozone Column

The long-term dataset of total ozone is one of the longest in all of Europe. It is a fundamental part in understanding the ozone layer above Austria in its present state and to predict its future development and changes. The Montreal Protocol proves successful because the reduction in the concentration of ozone-depleting substances has led to a slight recovery in total ozone which can be observed. At the same time, an increase in total ozone variability, caused by the changing meteorological parameters under the changing global climate, can be seen. Because of these climate-ozone interactions, it is very important to closely monitor the ozone layer under the influence of our future changing climate.

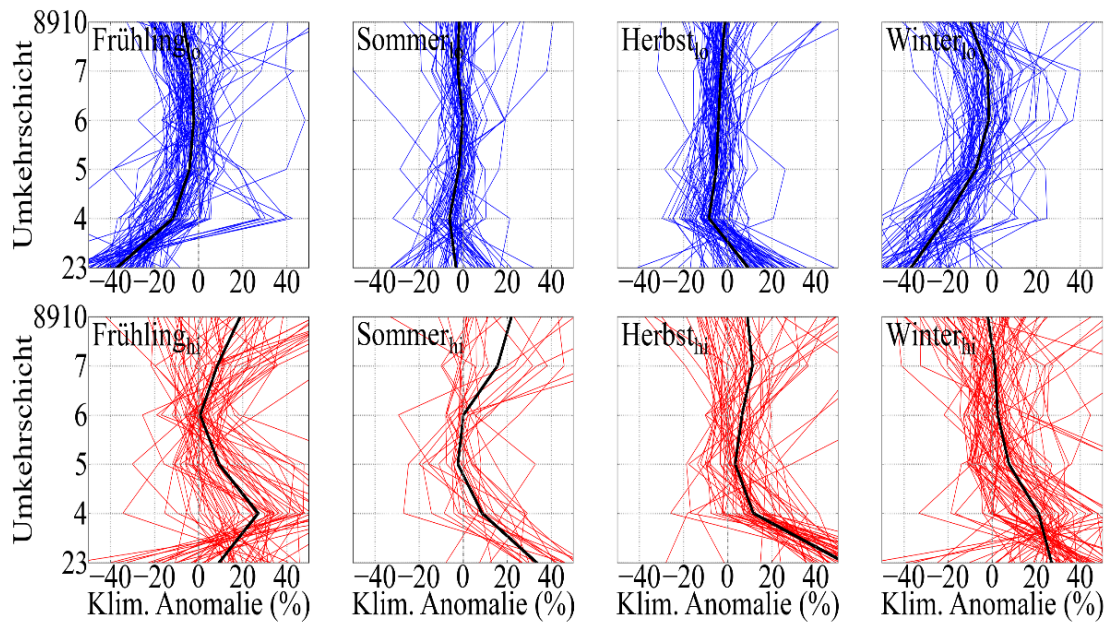
### Vertically Resolved Ozone – Umkehr Layers

Vertical ozone profiles can be measured with the Brewer spectrophotometer too and are routinely produced since 1994, using the so called Umkehr-method. These profiles are interesting because the influencing factors on the top of the stratosphere are entirely different to the bottom. Near the tropopause (approx. 15 km) dynamic influences dominate ozone concentration while near the stratopause (approx. 50 km) photochemical processes prevail.





**Figure 20** Daily Mean (upper graph) and trend in mean anomalies of total ozone measured at Hoher Sonnblick Observatory in 1994-2016.



**Figure 21** Seasonal anomalies of vertical ozone compared to the climatological mean. Red represents high-ozone and blue low-ozone events.

Essential Climate Variables – Atmospheric Observations - Composition

Parameter measured/observed	total ozone column and vertical ozone profiles
Starting date	01.01.1994
Temporal Resolution	Daily datasets of total ozone and vertically resolved ozone.
Observational Network	Sonnblick Observatory
Stations	A Brewer MkIV spectrophotometer located at High Alpine Observatory Hoher Sonnblick.
Data Portal	NDACC: <a href="http://www.ndsc.ncep.noaa.gov/data/">http://www.ndsc.ncep.noaa.gov/data/</a> BOKU: <a href="https://imp.boku.ac.at/Strahlung/messwert.htm">https://imp.boku.ac.at/Strahlung/messwert.htm</a>
Supervising Organization	BOKU, BMLFUW
National and/or international Networks or Programs	NDACC (Network for the Detection Atmospheric Composition Change)
Data Submission	The log Files of the Brewer instrument are transferred daily to a server at BOKU.
Licenses	general BOKU data conditions
Use Limitation	Use for research only
Data Format	ASCII
Data Access	Total ozone column is made publicly available at: <a href="https://imp.boku.ac.at/Strahlung/messwert.htm">https://imp.boku.ac.at/Strahlung/messwert.htm</a> and <a href="http://teletext.orf.at/600/644_0006.htm">http://teletext.orf.at/600/644_0006.htm</a>
Data Quality	High-quality standard of NDACC
Performance Monitoring	The instrument and data availability are supervised by the work group „UV Radiation and Ozone“ at the Institute of Meteorology at University of Natural Resources and Life Sciences, Vienna (BOKU).
Publications	Publications are listed here: <a href="http://www.wau.boku.ac.at/en/met/forschungsthemen/atmosphaerische-strahlung/forschungsbereich-uv-strahlung-und-gesamtozon/publikationen/">http://www.wau.boku.ac.at/en/met/forschungsthemen/atmosphaerische-strahlung/forschungsbereich-uv-strahlung-und-gesamtozon/publikationen/</a>
Contact (National correspondent, focal point)	Dr. Stana Simic BOKU Wien, Institut für Meteorologie Department für Wasser-Atmosphäre-Umwelt Gregor-Mendel-Straße 33, 1180 Wien Telefon: (+43) (0)1 47654-81430, <a href="http://www.wau.boku.ac.at/met.html">www.wau.boku.ac.at/met.html</a>
Remarks	

## Air quality monitoring network

Iris Buxbaum (UBA)

The Environment Agency Austria (Umweltbundesamt) operates the Austrian background monitoring network. Air pollutants and meteorological parameters are measured at seven stations (figure 22).

The objectives of the measurements are the assessment of

- the large-scale background levels,
- the trend of background levels,
- the long-range transport of air pollutants and
- the monitoring of compliance with limit and target values for the protection of human health and for the protection of ecosystems and vegetation according to the Ozone Act, the Ambient Air Quality Act and related ordinances.

Some of these stations are integrated into international measuring programs. Three of the sites (Illmitz, Vorhegg and Zöbelboden) are part of the European Monitoring and Evaluation Programme (EMEP) under the Convention on Long-range Transboundary Air Pollution (CLRTAP). The Zöbelboden site is also integrated into the Integrated Monitoring measurement program of the UNECE for long-term ecosystem monitoring. The monitoring site at Sonnblick is part of the "Global Atmosphere Watch" program (GAW) of the World Meteorological Organization (WMO). The measurements are used for the investigation of large-scale pollutant transports across Central Europe and the long-term monitoring of pollutant trends in the alpine region.

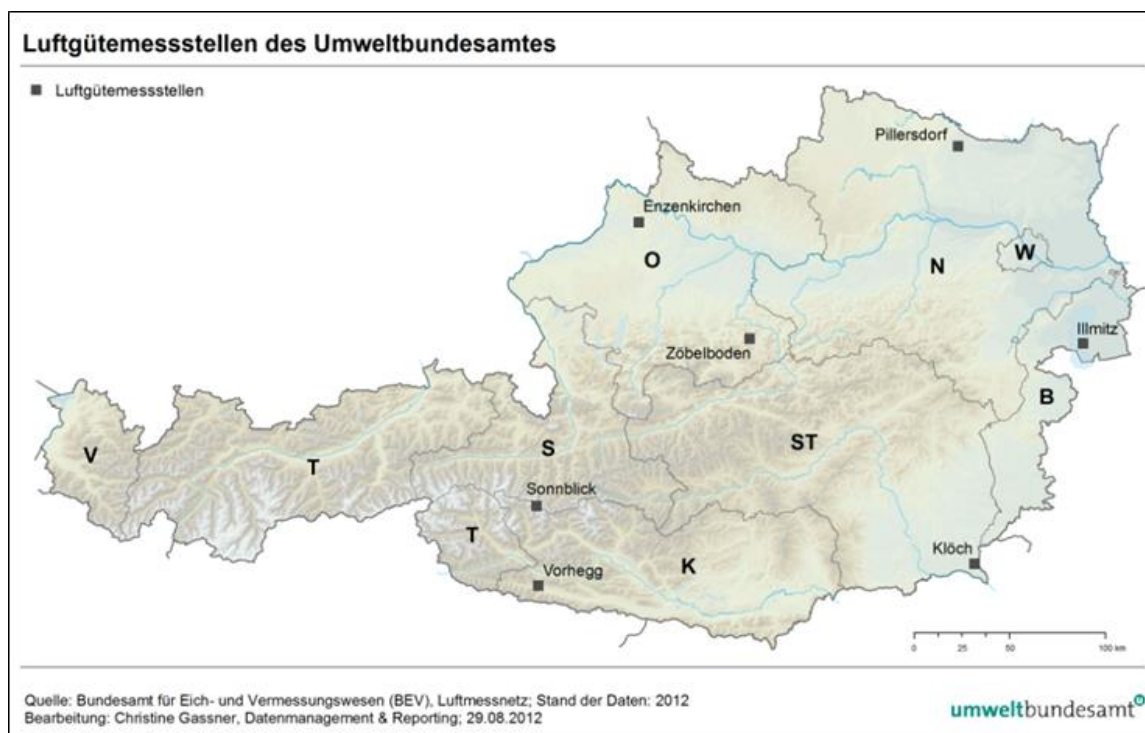


Figure 22 Network of air quality monitoring stations of the Environment Agency Austria.

Essential Climate Variables – Atmospheric Observations - Composition

<b>Parameter measured/observed</b>	<p>ozone, sulfur dioxide, nitrogen oxides, carbon monoxide, carbon dioxide, methane, particulate matter (PM<sub>10</sub>, PM<sub>2,5</sub>, PM<sub>1</sub>), heavy metals (As, Cd, Hg, Ni, Pb), PAH, VOC, EC/OC</p> <p>air temperature and humidity, wind speed and direction, pressure, precipitation, sunshine duration, global radiation, surface radiation budget</p>
<b>Starting date</b>	<p>Enzenkirchen since 03.06.1998                  Illmitz since 01.01.1978                  Klöch since 01.08.1995                  Pillersdorf since 27.02.1992                  Sonnblick since 01.01.1989                  Vorhegg since 11.12.1990                  Zöbelboden since 01.09.1993</p>
<b>Temporal Resolution</b>	<p>Half-hour mean values, daily mean values for gravimetric particulate matter measurements, monthly and yearly mean values for heavy metals, PAH, VOC, EC/OC</p>
<b>Observational Network</b>	<p>Austrian background air quality monitoring network according to the Austrian Ambient Air Quality Act and Ozone Act</p>
<b>Stations</b>	<p>Enzenkirchen, Illmitz, Klöch, Pillersdorf, Sonnblick, Vorhegg, Zöbelboden</p> <p><a href="https://www.umweltbundesamt.at/umweltthemen/luft/messnetz/unsere-luftguetemessstellen">https://www.umweltbundesamt.at/umweltthemen/luft/messnetz/unsere-luftguetemessstellen</a></p>
<b>Data Portal</b>	<p>Contact: <a href="mailto:luft@umweltbundesamt.at">luft@umweltbundesamt.at</a></p> <p>Webpage:  <a href="https://www.umweltbundesamt.at/umweltthemen/luft/daten-luft">https://www.umweltbundesamt.at/umweltthemen/luft/daten-luft</a></p> <p>Open Data Portal for Ozone:  <a href="https://www.data.gv.at/katalog/dataset/8b3b3cdf-2be6-4f0b-8c86-f6be67e5b002">https://www.data.gv.at/katalog/dataset/8b3b3cdf-2be6-4f0b-8c86-f6be67e5b002</a></p> <p>European Air Quality Portal (by EEA -European Environment Agency): <a href="https://aqportal.discomap.eea.europa.eu/">https://aqportal.discomap.eea.europa.eu/</a></p> <p>Data from Sonnblick site: GAW World Data Centre for Reactive Gases (WDCRG, <a href="http://www.gaw-wdcr.org/">http://www.gaw-wdcr.org/</a>) and World Data Centre for Greenhouse Gases (WDCGG, <a href="https://gaw.kishou.go.jp/">https://gaw.kishou.go.jp/</a>)</p> <p>Data from EMEP-sites: <a href="http://ebas.nilu.no/">http://ebas.nilu.no/</a></p>
<b>Supervising Organization</b>	<p>Umweltbundesamt (Environment Agency Austria)  <a href="http://www.umweltbundesamt.at">www.umweltbundesamt.at</a></p>

<b>National and/or international Networks or Programs</b>	GAW - Global Atmosphere Watch Programme ( <a href="https://community.wmo.int/activity-areas/gaw">https://community.wmo.int/activity-areas/gaw</a> ) EMEP - European Monitoring and Evaluation Programme ( <a href="http://www.emep.int/">http://www.emep.int/</a> )
<b>Data Submission</b>	Up-to-date air quality data and yearly submission of validated data
<b>Licenses</b>	CC BY 3.0 AT <a href="http://creativecommons.org/licenses/by/3.0/at/deed.de">http://creativecommons.org/licenses/by/3.0/at/deed.de</a>
<b>Use Limitation</b>	No limitations, references to data sources are obligatory.
<b>Data Format</b>	Download of the data as csv (European Air Quality Portal, WDCGG), as NASA-Ames Files (EMEP, WDCRG) or as .json (OpenData Portal for Ozone) Contact <a href="mailto:luft@umweltbundesamt.at">luft@umweltbundesamt.at</a> for data as .xlsx
<b>Data Access</b>	Download via various data portals (see <b>Data Portal</b> ) or contact <a href="mailto:luft@umweltbundesamt.at">luft@umweltbundesamt.at</a> Open access
<b>Data Quality</b>	Data quality control is done by the Environment Agency Austria according to the requirements of the Directive 2008/50/EC and Directive 2004/107/EC. Data quality objectives as laid down in Directive 2008/50/EC and Directive 2004/107/EC. Up-to-date data are not validated.
<b>Performance Monitoring</b>	Data availability is supervised by the Environment Agency Austria.
<b>Publications</b>	Monthly and yearly reports (in German, download via <a href="https://www.umweltbundesamt.at/luft-monatsberichte">https://www.umweltbundesamt.at/luft-monatsberichte</a> and <a href="https://www.umweltbundesamt.at/luft-jahresberichte">https://www.umweltbundesamt.at/luft-jahresberichte</a> )
<b>Contact (National correspondent, focal point)</b>	Contact: <a href="mailto:luft@umweltbundesamt.at">luft@umweltbundesamt.at</a>
<b>Remarks</b>	

## Air quality monitoring of the federal states of Austria

*Elisabeth Scheicher (Amt der NÖ Landesregierung)*

Air pollution control in Austria is the responsibility of the individual countries.

At the air quality stations the parameters SO<sub>2</sub>, NO<sub>x</sub>, CO, O<sub>3</sub>, PM<sub>10</sub>, PM<sub>2,5</sub> are measured. Additionally the meteorological parameters wind speed, wind direction, temperature and at a few stations radiation balance, global radiation and relative humidity are observed.

A detailed overview of the position of the measuring points and the measured parameters can be found in the report "AIR QUALITY MONITORING SITES IN AUSTRIA 2017"

<http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0607.pdf>

The measured values are recorded and stored as half-hour values in the database. The quality assurance is carried out by the technicians of each office of the regional government. An annual comparison with the Umweltbundesamt ensures the comparability of the measurements in Austria.

### Overview of the individual measuring networks:

#### **Burgenland**

*Gabriele Wieger (Amt der Burgenländischen Landesregierung)*

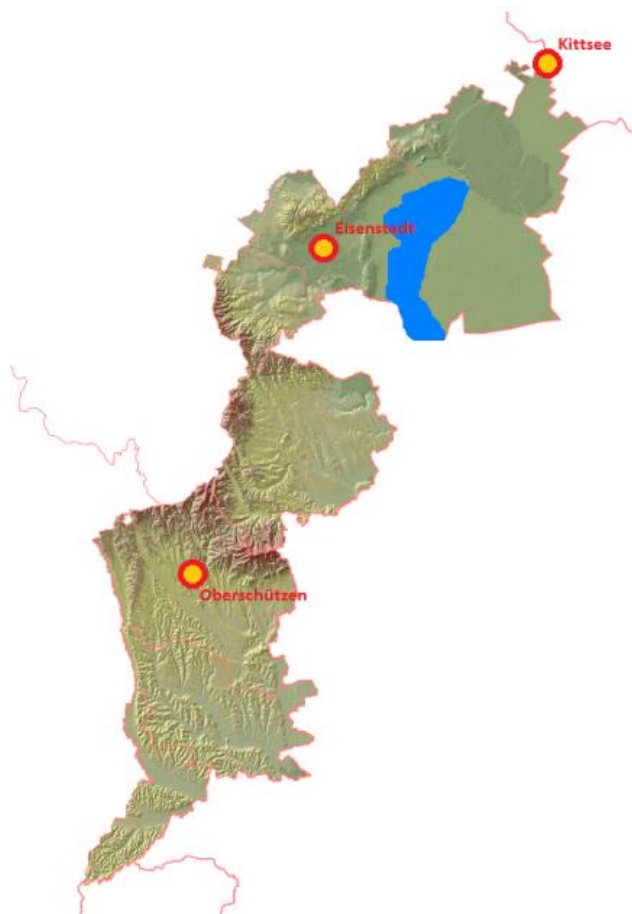


Figure 23 Monitoring stations, Burgenland.

**Essential Climate Variables - Atmospheric Observations – Composition**

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , BTEX, wind, air temperature, global radiation, relative humidity
<b>Starting date</b>	1994 (only few stations), the development of the whole network was done in 1997
<b>Temporal Resolution</b>	Half-hour mean values , BTEX as yearly mean values, PM <sub>2,5</sub> as daily mean values
<b>Observational Network</b>	Burgenländisches Luftgütemessnetz
<b>Stations</b>	3 fix and 3 mobile stations
<b>Data Portal</b>	<a href="http://www.burgenland.at/themen/umwelt/luftguete">http://www.burgenland.at/themen/umwelt/luftguete</a>
<b>Supervising Organization</b>	Amt der Burgenländischen Landesregierung
<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	Half-hourly
<b>Licenses</b>	none
<b>Use Limitation</b>	none
<b>Data Format</b>	MySQL-Datenbank
<b>Data Access</b>	Download via various data portals (see Data Portal) or contact <a href="mailto:post.a4-luft@bgld.gv.at">post.a4-luft@bgld.gv.at</a> Open access
<b>Data Quality</b>	Data quality control is done by Amt der Burgenländischen Landesregierung
<b>Performance Monitoring</b>	Data availability is supervised by the Amt der Burgenländischen Landesregierung
<b>Publications</b>	Monthly and yearly reports, and also reports of special measurements
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:post.a4-luft@bgld.gv.at">post.a4-luft@bgld.gv.at</a>
<b>Remarks</b>	



## Carinthia

Gerhard Heimburger (Amt der Kärntner Landesregierung)

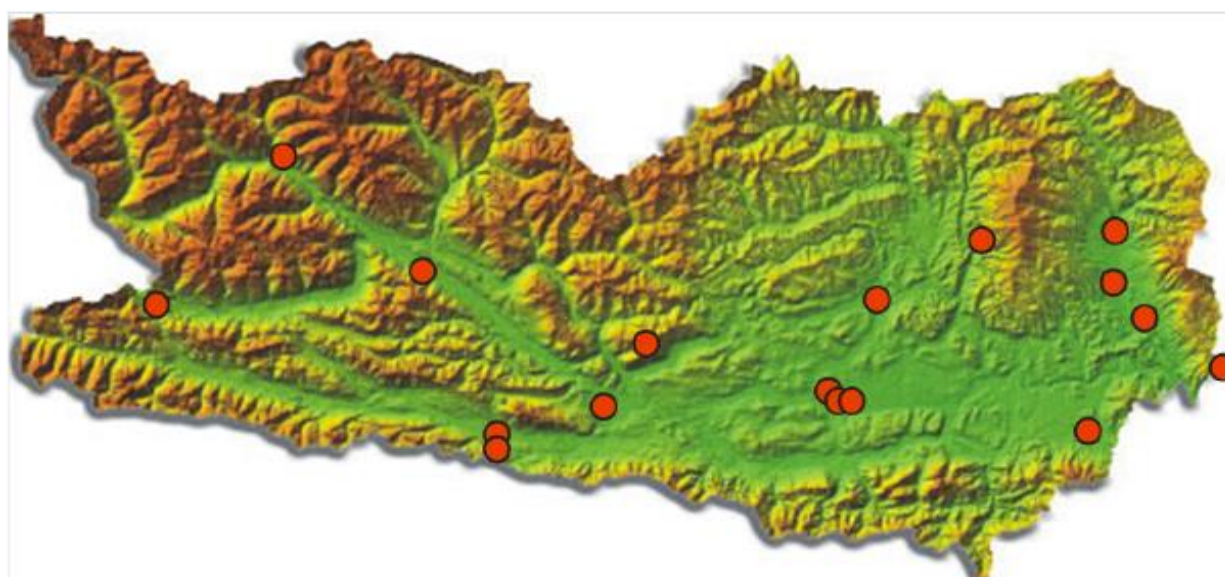


Figure 24 Monitoring stations, Carinthia.

### Essential Climate Variable - Atmospheric Observation – Composition

**Parameter measured/observed**

Sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>, NO, NO<sub>2</sub>), ozone (O<sub>3</sub>), fine dust (PM<sub>10</sub>, PM<sub>2,5</sub>), carbon monoxide (CO), benzene, benzo(a)pyrene (B(a)P), heavy metals in PM<sub>10</sub> (lead, cadmium), meteorological parameters (air temperature, relative humidity, wind direction, wind speed)



<b>Starting date</b>	From late 1990 onwards
<b>Temporal Resolution</b>	Half-hourly, daily, monthly and annual means
<b>Observational Network</b>	LGMK
<b>Stations</b>	Circa 25 air quality measurement stations in Carinthia
<b>Data Portal</b>	<p><a href="http://www.umwelt.ktn.gv.at/luft/">www.umwelt.ktn.gv.at/luft/</a>  <a href="http://www.umweltbundesamt.at/luft">www.umweltbundesamt.at/luft</a></p> <p>Meteorological data only on request since they are mainly used for the assessment of the recorded air pollutant concentrations or air pollutant dispersion conditions, and therefore generally neither published nor transmitted to other data networks</p>
<b>Supervising Organization</b>	Provincial Government of Carinthia, Department 8 – Environment, Water and Nature Protection, Subdivision Ecology and Monitoring, Emission Control
<b>National and/or international Networks or Programs</b>	None
<b>Data Submission</b>	Half-year to annual mean values, transmission path of the continuously recorded measurement data is UMTS, the data are forwarded to the Austrian immission data network (IDV)
<b>Licenses</b>	None
<b>Use Limitation</b>	None
<b>Data Format</b>	ODV = Data format of the Austrian immission data network
<b>Data Access</b>	<p>Generation of Austrian wide uniform time-series through the website of the Umweltbundesamt GmbH  <a href="http://www.umweltbundesamt.at/luft/">www.umweltbundesamt.at/luft/</a></p> <p>Region wide to a limited extent through  <a href="http://www.umwelt.ktn.gv.at/luft/">www.umwelt.ktn.gv.at/luft/</a></p> <p>Meteorological data only on request since they are mainly used for the assessment of the recorded air pollutant concentrations or air pollutant dispersion conditions, and therefore generally neither published nor transmitted to other data networks</p>
<b>Data Quality</b>	Daily data checks are performed by the Provincial Government of Carinthia, Department 8 – Environment, Water and Nature Protection, Subdivision Ecology and Monitoring, Emission Control. From this point the data are considered as seen and are referred to as provisional data. Final inspection is carried out within the framework of the preparation of the annual report - from this point they are also available to fulfil the national reporting requirements (UBA-EU).

	The comparability and traceability of the measured data is ensured by at least one annual link to primary or reference standards of a reference laboratory and by the regular participation in ring tests.
<b>Performance Monitoring</b>	Provincial Government of Carinthia, Department 8 – Environment, Water and Nature Protection, Subdivision Ecology and Monitoring, Emission Control
<b>Publications</b>	According to the IG-L or Ozone Law, daily reports, monthly reports and annual reports are created and published  <a href="http://www.umwelt.ktn.gv.at/luft/">www.umwelt.ktn.gv.at/luft/</a>
<b>Contact (National correspondent, focal point)</b>	Provincial Government of Carinthia, Department 8 – Environment, Water and Nature Protection, Subdivision Ecology and Monitoring, Emission Control <a href="mailto:Abt8.post@ktn.gv.at">Abt8.post@ktn.gv.at</a>  Umweltbundesamt GmbH, Spittelauer Lände 5, 1090 Wien <a href="mailto:office@umweltbundesamt.at">office@umweltbundesamt.at</a>
<b>Remarks</b>	

## Lower Austria

Elisabeth Scheicher (Amt der NÖ Landesregierung)



Figure 25 Monitoring stations, Lower Austria (NÖ).

Essential Climate Variable - Atmospheric Observation – Composition

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , B(a)P, wind, temperature, radiation balance, global radiation, relative humidity
<b>Starting date</b>	01.10.1984 (only a few station) the development of the whole network was done in 1990
<b>Temporal Resolution</b>	30 minute values
<b>Observational Network</b>	NUMBIS (Niederösterreichisches Umwelt- Beobachtungs- und Informationssystem)
<b>Stations</b>	42 stations as part of the air quality network
<b>Data Portal</b>	<a href="https://www.data.gv.at/">https://www.data.gv.at/</a> <a href="http://numbis.noel.gv.at/numbis/diagramme.jsp">http://numbis.noel.gv.at/numbis/diagramme.jsp</a> <a href="mailto:post.bd4numbis@noel.gv.at">post.bd4numbis@noel.gv.at</a>
<b>Supervising Organization</b>	Amt der NÖ Landesregierung
<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	<a href="https://www.data.gv.at/">https://www.data.gv.at/</a> : Hourly, but only one complete day available <a href="http://numbis.noel.gv.at/numbis/diagramme.jsp">http://numbis.noel.gv.at/numbis/diagramme.jsp</a> previous and actual year, half mean values, hourly and daily mean values
<b>Licenses</b>	Measurements are disseminated free of charge.
<b>Use Limitation</b>	none
<b>Data Format</b>	xls, csv, txt, ascii, pdf
<b>Data Access</b>	Open access for data.gv.at Open access for <a href="http://numbis.noel.gv.at/numbis/diagramme.jsp">http://numbis.noel.gv.at/numbis/diagramme.jsp</a> Access by contact via mail to numbis.at ( <a href="mailto:post.bd4numbis@noel.gv.at">post.bd4numbis@noel.gv.at</a> )
<b>Data Quality</b>	Quality control is done by Amt der NÖ Landesregierung
<b>Performance Monitoring</b>	by Amt der NÖ Landesregierung
<b>Publications</b>	Monthly and annual report published at <a href="http://www.numbis.at/publikationen">www.numbis.at/publikationen</a>
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:post.bd4numbis@noel.gv.at">post.bd4numbis@noel.gv.at</a>
<b>Remarks</b>	

## Upper Austria

Regina Pürmayr (Amt der OÖ Landesregierung)

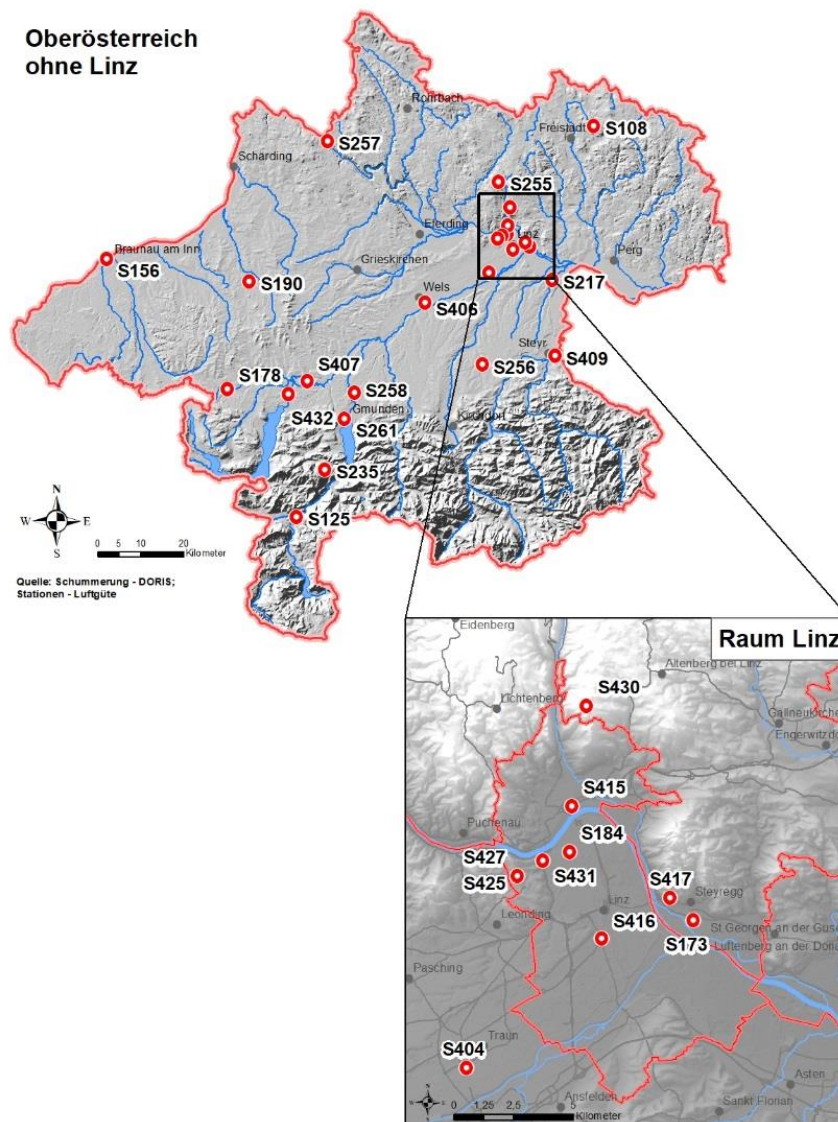


Figure 26 Monitoring stations, Upper Austria (OÖ).

### Essential Climate Variable - Atmospheric Observation – Composition

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , B(a)P, benzene, heavy metals, wind, temperature, radiation balance, global radiation, relative humidity, light pollution
------------------------------------	--

<b>Starting date</b>	01.02.1977 (only a few stations) the development of the main network was done in 1984, but the locations of various stations have changed since then
<b>Temporal Resolution</b>	B(a)P and benzene monthly, heavy metals yearly, PM <sub>10</sub> and PM <sub>2,5</sub> daily, other 30 minute values
<b>Observational Network</b>	OÖ Luftmessnetz
<b>Stations</b>	19 stations as part of the air quality network
<b>Data Portal</b>	<a href="http://www.land-oberoesterreich.gv.at/Luftgüte_und_Meteorologie">www.land-oberoesterreich.gv.at/Luftgüte_und_Meteorologie</a> <a href="http://www.land-oberoesterreich.gv.at/Lichtmessnetz">www.land-oberoesterreich.gv.at/Lichtmessnetz</a> <a href="http://www.land-oberoesterreich.gv.at/OpenData">www.land-oberoesterreich.gv.at/OpenData</a> <a href="http://www.data.gv.at/">www.data.gv.at/</a> <a href="mailto:us-goethe.post@ooe.gv.at">us-goethe.post@ooe.gv.at</a>
<b>Supervising Organization</b>	Amt der Oö Landesregierung
<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	Half-Hourly
<b>Licenses</b>	Measurements are disseminated free of charge.
<b>Use Limitation</b>	none
<b>Data Format</b>	xls, csv, txt, ascii, json
<b>Data Access</b>	Open access for data.gv.at Access by contact via mail to Land Oberösterreich ( <a href="mailto:us-goethe.post@ooe.gv.at">us-goethe.post@ooe.gv.at</a> )
<b>Data Quality</b>	Quality control is done by Amt der Oö Landesregierung
<b>Performance Monitoring</b>	by Amt der Oö Landesregierung
<b>Publications</b>	Monthly and annual report published at Luftgüteberichte und Messprogramme
<b>Contact (National correspondent, focal point)</b>	Amt der Oö Landesregierung Direktion Umwelt und Wasserwirtschaft Abteilung Umweltschutz 4021 Linz, Goethestraße86 <a href="mailto:us-goethe.post@ooe.gv.at">us-goethe.post@ooe.gv.at</a>
<b>Remark</b>	



## Salzburg

Alexander Kranabetter (Amt der Salzburger Landesregierung)

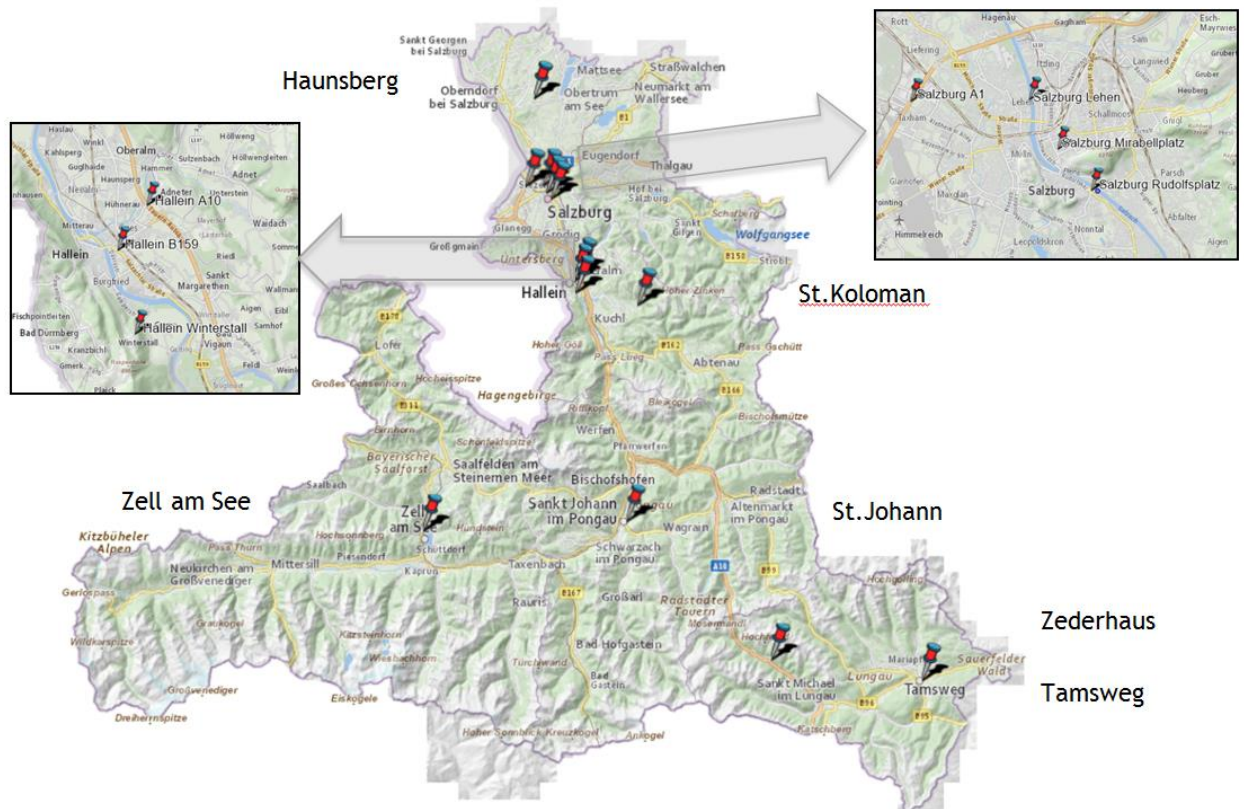


Figure 27 Monitoring stations, Salzburg.

## Essential Climate Variable - Atmospheric Observation – Composition

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , B(a)P, EC, particle number, benzene, heavy metals, wind, temperature, radiation balance, global radiation, relative humidity
<b>Starting date</b>	01.10.1978 (only a few stations) the development of the whole network was done in 1988
<b>Temporal Resolution</b>	B(a)P, EC, heavy metals yearly, PM <sub>10</sub> and PM <sub>2,5</sub> daily, other 30 minutes value
<b>Observational Network</b>	Section 5, Salzburger Luftgütemessnetz
<b>Stations</b>	16 stations as part of the air quality network
<b>Data Portal</b>	<a href="https://www.salzburg.gv.at/themen/umwelt/luft">https://www.salzburg.gv.at/themen/umwelt/luft</a> <a href="http://service.salzburg.gv.at/ogd/client/luftmessnetz@salzburg.gv.at">http://service.salzburg.gv.at/ogd/client/luftmessnetz@salzburg.gv.at</a>
<b>Supervising Organization</b>	Amt der Salzburger Landesregierung

<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	Half-Hourly
<b>Licenses</b>	Measurements are disseminated free of charge
<b>Use Limitation</b>	none
<b>Data Format</b>	csv
<b>Data Access</b>	Open access for data by <a href="http://service.salzburg.gv.at/ogd/client/">http://service.salzburg.gv.at/ogd/client/</a>
<b>Data Quality</b>	Quality control suits to Immissionsschutzgesetz & RL 2008/50/EG
<b>Performance Monitoring</b>	by Amt der Salzburger Landesregierung
<b>Publications</b>	Daily, monthly and annual reports: <a href="https://www.salzburg.gv.at/themen/umwelt/luft/luftberichte">https://www.salzburg.gv.at/themen/umwelt/luft/luftberichte</a>
<b>Contact (National correspondent, focal point)</b>	Land Salzburg Abteilung 5: Natur- und Umweltschutz, Gewerbe Referat 5/02: Immissionschutz Ulrich-Schreier-Straße 18, 5020 Salzburg Telefon: +43 662 8042-4592 Email: <a href="mailto:luftmessnetz@salzburg.gv.at">luftmessnetz@salzburg.gv.at</a>
<b>Remarks</b>	



## Styria

Thomas Pongratz (Amt der Steiermärkischen Landesregierung)

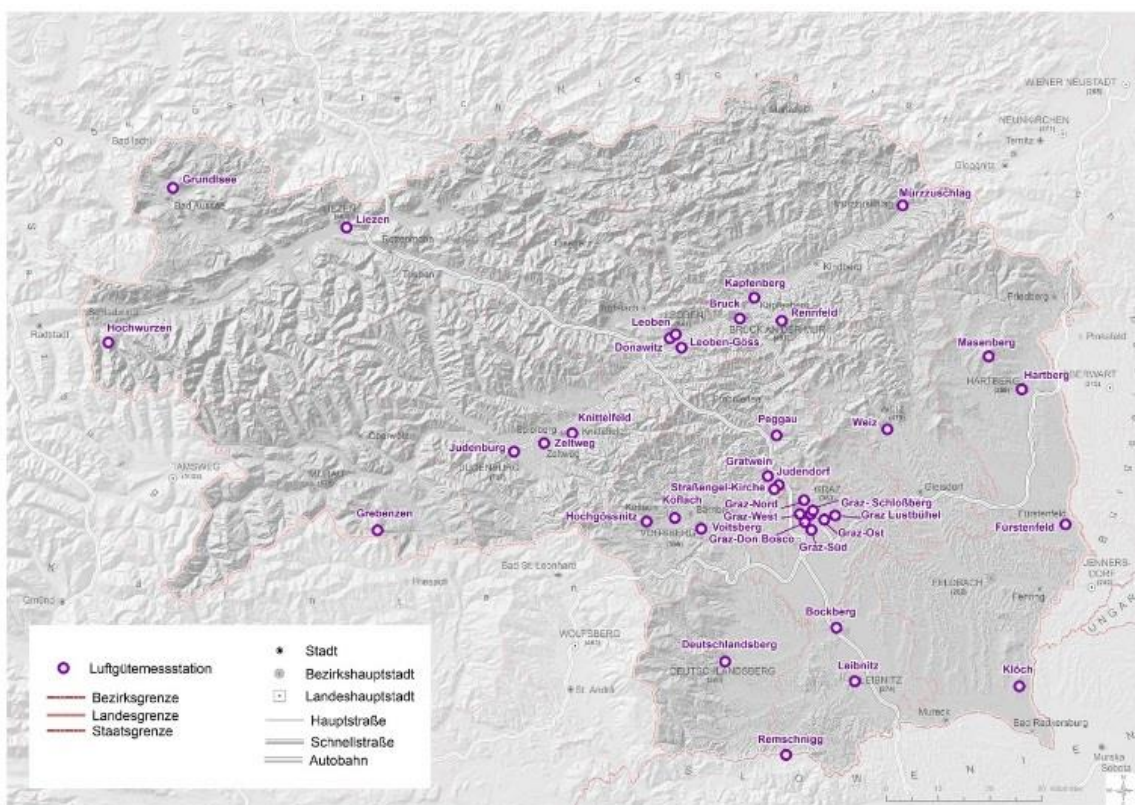


Figure 28 Monitoring stations, Styria.

### Essential Climate Variable - Atmospheric Observations - Composition

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , B(a)P, benzene wind speed and direction, temperature, , global radiation relative humidity
<b>Starting date</b>	Data since 1989 are stored in the Air quality database
<b>Temporal Resolution</b>	30 minute values
<b>Observational Network</b>	LUIS (Landesumweltinformation Steiermark)
<b>Stations</b>	37 air quality monitoring stations + 8 meteorological stations
<b>Data Portal</b>	Air quality measurements: <a href="http://www.umwelt.steiermark.at/cms/ziel/2061730/DE/">www.umwelt.steiermark.at/cms/ziel/2061730/DE/</a> Meteorological measurements: <a href="http://www.umwelt.steiermark.at/cms/ziel/2061802/DE/">www.umwelt.steiermark.at/cms/ziel/2061802/DE/</a>  Online data portal: <a href="http://www.umwelt.steiermark.at/cms/ziel/2060750/DE/luft@stmk.gv.at">www.umwelt.steiermark.at/cms/ziel/2060750/DE/luft@stmk.gv.at</a>

<b>Supervising Organization</b>	Amt der Steiermärkischen Landesregierung
<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	twice an hour (30 minutes mean values)
<b>Licenses</b>	Measurements are disseminated free of charge. Disclaimer and terms of use: <a href="http://www.umwelt.steiermark.at/cms/beitrag/10795434/2054533/">www.umwelt.steiermark.at/cms/beitrag/10795434/2054533/</a>
<b>Use Limitation</b>	none
<b>Data Format</b>	Data are available as xls File.
<b>Data Access</b>	Free access via online data portal: <a href="http://www.umwelt.steiermark.at/cms/ziel/2060750/DE/">www.umwelt.steiermark.at/cms/ziel/2060750/DE/</a> :
<b>Data Quality</b>	Quality control is done by Amt der Steiermärkischen Landesregierung
<b>Performance Monitoring</b>	Performance monitoring is done by Amt der Steiermärkischen Landesregierung.
<b>Publications</b>	<ul style="list-style-type: none"> <li>⇒ Monthly and annual data reports</li> <li>⇒ Air Quality plans and Programs</li> <li>⇒ Reports of mobile air quality measurements.</li> <li>⇒ Studies concerning Air Quality</li> </ul> <p>were published at <a href="http://www.umwelt.steiermark.at/cms/ziel/18437939/DE/">www.umwelt.steiermark.at/cms/ziel/18437939/DE/</a></p>
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:luft@stmk.gv.at">luft@stmk.gv.at</a>
<b>Remarks</b>	

## Tyrol

Walter Egger (Amt der Tiroler Landesregierung)

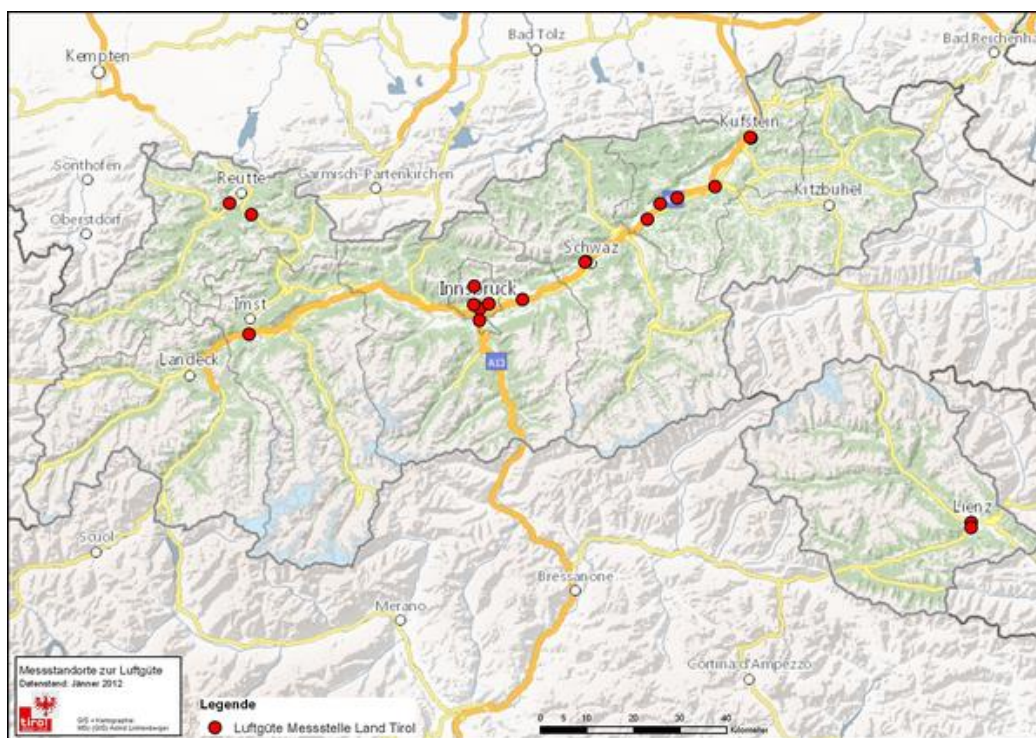


Figure 29 Monitoring stations, Tyrol.

## Essential Climate Variable - Atmospheric Observations – Composition

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , B(a)P, wind, temperature, global radiation, relative humidity
<b>Starting date</b>	1973 (only a few stations) most of the development of the actual network was done within 1995 and 2005.
<b>Temporal Resolution</b>	30 minute values except gravimetric PM <sub>10</sub> -measurements (daily mean)
<b>Observational Network</b>	Tiroler Luftmessnetz
<b>Stations</b>	19 stations as part of the air quality network
<b>Data Portal</b>	Immissionsdatenverbund at the Umweltbundesamt Contact Person: Spangl Wolfgang <a href="mailto:wolfgang.spangl@umweltbundesamt.at">wolfgang.spangl@umweltbundesamt.at</a> +43 (1) 31304 5861 Metadata: <a href="https://www.tirol.gv.at/umwelt/luftqualitaet/messnetz-galerie-webcams/">https://www.tirol.gv.at/umwelt/luftqualitaet/messnetz-galerie-webcams/</a>

<b>Supervising Organization</b>	Amt der Tiroler Landesregierung
<b>National and/or international Networks or Programs</b>	Immissionsdatenverbund at the Umweltbundesamt
<b>Data Submission</b>	Half-hourly
<b>Licenses</b>	Measurements are free of charge.
<b>Use Limitation</b>	none
<b>Data Format</b>	Contact: Spangl Wolfgang <a href="mailto:wolfgang.spangl@umweltbundesamt.at">wolfgang.spangl@umweltbundesamt.at</a> +43 (1) 31304 5861
<b>Data Access</b>	Contact: Spangl Wolfgang <a href="mailto:wolfgang.spangl@umweltbundesamt.at">wolfgang.spangl@umweltbundesamt.at</a> +43 (1) 31304 5861
<b>Data Quality</b>	Quality control is done by Amt der Tiroler Landesregierung; The quality control is carried out according to the requirements of the IG-L Messkonzeptverordnung and the Ozonmesskonzeptverordnung.
<b>Performance Monitoring</b>	by Amt der Tiroler Landesregierung/Abt.Waldschutz/Fachbereich Luftgüte
<b>Publications</b>	Monthly and annual report published at <a href="https://www.tirol.gv.at/umwelt/luftqualitaet/messwerte-berichte/">https://www.tirol.gv.at/umwelt/luftqualitaet/messwerte-berichte/</a>
<b>Contact (National correspondent, focal point)</b>	Contact: Spangl Wolfgang <a href="mailto:wolfgang.spangl@umweltbundesamt.at">wolfgang.spangl@umweltbundesamt.at</a> +43 (1) 31304 5861
<b>Remarks</b>	

## Vorarlberg

Bernhard Anwander (Institut für Umwelt und Lebensmittelsicherheit des Landes Vorarlberg)

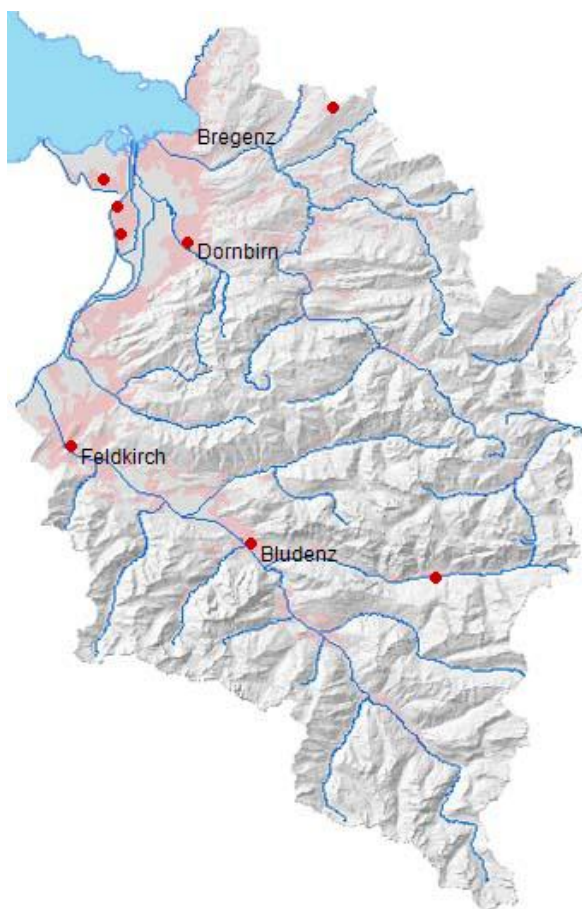


Figure 30 Monitoring stations, Vorarlberg.

### Essential Climate Variable - Atmospheric Observation –Composition

<b>Parameter measured/observed</b>	SO <sub>2</sub> , NO <sub>x</sub> , NO, NO <sub>2</sub> , CO, O <sub>3</sub> , PM <sub>10</sub> , PM <sub>2,5</sub> , B(a)P, benzene, heavy metals, EC/OC, wind, temperature, radiation balance, global radiation, relative humidity
<b>Starting date</b>	some data time series begins in 1980, but stations may vary
<b>Temporal Resolution</b>	B(a)P, heavy metals, EC/OC, benzene every 4 <sup>th</sup> day, PM <sub>10</sub> and PM <sub>2,5</sub> daily, other 30 minutes value
<b>Observational Network</b>	Air quality monitoring network
<b>Stations</b>	9 stations as part of the air quality network



<b>Data Portal</b>	<a href="http://www.vorarlberg-luft.at">http://www.vorarlberg-luft.at</a>
<b>Supervising Organization</b>	Umweltinstitut des Landes Vorarlberg
<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	
<b>Licenses</b>	Measurements are disseminated free of charge.
<b>Use Limitation</b>	none
<b>Data Format</b>	xls, csv
<b>Data Access</b>	Access by contact via mail to Umweltinstitut ( <a href="mailto:umweltinstitut@vorarlberg.at">umweltinstitut@vorarlberg.at</a> )
<b>Data Quality</b>	Quality control is done by Umweltinstitut
<b>Performance Monitoring</b>	by Umweltinstitut
<b>Publications</b>	Daily, monthly and annual report published at <a href="https://vorarlberg.at/web/land-vorarlberg/contentdetailseite/-/asset_publisher/qA6AJ38txu0k/content/luftguete-monatsberichte-und-jahresberichte?article_id=168351">https://vorarlberg.at/web/land-vorarlberg/contentdetailseite/-/asset_publisher/qA6AJ38txu0k/content/luftguete-monatsberichte-und-jahresberichte?article_id=168351</a>
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:umweltinstitut@vorarlberg.at">umweltinstitut@vorarlberg.at</a>
<b>Remarks</b>	

## Vienna

Rainer Plank (MA22)

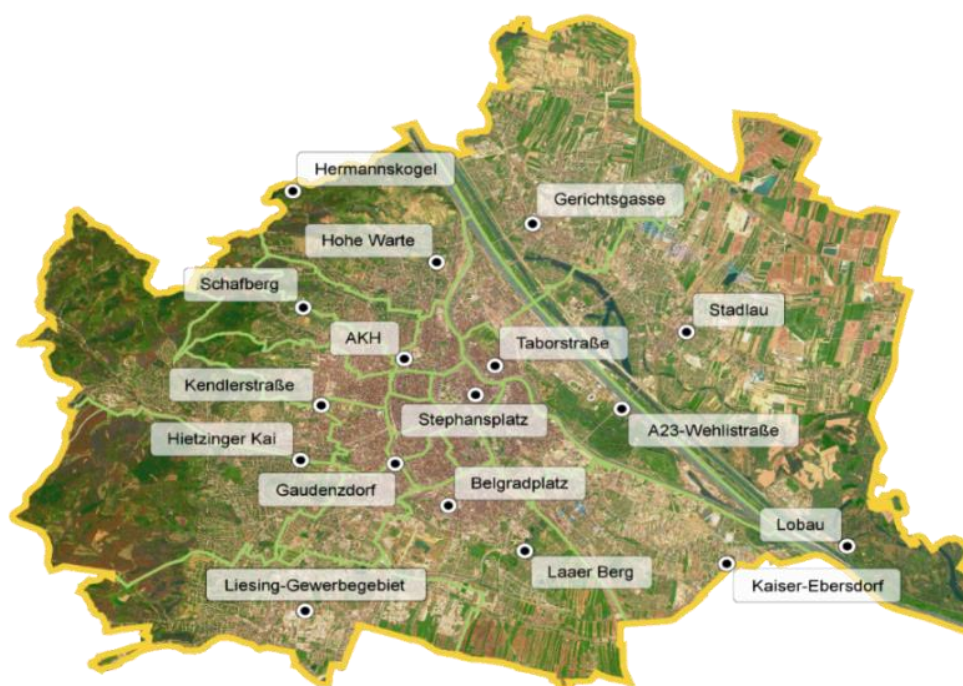


Figure 31 Monitoring stations, Vienna.

### Essential Climate Variable – Atmospheric Observations - Composition

<b>Parameter measured/observed</b>	wind direction, wind speed, air temperature, air pressure, sunshine duration, precipitation sulfur dioxide, nitrogen monoxide, nitrogen dioxide, carbon monoxide, ground-level ozone and particulate matter (PM <sub>10</sub> , PM <sub>2,5</sub> ), heavy metals (Pb, As, Cd, Ni), benzene, benzo(a)pyrene
<b>Starting date</b>	First monitoring sites in 1986
<b>Temporal Resolution</b>	Half-hourly averaged (not heavy metals, benzene, benzo(a)pyrene)
<b>Observational Network</b>	City of Vienna Municipal Department 22 – Environmental Protection Air Quality Monitoring Network
<b>Stations</b>	17 measuring stations located in Vienna (urban environment, traffic-oriented locations, recreation area and industrial zone)



<b>Data Portal</b>	<a href="https://www.wien.gv.at/ma22-lgb/luftgi.htm">https://www.wien.gv.at/ma22-lgb/luftgi.htm</a>
<b>Supervising Organization</b>	City of Vienna
<b>National and/or international Networks or Programs</b>	Environment Agency Austria (Umweltbundesamt) <a href="http://www.umweltbundesamt.at/">http://www.umweltbundesamt.at/</a>
<b>Data Submission</b>	real-time
<b>Licenses</b>	CC BY-NC
<b>Use Limitations</b>	For non-profit research
<b>Data Format</b>	on request (cvs, Excel, ...) or download or api
<b>Data Access</b>	Download via Municipal Department 22 – Environmental Protection in Vienna – homepage <a href="https://www.wien.gv.at/umwelt/luft/messwerte/berichte.html">https://www.wien.gv.at/umwelt/luft/messwerte/berichte.html</a> <a href="https://www.data.gv.at/">https://www.data.gv.at/</a> (Luftmessnetz: aktuelle Messdaten Wien)
<b>Data Quality</b>	Data quality control is done by Vienna’s Municipal Department 22
<b>Performance Monitoring</b>	Data availability is supervised by Vienna’s Municipal Department 22
<b>Publications</b>	daily, weekly, monthly and yearly reports Further publications on the dataset can be found at the web-site of Vienna’s Municipal Department 22: <a href="https://www.wien.gv.at/ma22-lgb/luftgi.htm">https://www.wien.gv.at/ma22-lgb/luftgi.htm</a> half-hourly averaged real time data <a href="https://www.data.gv.at/">https://www.data.gv.at/</a> (Luftmessnetz: aktuelle Messdaten Wien)
<b>Contact (National correspondent, focal point)</b>	Contact: <a href="mailto:luft@ma22.wien.gv.at">luft@ma22.wien.gv.at</a>
<b>Remarks</b>	

## Sonnblick Observatory - High-altitude research station

*Elke Ludewig (ZAMG)*

The Sonnblick Observatory is a high altitude research station in 3.106 m altitude and was established in 1886. Since then meteorological parameters have been recorded. Thus the Sonnblick Observatory provides climate time series of more than 130 years. In the 1980s, the Sonnblick Observatory was connected to the power supply system, which for the first time allowed measurements to be made in an almost emission-free environment. Since then, environmental monitoring has been continuously developed. The Sonnblick Observatory is operated by ZAMG (Zentralanstalt für Meteorologie und Geodynamik); however, the SBO is used by numerous institutions for monitoring tasks and research purposes. Measurements of trace gases started in 1998, measurements of greenhouse gases were added to the monitoring in 2012 in combination with aerosol measurements since 2010 and selected reactive gases since 2002. The Sonnblick Observatory is part of several international measuring networks, like NDACC (Network for the Detection of Atmospheric Composition Change) since 1997, BSRN (Baseline Surface Radiation Network) since 2011 and since 2016 it was upgraded to a global GAW (Global Atmosphere Watch) station. Beside the atmosphere the Sonnblick Observatory also focuses on the biosphere and the cryosphere considering the WMO programme GCW (Global Cryosphere Watch) and including measurements from the glacier Pasterze. The Sonnblick Observatory operates constantly, around the clock, all year long. A minimum of two technicians work at the site on a routine basis which is one important step of the data quality control. The data quality control is done in different steps starting directly at the observatory. The Sonnblick Observatory has got partner institution taking measurements at the site and contribute to the Sonnblick Observatory data set. Hence a part of the quality control is also done by the national partners like TU-Vienna, Umweltbundesamt or BOKU-Vienna, e.g. Data are uploaded yearly to the defined world data centres but can be also obtained via the Sonnblick Observatory and its partner institutions.



**Figure 32** The hut Zittelhaus and the Sonnblick Observatory in 2019



**Figure 33** The Sonnblick Observatory with its measuring platforms and towers. The observatory is located in Austria at the alpine ridge between the provinces Salzburg and Carinthia at 3.106m altitude. It was established in 1886 having the focus on atmosphere, cryosphere and biosphere. Research and monitoring is defined within the program called ENVISON (Environmental Research and Monitoring SONNBLICK).

---

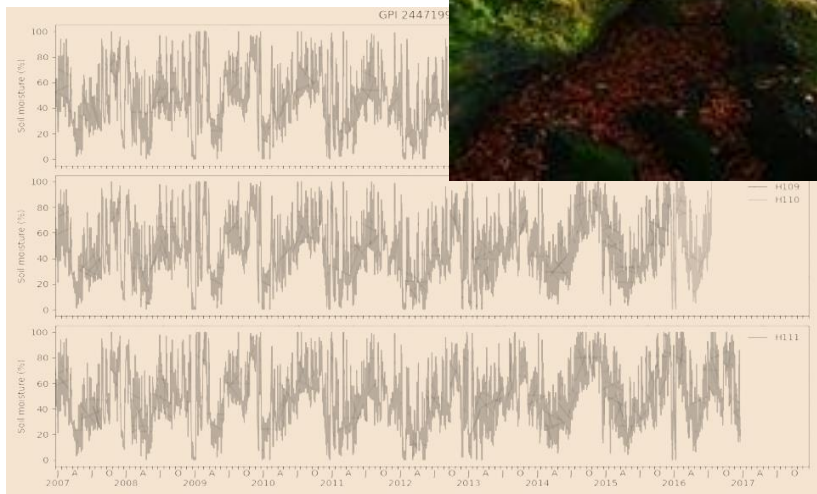
## Essential Climate Variables – Atmospheric Observations - Composition

---

<b>Parameter measured/observed</b>	<p><b>Meteorological parameters (1886 - ongoing)</b> air temperature, relative humidity resp. dew point temperature, precipitation, snow depth, air pressure, global radiation, direct beam solar radiation, wind speed, wind direction, sun shine duration, electrical field strength, clouds, visibility</p> <p><b>Additional meteorological parameters</b> <b>(2011 - ongoing):</b> direct radiation, diffuse radiation, global radiation, longwave radiation <b>(1994/97 - ongoing):</b> spectral UV, total column ozone, UV-B</p> <p><b>Trace gases, selected reactive gases</b> <b>(1989 - ongoing):</b> surface O<sub>3</sub> <b>(2002 - ongoing):</b> CO, NO, NO<sub>x</sub>, NO<sub>2</sub>, SO<sub>2</sub> <b>(2012 - ongoing):</b> CH<sub>4</sub>, CO<sub>2</sub></p> <p><b>Aerosols (2010-ongoing):</b> particulate mass concentration, mass concentration of major chemical components, particle number concentration, particle number size distribution, light absorption coefficient at 7 wavelengths, light scattering coefficient at 3 wavelengths,</p>
------------------------------------	--

	<p>equivalent black carbon (BC) concentration, total suspended particles matter (TSP)</p> <p><b>Precipitation Chemistry (1983/84-ongoing):</b> Hydrogen ion (H<sup>+</sup>) or pH in precipitation, electrical conductivity, inorganic anions (Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>), inorganic cations (Na<sup>+</sup>, NH<sub>4</sub><sup>+</sup>, K<sup>+</sup>, CA<sup>2+</sup>, Mg<sup>2+</sup>)</p> <p><b>Snow Chemistry (1987 - ongoing):</b> snow profiles, chloride, nitrate, sulfate, sodium, ammonium, potassium, magnesium, calcium, hydrogen</p> <p><b>Permafrost (2007/08 - ongoing):</b> temperature in different layers</p> <p><b>Glaciology</b> <b>(1986/87 - ongoing):</b> mass balance Goldbergkees <b>(1998/99 - ongoing):</b> mass balance Kleinfleiss Kees <b>(2012/13 - ongoing):</b> mass balance Pasterze mass change, meteorological data, outflow rate, snow coverage</p> <p><b>Radioactivity</b> <b>(1984 - ongoing):</b> ambient dose rate <b>(1996 - ongoing):</b> Be-7 <b>(2003 - ongoing):</b> Radon-222</p> <p><b>Air glow via GRIPS 16 Mesopause (80 - 100 km)</b> OH rational temperature, peak and band intensities</p>
<b>Starting date</b>	Measurements began in 1886 and the measuring program continues to evolve. Exact starting times of the respective monitoring can be found in the list of parameters.
<b>Temporal Resolution</b>	Different time resolutions depending on the data center. Data sets are mostly available as minute averages, some checked data sets are only available as ten-minute or half-hour values.
<b>Observational Network</b>	TAWES, HISTALP, ENVISON, WMO-GTS
<b>Stations</b>	<p><b>Full name of the site:</b> Sonnblick Observatory <b>Short name of the site:</b> SBO <b>GPS coordinates:</b> 47.08538902283°N, 12.9588890076°E <b>Altitude:</b> 3.106m <b>City:</b> The station Sonnblick Observatory is located at Mt. Hoher Sonnblick, close to the villages Rauris and Kolm Saigurn. <b>Data:</b> All measurements are performed directly at the Sonnblick Observatory station and its surroundings. Glaciological measurements of the Pasterze are additionally coordinated by the Sonnblick Observatory.</p>
<b>Data Portal</b>	data can be retrieved via the world data centres, or via the Sonnblick Observatory <a href="https://www.sonnblick.net/en/">https://www.sonnblick.net/en/</a>
<b>Supervising Organization</b>	Zentralanstalt für Meteorologie und Geodynamik (ZAMG)

<b>National and/or international Networks or Programs</b>	NDACC, WMO-GAW, WMO-GCW, BSRN, ARAD, WMO-GTS, LTER, ACTRIS, GTN-P, GTN-G WGMS, WDC-NDMC, VAO
<b>Data Submission</b>	depending on the network, yearly and monthly data submission, partly near-real time to SBO data base
<b>Licenses</b>	free of charge for research
<b>use limitation</b>	for non-profit research only
<b>Data Format</b>	different data formats possible, mostly requested .csv
<b>Data Access</b>	access rules of the data centres, registration
<b>Data Quality</b>	Data quality meets the standards of the respective monitoring programme. Data control is carried out by employees of ZAMG, but also by partner institutions such as TU Vienna, BOKU, Umweltbundesamt GmbH, etc.
<b>Performance Monitoring</b>	data availability is supervised by ZAMG, but also depends on the partner institutions high performance less data gaps
<b>Publications</b>	list of papers: <a href="https://www.sonnblick.net/en/science/publications/">https://www.sonnblick.net/en/science/publications/</a> data viewer: <a href="https://www.sonnblick.net/en/data/data-viewer/">https://www.sonnblick.net/en/data/data-viewer/</a> yearly summary of research activities in the Sonnblick Brochure: <a href="https://www.sonnblick.net/en/data/download-portal/reports/">https://www.sonnblick.net/en/data/download-portal/reports/</a>
<b>Contact (National correspondent, focal point)</b>	common contact: <a href="mailto:dion@zamg.ac.at">dion@zamg.ac.at</a> direct contact to the Sonnblick Observatory: <a href="https://www.sonnblick.net/en/contact/">https://www.sonnblick.net/en/contact/</a>
<b>Remarks</b>	In addition to ZAMG, various institutions contribute to the Sonnblick Observatory's data set.



# Terrestrial Observations

## Hydrosphere



## Hydrological Service of Austria (eHYD)

Viktor Weilguni (BMLRT)

The hydrological service (“Hydrographischer Dienst”) in Austria operates a modern hydrometrical network for the quantification of the water cycle in Austria. The monitoring network consists of about 800 discharge, 900 precipitation and 3800 groundwater stations. All data on the water cycle in Austria are collected, quality checked and disseminated by the hydrological service. The data accessibility is guaranteed by the platform eHYD.

eHYD is a platform to provide data for all interested users <http://ehyd.gv.at/>. The data are free of charge - provided the sources are acknowledged – and for non-profit research.

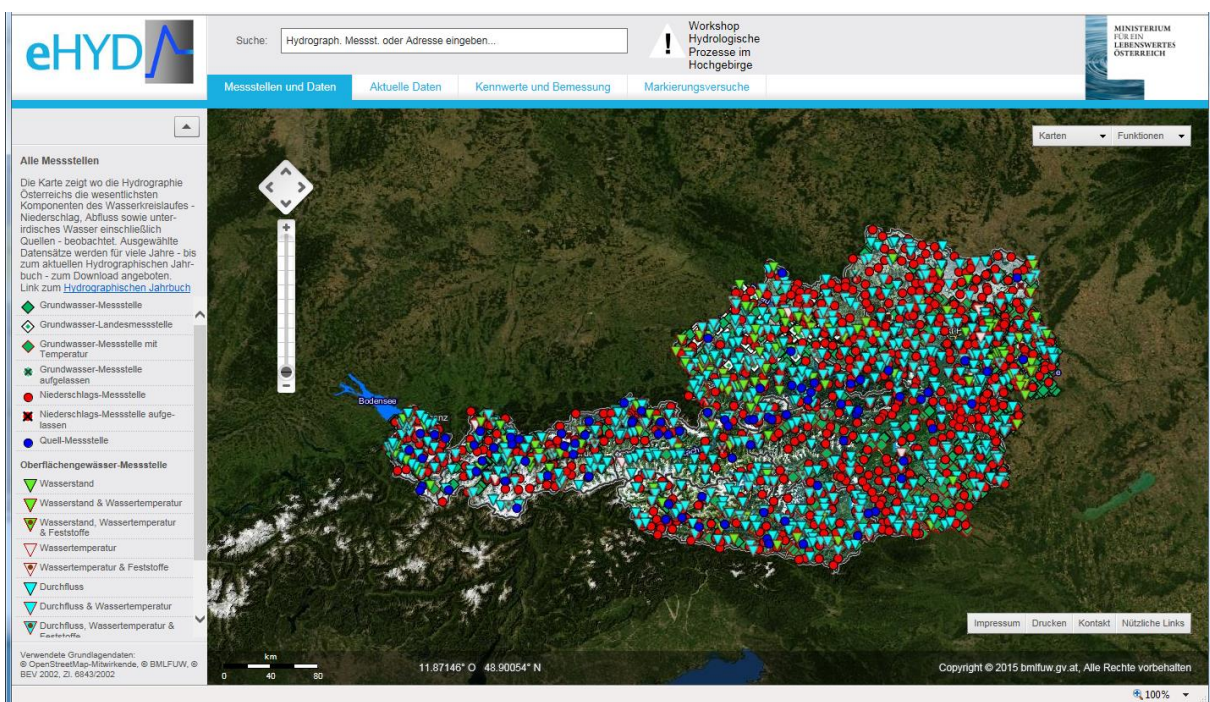


Figure 34 Overview of the stations

## Essential Climate Variables - Terrestrial Observations - Hydrosphere

<b>Parameter measured/observed</b>	Atmospheric Surface, Cryosphere: precipitation, new Snow depth, Snow depth Hydrology: discharge, water level groundwater level, groundwater temperature
<b>Starting date</b>	precipitation, new snow depth, snow depth: 1971 discharge, water level: earliest time series 1950 groundwater level, groundwater temperature: earliest time series 1966

<b>Temporal Resolution</b>	precipitation, new snow depth, snow depth and discharge, water level: daily data groundwater level, groundwater temperature: monthly data
<b>Observational Network</b>	Hydrological service (“Hydrographischer Dienst”) and other national data providers. precipitation, new snow depth, snow depth: without the ZAMG-network
<b>Stations</b>	precipitation, new snow depth, snow depth about 900 stations in Austria discharge, water level: about 800 stations in Austria groundwater level, groundwater temperature: about 3800 stations in Austria
<b>Data Portal</b>	<a href="http://ehyd.gv.at/">http://ehyd.gv.at/</a> “Messstellen und Daten” precipitation, new snow depth, snow depth: “Niederschlag” discharge, water level: “Oberflächengewässer” groundwater level, groundwater temperature: “Grundwasser”
<b>Supervising Organization</b>	Federal Ministry of Agriculture, Regions and Tourism Division 1/3, Water Balance
<b>National and/or international Networks or Programs</b>	
<b>Data Submission</b>	The data are updated once a year
<b>Licenses</b>	Free of charge, provided the sources are acknowledged CC-BY-NC
<b>Use Limitation</b>	For non-profit research
<b>Data Format</b>	Download of the data as ASCII csv
<b>Data Access</b>	Download via the eHYD-homepage <a href="http://ehyd.gv.at/">http://ehyd.gv.at/</a> Open access
<b>Data Quality</b>	Data quality control is done by the hydrological service (“Hydrographischer Dienst”)
<b>Performance Monitoring</b>	Data availability is supervised by the Federal Ministry of Agriculture, Regions and Tourism Division 1/3, Water Balance
<b>Publications</b>	Yearbook (once a year) – an overview of the behaviour of the data in the (yearbook) year in relation to the long term mean values
<b>Contact (National correspondent, focal point)</b>	Contact: Division 1/3, Water Balance: <a href="mailto:wasserhaushalt@bmlrt.gv.at">wasserhaushalt@bmlrt.gv.at</a>
<b>Remarks</b>	

## Tuxer Alps

Reinhard Fromm (BFW)

The units 'Snow and Avalanches' and 'Torrent Processes and Hydrology' of the Department of Natural Hazards operate 6 stations in the Tuxer Alps with different configurations. The main objectives are investigations of the hydrological processes in the catchment and themes concerning the snowpack and snow avalanches. Depending on research questions of projects the configurations of the stations changed and they will be adapted to fit the requirements in future. In this context additional data acquisitions were performed (automated terrestrial laser scanning – spatial distribution of snow; photogrammetry with images taken by remotely piloted systems – snow depth maps and orthophotos).

### Essential Climate Variables - Terrestrial Observations - Hydrosphere

<b>Parameter measured/observed</b>	air temperature, humidity, wind speed and direction, gusts, global radiation, reflected shortwave radiation, incoming outgoing longwave radiation precipitation, river discharge, snow height, snow water equivalent, snow temperatures, snow surface temperature, soil temperatures
<b>Starting date</b>	different, first data February 2006
<b>Temporal Resolution</b>	1 min, 10 min It depends on the station and parameter.
<b>Observational Network</b>	long term data acquisition of the Institute of Natural Hazards
<b>Stations</b>	Tarntalerboden, Lizumberboden, Snowpillow, Lizumbach, Mölsbach, Finkenberg
<b>Data Portal</b>	no
<b>Supervising Organization</b>	Department of Natural Hazards, Austrian Research Centre for Forests (BFW)
<b>National and/or international Networks or Programs</b>	Hydrological data are used by the Hydrological Service. Snow and weather data are used by the Avalanche Warning Service.
<b>Data Submission</b>	automatic data collection: intervals 2 - 4 hours
<b>Licenses</b>	different, depending on work contracts
<b>Use Limitation</b>	different, depending on work contracts
<b>Data Format</b>	csv
<b>Data Access</b>	restricted
<b>Data Quality</b>	simple automatic quality check
<b>Performance Monitoring</b>	Data availability is supervised by BFW.

<b>Publications</b>	Data were used in several publications concerning snow avalanche research and hydrological investigations.
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:reinhard.fromm@bfw.gv.at">reinhard.fromm@bfw.gv.at</a> <a href="mailto:gerhard.markart@bfw.gv.at">gerhard.markart@bfw.gv.at</a>
<b>Remarks</b>	Additional data acquisitions were carried out in the test site. This includes terrestrial laser scanning and photogrammetry which uses images taken with remotely piloted systems. Results are snow depth maps, spatial snow depth changes, depositions of snow avalanches, orthophotos, landslides, etc.

## Torrent Research Areas – Monitoring data

Ulrike Stary (BFW)

Since the beginning of settlements in the alpine space, natural hazards such as torrents have been a major threat to human beings. Increasing conflicts between natural geophysical processes and increasing human demands on natural resources require improved protection strategies and protection measures. Occurrence probability and potential impacts of this risk in terms of damages to property define the degree of the risk. Natural hazards cannot be totally avoided through targeted countermeasures but certain risk management strategies and actions may be derived thereof: prevention before, reaction during and rebuilding after the disaster.

Data for process analyses are collected within monitoring systems implemented in torrent research areas. These are equipped with a large number of measuring instruments. For nearly 50 years the Department of Natural Hazards of the BFW has been engaged in research in the Alpine region recording measuring data at extreme sites. Data series of this duration provide also a good insight into the evolution of climate parameters. Extrapolations derived from it are suitable for comparison with results from climate change models or supplement them with regard to their informative value. This is useful because climate change models describe a simplified picture of reality based on the size of the data grid they use.



Figure 35 Location of the Torrent Research Areas (TORA)

## Essential Climate Variables - Terrestrial Observations - Hydrosphere

<b>Parameter measured/observed</b>	precipitation, air temperature, wind speed and direction, humidity, snow height and water equivalent, global radiation river discharge, groundwater (level and temperature)
<b>Starting date</b>	earliest time series in 1969
<b>Temporal Resolution</b>	5 min, 15 min, 1 hour, daily, weekly, depending on parameters
<b>Observational Network</b>	long term series of the Alpine region and Alpine lowland from BFW
<b>Stations</b>	about 20 stations located in Lower Austria and Carinthia
<b>Data Portal</b>	no
<b>Supervising Organization</b>	Department of Natural Hazards, Austrian Research Centre for Forests (BFW)
<b>National and/or international Networks or Programs</b>	no
<b>Data Submission</b>	daily GSM calls, weekly data transmissions of Excel files
<b>Licenses</b>	different, depending on work contracts
<b>Use Limitation</b>	different, depending on work contracts
<b>Data Format</b>	text, .mis, .xlsx, access, ascii
<b>Data Access</b>	restricted
<b>Data Quality</b>	Data quality control is done by employees of BFW.
<b>Performance Monitoring</b>	Data availability is supervised by BFW.
<b>Publications</b>	BFW reports, (former: FBVA reports)
<b>Contact (National correspondent, focal point)</b>	Contact: <a href="mailto:erich.lang@bfw.gv.at">erich.lang@bfw.gv.at</a>
<b>Remarks</b>	



## ISMN - In situ soil moisture observations

Wouter Dorigo (TU Wien), Angelika Xaver (TU Wien)

Since 2010, the International Soil Moisture Network (ISMN; <http://ismn.geo.tuwien.ac.at>) is being developed, hosted, and operated by TU Wien. It acts as a data repository for ground-based soil moisture observations. Soil moisture measurements are collected from individual networks and data providers distributed all over the globe. The collected observations are highly diverse. They result not only from different measurement principles, but also their format, structure and means of provision are inhomogeneous. Within a fully automated processing chain the datasets are harmonized with respect to measurement unit, temporal resolution, and data format. Advanced quality control procedures are an essential part of the processing algorithms, assigning quality indicators to each single observation. The harmonized observations are visualized in a web portal where they become available for download to registered users.

At present, 57 networks consisting of 2260 stations are part of the ISMN (Figure 35). Due to the fact that each network is organised individually the datasets vary in observation depth, ancillary metadata and available time span. Data availability ranges from historical observations starting in 1952 to recent measurements measured only a few days ago. In addition to soil moisture, other climate variables such as air temperature, soil temperature, precipitation, snow depth, and snow water equivalent are provided through the ISMN (Figure 36).

The primary goal of the ISMN is to provide reference data for satellite product validation, e.g. for the operational Copernicus Climate Change Service (C3S; <http://climate.copernicus.eu/>) and Copernicus Global Land Service (<http://land.copernicus.eu/global/index.html>), the Climate Change Initiative (<http://www.esa-soilmoisture-cci.org/>) and SMOS mission (<http://www.catds.fr/>) of the European Space Agency (ESA), and the operational soil moisture products produced by EUMETSAT (<http://hsaf.meteoam.it/>, <https://navigator.eumetsat.int/search?query=soil%20moisture%20metop>). For many years, these services have had a strong involvement of Austrian research institutes, public services, universities, and private companies.

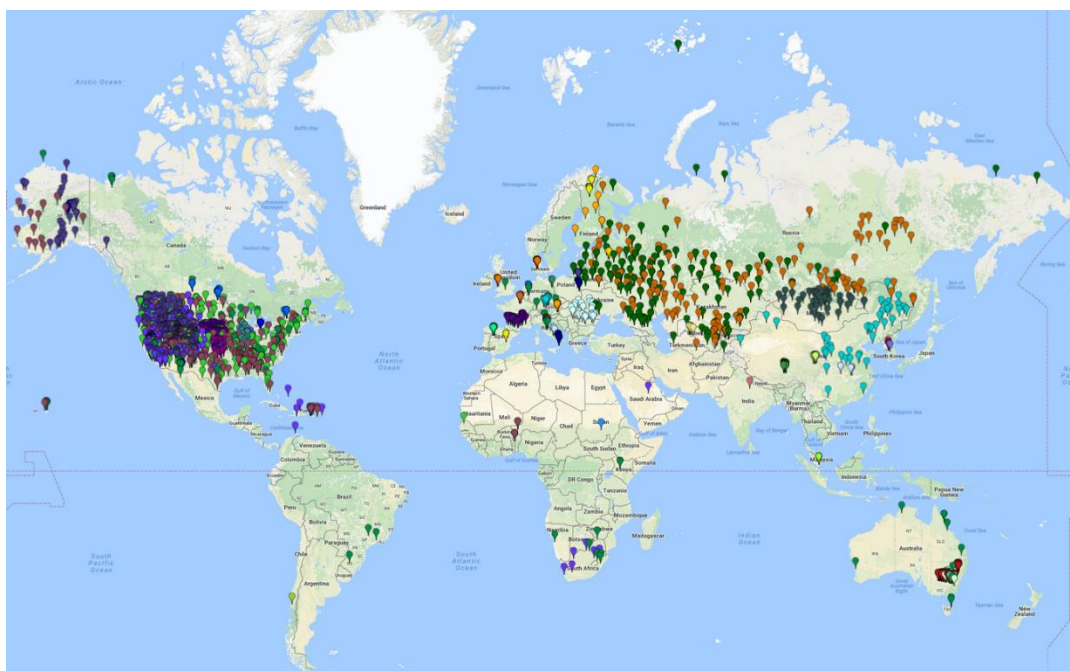


Figure 36 Overview of stations contained in the ISMN.



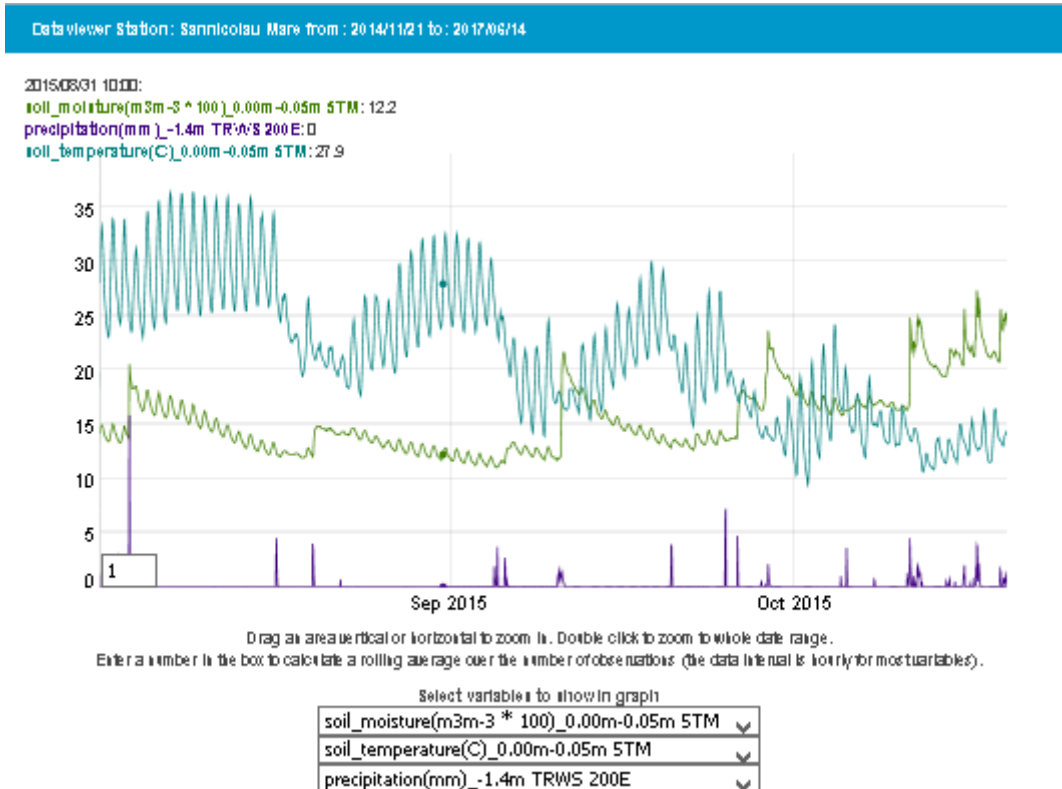


Figure 37 Example of soil moisture, soil temperature and precipitation data of a Romanian station, visualized through the ISMN data viewer.

## Essential Climate Variables - Terrestrial Observations - Hydrosphere

<b>Parameter measured/observed</b>	Soil moisture, soil temperature, air temperature, precipitation, soil properties
<b>Starting date</b>	Earliest observations from 1952
<b>Temporal Resolution</b>	1 hour (~1 week for earliest observations)
<b>Observational Network</b>	Various individual data providers and networks (>60)
<b>Stations</b>	2600 (globally distributed)
<b>Data Portal</b>	<a href="https://ismn.geo.tuwien.ac.at/">https://ismn.geo.tuwien.ac.at/</a>
<b>Supervising Organization</b>	TU Wien
<b>National and/or international Networks or Programs</b>	ISMN, currently sponsored by ESA SPPA programme (funding guaranteed until December 31st 2020)
<b>Data Submission</b>	Variable, ranging from irregular updates approximately once a year to automated daily updates, using various data exchange protocols (email, ftp, https, etc.)

<b>Licences</b>	Free of charge, data origin shall be acknowledged and referenced (see <a href="http://ismn.geo.tuwien.ac.at/terms-and-conditions/">http://ismn.geo.tuwien.ac.at/terms-and-conditions/</a> )
<b>Use Limitation</b>	For scientific use only
<b>Data Format</b>	Downloaded datasets are provided in text format
<b>Data Access</b>	Access by registration
<b>Data Quality</b>	All datasets implemented in the ISMN have to run through a series of automated quality control procedures. Each observation is then associated by a quality indicator (see also <a href="http://ismn.geo.tuwien.ac.at/data-access/quality-flags/">http://ismn.geo.tuwien.ac.at/data-access/quality-flags/</a> ).
<b>Performance Monitoring</b>	Supervised by TU Wien, although data availability depends on the individual data providers.
<b>Publications</b>	A list of relevant publications can be found online: <a href="http://ismn.geo.tuwien.ac.at/publications/">http://ismn.geo.tuwien.ac.at/publications/</a>
<b>Contact (National correspondent, focal point)</b>	Wouter Dorigo: <a href="mailto:wouter.dorigo@tuwien.ac.at">wouter.dorigo@tuwien.ac.at</a> Irene.himmelbauer@tuwien.ac.at
<b>Remarks</b>	

## ASCAT surface soil moisture data records

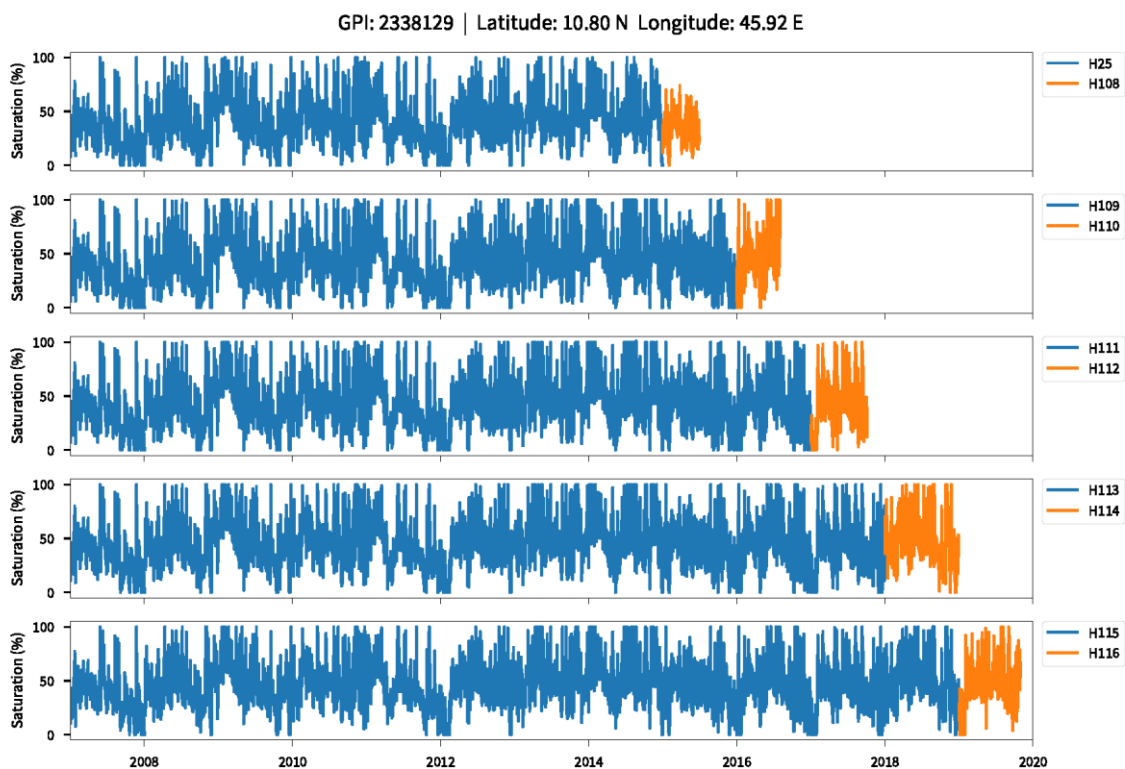
*Sebastian Hahn (TU-Wien), Alexander Jann (ZAMG), Wolfgang Wagner (TU-Wien)*

In the framework of the Satellite Application Facility on Support to Operational Hydrology and Water Management (<http://hsaf.meteoam.it/>), several soil moisture products are generated on a regular basis and distributed to users. Besides Near Real Time (NRT) products targeted for Numerical Weather Prediction (NWP) systems, are Climate Data Records (CDR) important for re-analysis of historic events. These Surface Soil Moisture (SSM) CDRs represent the top-most soil layer (< 5 cm) and are expressed in relative units degree of saturation (0% dry and 100% fully saturated soil). The SSM CDRs are derived from backscatter measurements of the Advanced Scatterometer (ASCAT) on-board the series of Metop satellites. ASCAT is an active radar instrument operating in C-band (5.255 GHz) and on-board the three Metop satellites: Metop-A (launched October 2006), Metop-B (launched September 2012) and Metop-C (launched November 2018). Currently (2020) all three satellites share the same sun-synchronous 29-day repeat cycle orbit and are shifted by half an orbital period (approximately 51 minutes).

The TU Wien soil moisture retrieval algorithm [1, 2] is used to derive relative surface soil moisture information from the ASCAT backscatter measurements. The retrieval represents a physics-based change detection method exploiting the multi-angle measurement capability of fan-beam scatterometer. The SSM retrieval algorithm requires long-term backscatter measurements (> 3-4 years) to model the incidence angle dependency of backscatter, which allows to normalize backscatter to a common reference incidence angle. The relative surface soil moisture estimates are derived by scaling the normalized backscatter between the lowest/highest backscatter observation corresponding to the driest/wettest soil conditions.

The ASCAT Level 1b backscatter product with a spatial sampling of 12.5 km is used as input in the SSM retrieval algorithm. It is planned to process a new ASCAT SSM CDR each year containing the complete soil moisture history. Depending on the version of the algorithm and the version of the ASCAT Level 1b input data, CDRs can be different from version to another. Therefore, users are advised to use the latest ASCAT SSM CDR product available. Since a CDR is a self-contained data set and it is not foreseen to manipulate the data retrospectively, regular extensions of the CDR are provided on a monthly time scale. It is important to use the same version of the SSM retrieval algorithm and ASCAT Level 1b input data in order to get a compliant extension of the CDR product. The processing of an CDR extension is maintained until a new ASCAT SSM CDR is released. Figure 37 illustrates the relationships between the CDR variants.

The ASCAT SSM CDR products are one of the main input data sets for the European Space Agency's Climate Change Initiative for Soil Moisture (ESA CCI SM) responsible for generating consistent quality-controlled long-term (1978–2018) climate data records for soil moisture [3]. Both, active- and passive-microwave-based soil moisture products are quality-controlled, harmonized, merged and distributed globally to the climate user community. In general, ASCAT soil moisture products have been used for various applications, including but not limited to: rainfall estimation, flood forecasting, drought monitoring and landslide prediction [4].



**Figure 38** ASCAT Surface Soil Moisture Climate Data Records (blue) and intermediate extensions (orange) for the same location.

### References:

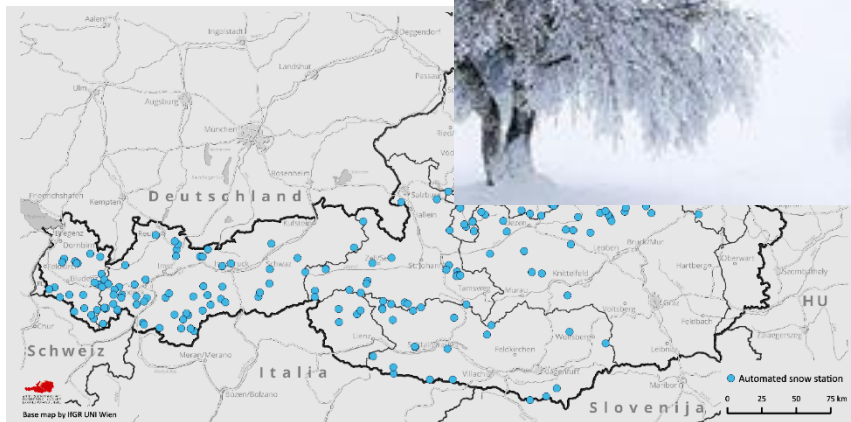
- [1] W. Wagner, G. Lemoine, and H. Rott, "A method for estimating soil moisture from ERS scatterometer and soil data," *Rem.Sens.Environ.*, **70**, 191–207 (2009).
- [2] V. Naeimi, K. Scipal, Z. Bartalis, S. Hasenauer, and W. Wagner, "An Improved Soil Moisture Retrieval Algorithm for ERS and METOP Scatterometer Observations," *IEEE Trans. Geosci. Remote Sensing*, **47**, 1999–2013 (2009).
- [3] Gruber, A., Scanlon, T., van der Schalie, R., Wagner, W., & Dorigo, W. (2019). Evolution of the ESA CCI Soil Moisture climate data records and their underlying merging methodology. *Earth System Science Data*, 1-37.

[4] L. Brocca et al., "A Review of the Applications of ASCAT Soil Moisture Products," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 10, no. 5, pp. 2285-2306, May 2017.

Additional source used: S. Hahn, T. Melzer, S. Elefante (2017): „Product User Manual (PUM): Metop ASCAT Soil Moisture CDR and offline products“. Project documentation, EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management, revision 0.6.

### Essential Climate Variables - Terrestrial Observations - Hydrosphere

<b>Parameter measured/observed</b>	Soil moisture
<b>Starting date</b>	2007-01-01
<b>Temporal Resolution</b>	Regular, every 12h – 36h
<b>Observational Network</b>	ASCAT on-board Metop-A, Metop-B and Metop-C
<b>Stations</b>	
<b>Data Portal</b>	<a href="http://hsaf.meteoam.it/">http://hsaf.meteoam.it/</a>
<b>Supervising Organization</b>	TU Wien
<b>National and/or international Networks or Programs</b>	EUMETSAT Satellite Application Facility on Support to Operational Hydrology and Water Management
<b>Data Submission</b>	FTP, <a href="ftp://ftp.meteoam.it/">ftp://ftp.meteoam.it/</a>
<b>Licenses</b>	
<b>Use Limitation</b>	EUMETSAT Data Policy: <a href="https://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&amp;dDocName=PDF_LEG_DATA_POLICY&amp;RevisionSelectionMethod=LatestReleased&amp;Rendition=Web">https://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&amp;dDocName=PDF_LEG_DATA_POLICY&amp;RevisionSelectionMethod=LatestReleased&amp;Rendition=Web</a>
<b>Data Format</b>	netCDF
<b>Data Access</b>	Access by registration
<b>Data Format</b>	netCDF
<b>Data Access</b>	Access by registration
<b>Data Quality</b>	
<b>Performance Monitoring</b>	Product Validation Report: <a href="http://hsaf.meteoam.it/documents/PVR/H111_ASCAT_SSM_CDR_PVR_v0.3.pdf">http://hsaf.meteoam.it/documents/PVR/H111_ASCAT_SSM_CDR_PVR_v0.3.pdf</a>
<b>Publications</b>	
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:Wolfgang.Wagner@geo.tuwien.ac.at">Wolfgang.Wagner@geo.tuwien.ac.at</a> <a href="mailto:Apostolos.Giannakos@zamg.ac.at">Apostolos.Giannakos@zamg.ac.at</a>
<b>Remarks</b>	



# Terrestrial Observations

## Cryosphere

## SNOW

Marion Greilinger (ZAMG), Thomas Nagler (ENVEO), Helmut Rott (ENVEO), Gabriele Schwaizer (ENVEO)

Snow parameters which are regularly obtained are snow height, snow water equivalent and snow covered area. The first two are obtained in situ, the latter by remote sensing methods. Snow height measurements are available since the end of the 19th century for several stations.

Standard measurements include snow depth, advanced records also provide Snow water equivalent (SWE) and snow temperature. Based on the existing TAWES network from ZAMG with about 260 stations, 94 stations contribute to regular, quality controlled snow monitoring of snow depth. Measurements are available from 750 further sites which are maintained by local authorities (HD – Hydrografischer Dienst) and distributed via the eHyd portal on federal level. Additional records are collected by the avalanche services. This comprises additional parameters and locations.

SWE measurements are obtained regularly at 54 sites. 48 are part of the HD network (weekly intervals), four are maintained by the avalanche warning services (15 minutes intervals). In addition, a published record of SWE and snow temperatures by the TIWAG-Tiroler Wasserkraft AG is available for the Kühtai station in Tyrol, starting in 1990. The BFW (Bundesforschungszentrum für Wald) maintains an experimental site at Lizum/Walchen in Tyrol.

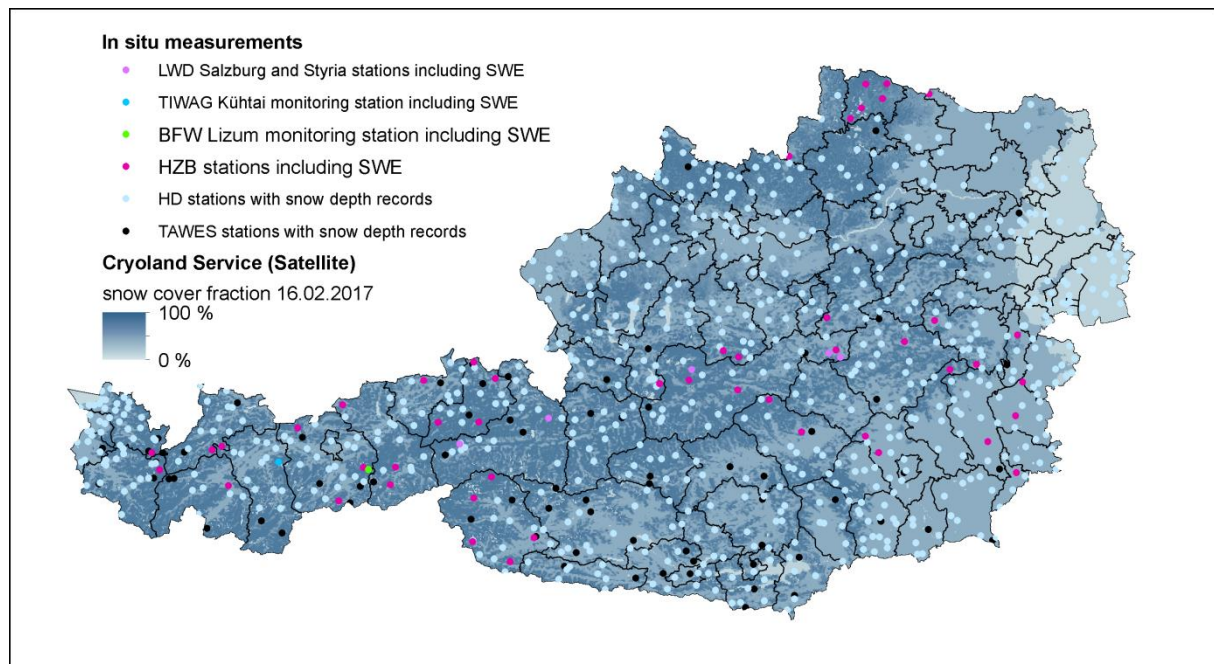


Figure 39 Overview of the stations.

An annual summary of the records is published by the section 'Wasserhaushalt' (HZB) of the BMLRT. This includes averages, maxima and snow cover duration.

Satellite snow coverage fraction maps are regularly available since 2000 and are updated as part of the Copernicus services. Daily maps with 1 km spatial resolution are disseminated via the CryoLand Portal. They are currently based on MODIS records and will soon be extended with records from Sentinel-3 SLSTR/OLCI.



Snow water equivalent records:

- Hydrographical Central Bureau (HD; since 01.12.1980)
- Avalanche warning services (Salzburg: since 07.10.2008, Styria: since 17.11.2010)
  - o Hinterwildalpen
  - o Maria Alm
  - o Neukirchen/Wildkogel
  - o Lawinenstein (2010-2012)
  - o Wildalpen/Siebensee
- TIWAG: Kühtai, since 1990
- BFW: Lizum/Walchen

Municipal Department 31 – Vienna Water (MA 31 Wiener Wasser): since 21.01.2016

---

### Essential Climate Variables - Terrestrial Observations - Cryosphere

---

Parameter measured/observed	Snow height
Starting date	manual observation since 01.01.1911 at 13 stations automatic measurements since 3.11.2004
Temporal Resolution	daily
Observational Network	TAWES, eHYD
Stations	74 stations as part of the TAWES network. 723 HD – Hydrografischer Dienst
Data Portal	<a href="https://ehyd.gv.at/">https://ehyd.gv.at/</a> <a href="http://www.zamg.ac.at/cms/de/klima/messnetze/wetterstationen">www.zamg.ac.at/cms/de/klima/messnetze/wetterstationen</a>
Supervising Organization	ZAMG BMLFUW – Abteilung VII/3 – Wasserhaushalt
National and/or international Networks or Programs	TAWES, eHYD
Data Submission	automatic
Licenses	eHYD: CC-BY-NC TAWES: general ZAMG data conditions
Use Limitation	Varying, partly for research only
Data Format	csv
Data Access	Varying, partially restricted
Data Quality	Data quality under the responsibility of the individual institutions providing the data.

Performance Monitoring	Regularity by ZAMG, regularity by HD
Publications	
Contact (National correspondent, focal point)	eHyd: <a href="mailto:wasserhaushalt@bmlrt.gv.at">wasserhaushalt@bmlrt.gv.at</a> TAWES: <a href="mailto:roland.potzmann@zamg.ac.at">roland.potzmann@zamg.ac.at</a>
Remarks	

### Essential Climate Variables - Terrestrial Observations - Cryosphere

Parameter measured/observed	Fractional Snow Cover Extent
Starting date	01.11.2000 (from MODIS, for Pan-European domain) January 2018 (from VIIRS, for the Northern Hemisphere) January 2020 (from Sentinel-3 SLSTR, for the Northern Hemisphere)
Temporal Resolution	Daily
Observational Network	Terra MODIS Suomi-NPP VIIRS Sentinel-3 A/B SLSTR  In future: Sentinel-3 A/B SLSTR/OLCI
Stations	
Data Portal	<a href="http://neso1.cryoland.enveo.at/cryoclient/">http://neso1.cryoland.enveo.at/cryoclient/</a> <a href="http://cryoportal.enveo.at/">http://cryoportal.enveo.at/</a> <a href="http://land.copernicus.eu/global/products/sce">http://land.copernicus.eu/global/products/sce</a>
Supervising Organization	ENVEO IT GmbH
National and/or international Networks or Programs	EU FP7 project CryoLand (No. 262925, 2011 – 2015, lead: ENVEO) Copernicus Land Monitoring Service – Cryosphere (snow cover extent under lead of ENVEO) (2016 – 2020) ESA CCI+ Snow (2018 – 2021, lead: ENVEO)
Data Submission	Automated daily product generation and upload on server via FTP
Licenses	CC BY ENVEO NC ND Further details: <a href="http://cryoportal.enveo.at/disclaimer/">http://cryoportal.enveo.at/disclaimer/</a>
Use Limitation	For research only Further details: <a href="http://cryoportal.enveo.at/disclaimer/">http://cryoportal.enveo.at/disclaimer/</a>
Data Format	GeoTIFF, NetCDF, JPEG2000, HDF-4

Data Access	Open Access
Data Quality	Intensive validation activities since the EU FP7 project CryoLand (2011 – 2015), where this product was developed. Product participated in the ESA QA4EO project SnowPEX - Satellite Snow Product Intercomparison and Evaluation Exercise (2014 – 2016, lead: ENVEO). Product Validation Report prepared by ENVEO for the Copernicus Global Land Monitoring Service is available at <a href="http://land.copernicus.eu/global/products/sce">http://land.copernicus.eu/global/products/sce</a> . Daily uncertainty layer, providing unbiased Root Mean Square Error per pixel (available at <a href="http://neso1.cryoland.enveo.at/cryoclient/">http://neso1.cryoland.enveo.at/cryoclient/</a> )
Performance Monitoring	Daily, automated procedure
Publications	Project related reports and documents Scientific publications on snow and ice parameters retrieved by means of remote sensing
Contact (National correspondent, focal point)	Thomas Nagler: <a href="mailto:thomas.nagler@enveo.at">thomas.nagler@enveo.at</a> Gabriele Schwaizer: <a href="mailto:gabriele.schwaizer@enveo.at">gabriele.schwaizer@enveo.at</a> Helmut Rott: <a href="mailto:helmut.rott@uibk.ac.at">helmut.rott@uibk.ac.at</a>
Remarks	

## Essential Climate Variables - Terrestrial Observations - Cryosphere

Parameter measured/observed	Snow water equivalent, Snow temperature
Starting date	TIWAG: Kühtai 1990 Avalanche warning service, Salzburg: since 07.10.2008 Avalanche warning service, Styria: since 17.11.2010 Municipal Department 31 – Vienna Water (MA 31 Wiener Wasser): since 21.01.2016 Hydrographical Central Bureau, Tyrol: since 01.12.1980 BFW: Lizum, since February 2006
Temporal Resolution	TIWAG: Kühtai 15 min Avalanche warning service /MA 31: 10 min Hydrographical Central Bureau, Tyrol: weekly
Observational Network	
Stations	TIWAG: Kühtai Avalanche warning service /MA 31: Hinterwildalpen, Maria Alm, Neukirchen/Wildkogel, Lawinenstein, Wildalpen/Siebensee Hydrographical Central Bureau, Tyrol: 24 stations in Tyrol BFW: Lizum

Data Portal	TIWAG: Kühtai <a href="http://onlinelibrary.wiley.com/store/10.1002/2017WR020445/asset/supinfo/wrcr22701-sup-0002-2017WR020445-ds01.txt?v=1&amp;s=7df0aeb235e5329a292b92b12fcd8fc769e55c62">http://onlinelibrary.wiley.com/store/10.1002/2017WR020445/asset/supinfo/wrcr22701-sup-0002-2017WR020445-ds01.txt?v=1&amp;s=7df0aeb235e5329a292b92b12fcd8fc769e55c62</a>
Supervising Organization	TIWAG-Tiroler Wasserkraft AG, Hydropower planning department, Innsbruck, Austria Avalanche warning service, Salzburg, Austria Avalanche warning service, Styria, Austria Municipal Department 31 – Vienna Water Hydrographical Central Bureau of Austria BFW-Austrian Research Center for Forests
National and/or international Networks or Programs	
Data Submission	Technical report, once
Licenses	CC BY, BFW: depending on work contracts
Use Limitation	BFW: depending on work contracts
Data Format	csv
Data Access	Open BFW: restricted
Data Quality	
Performance Monitoring	TIWAG Avalanche warning service, Salzburg, Austria Avalanche warning service, Styria, Austria Municipal Department 31 – Vienna Water Hydrographical Central Bureau of Austria BFW- Austrian Research Center for Forests
Publications	
Contact (National correspondent, focal point)	Global Cryosphere Watch - Focal Point Elke Ludewig, <a href="mailto:elke.ludewig@zamg.ac.at">elke.ludewig@zamg.ac.at</a>
Remarks	

## Glaciers

Marion Greilinger (ZAMG), Andrea Fischer (IGF), Thomas Nagler (ENVEO),  
Helmut Rott (ENVEO), Gabriele Schwaizer (ENVEO)

More than 900 glaciers have been identified within the Austrian Alps. Their properties are continuously monitored by in situ observations as well as remote sensing methods. This is achieved by combined effort on national level between a range of organizations including universities, research institutions, associations, companies and local authorities. These activities are embedded into international efforts such as the World Glacier Monitoring Service (WGMS). In situ observations require a substantial amount of man power and the use of automatized methods is limited. Volunteers therefore substantially contribute to the glacier service of the Austrian Alpine Club. Currently coordinated measurement of different parameters are performed at 92 glaciers in Austria and were initiated already in 1891 at single sites following a call of Eduard Richter, although single measurements also exist from earlier times. Data are regularly reported to the WGMS and to the corresponding data portals of the Global Terrestrial Networks for glaciers (GTN-G) and permafrost (GTN-P).

Of all glaciers in Austria only 10 % are monitored by length measurements and 1 % by actual mass balance retrievals. Mass balance measurements have started on Hintereisferner in 1952/53, with a continuous increase of sites since the 1960s whereas length measurements started already at the end of the 19<sup>th</sup> century at single sites. An annual summary of length and mass balance records is published by the section 'Wasserhaushalt' (HZB) of the BMLRT and in the bulletins of the Austrian Alpine Club.

Satellite and airborne data complement the ground based measurements. Glacier covered area is obtained in irregular intervals, depending on data availability. These inventories are part of international initiatives such as the Randolph glacier inventory (GLIMS) and the Climate Change Initiative of the European Space Agency.

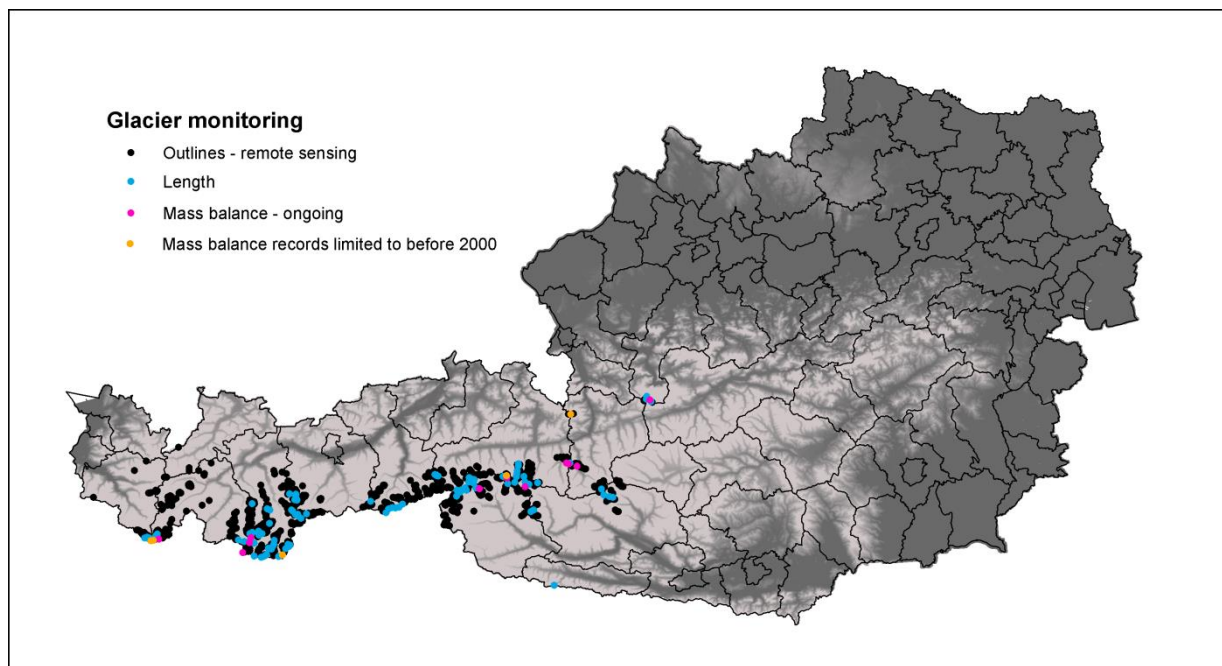


Figure 40 Overview of monitored glaciers

Essential Climate Variables - Terrestrial Observations - Cryosphere

Parameter measured/observed	Glacier mass balance
Starting date	varying
Temporal Resolution	Annual, seasonal
Observational Network	World glacier monitoring service (WGMS)
Stations	Hintereisferner (since 1952/53) Kesselwandferner (since 1952/53, with change in method in 1966) Stubacher Sonnblick Kees (since 1963/64), also LTER Oberes Stubachtal Vernagtferner (since 1970/71) Wurtenkees (since 1982/83) Goldbergkees (since 1986/87) Jamtal Ferner (since 1988/89), also LTSER Tyrolean Alps Kleinfleiss Kees (since 1998/99) Hallstätter Gletscher (since 2006/07 ) Mullwitz Kees (since 2006/07) Pasterze (since 2012/13) Venediger Kees (since 2012/13) Langtaler Ferner (1963-1970) Übergossene Alm (1964-1975) Filleck Kees(1964-1980) Vermuntgletscher (1991-1999) Ochsentaler Gletscher (1991-1999)
Data Portal	WGMS, <a href="https://wgms.ch/fogbrowser/">https://wgms.ch/fogbrowser/</a>
Supervising Organization	WGMS, <a href="http://wgms.ch/">http://wgms.ch/</a>
National and/or international Networks or Programs	WGMS Global Cryosphere Watch (GCW)
Data Submission	Annual, after the official WGMS “call for data”
Licenses	No formal license. WGMS Website citation: “Open access under requirement of correct citation” (Source: <a href="http://wgms.ch/data_databaseversions">http://wgms.ch/data_databaseversions</a> )
Use Limitation	For research only
Data Format	csv
Data Access	open access
Data Quality	Data quality under the responsibility of the individual institutions providing the data. Minimal quality check by the WGMS itself.



Performance Monitoring	Performed by the respective institutions responsible for the measurements
Publications	<p>Fischer, Andrea; Seiser, Bernd; Stocker-Waldhuber, Martin; Mitterer, Christian; Abermann, Jakob (2015): Tracing glacier changes in Austria from the Little Ice Age to the present using a lidar-based high-resolution glacier inventory in Austria. <i>The Cryosphere</i>, 9(2), 753-766, doi:10.5194/tc-9-753-2015</p> <p>Fischer, Andrea; Seiser, Bernd; Stocker-Waldhuber, Martin; Mitterer, Christian; Abermann, Jakob (2015): The Austrian Glacier Inventories GI 1 (1969), GI 2 (1998), GI 3 (2006), and GI LIA in ArcGIS (shapefile) format. PANGAEA, <a href="https://doi.org/10.1594/PANGAEA.844988">https://doi.org/10.1594/PANGAEA.844988</a></p>
Contact (National correspondent, focal point)	<p>Andrea Fischer            Institut für Interdisziplinäre Gebirgsforschung, Österreichische Akademie der Wissenschaften  <a href="mailto:andrea.fischer@oeaw.ac.at">andrea.fischer@oeaw.ac.at</a></p>
Remarks	

---

### Essential Climate Variables - Terrestrial Observations - Cryosphere

---

Parameter measured/observed	Length of glaciers
Starting date	varying
Temporal Resolution	Annual
Observational Network	World glacier monitoring service (WGMS) Glacier service of the Austrian Alpine Club
Stations	Varying, depending on logistical (access) and snow cover conditions at the glacier terminus (92 glaciers for the budget year 2018/2019)
Data Portal	WGMS, <a href="https://wgms.ch/fogbrowser/">https://wgms.ch/fogbrowser/</a> Annual reports from the Austrian Alpine Club ("Gletscherbericht")
Supervising Organization	WGMS Austrian Alpine Club
National and/or international Networks or Programs	World Glacier Monitoring service (WGMS)
Data Submission	Annually to the Austrian Alpine Club by members of different glacier monitoring teams (at the moment 19 different teams submitting their reports and data to the coordinator of the glacier monitoring program)

Licenses	No formal license.
Use Limitation	Free to use
Data Format	Print and pdf copy of data table in the annual reports of the Austrian Alpine Club as well as csv via WGMS
Data Access	open access
Data Quality	Basic quality check by the glacier service of the Austrian Alpine Club
Performance Monitoring	Performed by the respective institutions responsible for the measurements
Publications	Annual reports from the Austrian Alpine Club ("Gletscherbericht") <a href="http://www.alpenverein.at/portal/museum-archiv/gletschermessdienst/archiv-gletscherberichte/archiv-gletscherberichte.php">http://www.alpenverein.at/portal/museum-archiv/gletschermessdienst/archiv-gletscherberichte/archiv-gletscherberichte.php</a>
Contact (National correspondent, focal point)	Head of the glacier service of the Austrian Alpine Club Andreas Kellerer-Pirklbauer: <a href="mailto:andreas.kellerer@uni-graz.at">andreas.kellerer@uni-graz.at</a> Gerhard Lieb: <a href="mailto:gerhard.lieb@uni-graz.at">gerhard.lieb@uni-graz.at</a>
Remarks	

## Essential Climate Variables - Terrestrial Observations - Cryosphere

Parameter measured/observed	Glacier outlines/extent, glacier facies, ice surface velocity, calving fronts, grounding lines
Starting date	Depends on parameter and available satellite data per region. Earliest products are from satellite images of the 1980s.
Temporal Resolution	Depends on the availability of satellite imagery. GLO/GLS/GLF/CF/GLL: (multi-)annually IV: 6-days since 2017, 12-days since 2014, monthly/seasonally/(multi-)annually before 2014 (depending on region).
Observational Network	NA
Stations	Satellite sensors: Sentinel-2 A/B MSI, Landsat 5 TM / 7 ETM+ / 8 OLI, SPOT-5 HRG, Sentinel-1 A/B SAR, TerraSAR-X, ERS-1/2
Data Portal	<a href="http://cryoportal.enveo.at/">http://cryoportal.enveo.at/</a> <a href="http://neso1.cryoland.enveo.at/cryoclient/">http://neso1.cryoland.enveo.at/cryoclient/</a> (viewing service only for glacier outlines) Partially related: GLIMS Randolph Glacier Inventory, archived by the National Snow and Ice Data Center (NSIDC). <a href="https://www.glims.org/RGI/rgi60_dl.html">https://www.glims.org/RGI/rgi60_dl.html</a>

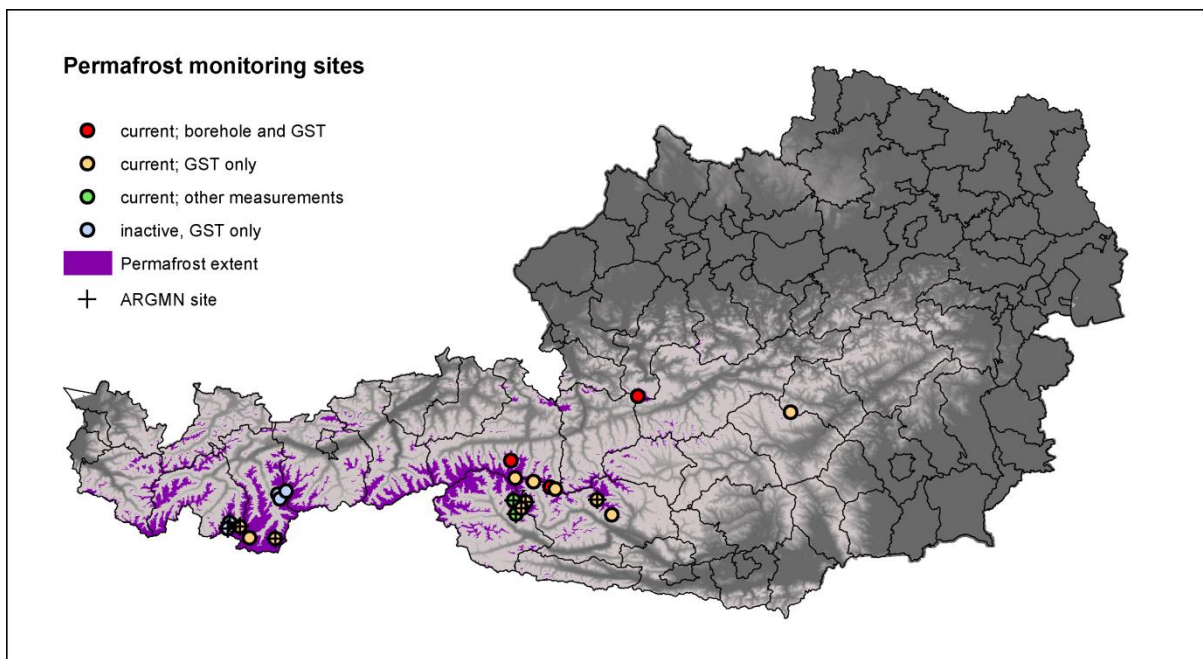
Supervising Organization	ENVEO IT GmbH for CryoPortal
National and/or international Networks or Programs	See remarks
Data Submission	Frequency of data submission depends on parameter and available data base (ranges between weekly and multi-annually updates). Upload on CryoPortal server via FTP
Licenses	CryoPortal: CC BY ENVEO NC ND Further details: <a href="http://cryoportal.enveo.at/disclaimer/">http://cryoportal.enveo.at/disclaimer/</a>
Use Limitation	CryoPortal: For research only Further-details: <a href="http://cryoportal.enveo.at/disclaimer/">http://cryoportal.enveo.at/disclaimer/</a>
Data Format	GeoTIFF, ESRI Shapefile (depending on parameter)
Data Access	open access
Data Quality	CryoPortal: Evaluation and intercomparison activities performed and documented within several ESA projects. GLIMS: Minimal quality check. Data quality under the responsibility of the individual institutions providing the data.
Performance Monitoring	Automated controlling of data on CryoPortal by ENVEO
Publications	CryoPortal: Project related reports and documents, Scientific publications on snow and ice parameters retrieved by means of remote sensing
Contact (National correspondent, focal point)	CryoPortal: Thomas Nagler: <a href="mailto:thomas.nagler@enveo.at">thomas.nagler@enveo.at</a> Gabriele Schwaizer: <a href="mailto:gabriele.schwaizer@enveo.at">gabriele.schwaizer@enveo.at</a> Helmut Rott: <a href="mailto:helmut.rott@enveo.at">helmut.rott@enveo.at</a> GLIMS (Austrian Alps): Helmut Rott: <a href="mailto:helmut.rott@uibk.ac.at">helmut.rott@uibk.ac.at</a>
Remarks	Related initiatives/funding sources: EU FP7 project CryoLand (No. 262925, 2011 – 2015, lead: ENVEO) ESA Glaciers CCI (Phase 1: 2010 – 2013; Phase 2: 2015 – 2018) ESA Greenland Ice Sheet CCI (Phase 1: 2012 – 2014; Phase 2: 2015 – 2018) ESA Antarctic Ice Sheet CCI (2015 – 2018) Copernicus Climate Change Service (C3S) (2018 – 2021) ESA Antarctic Ice Sheet CCI+ (2019 – 2021) ESA Greenland Ice Sheet CCI+ (2019 – 2021) ESA Glaciers CCI+ (2019 – 2021)

## Permafrost

*Marion Greilinger (ZAMG), Ingo Hartmeyer (GEORESEARCH), Viktor Kaufmann (TU Graz), Andreas Kellerer-Pirklbauer (Universität Graz), Karl Krainer (Universität Innsbruck), Thomas Wagner (Universität Graz), Gerfried Winkler (Universität Graz)*

Approximately 2.5 % of Austria is characterized by permanently frozen ground which is overlain by a seasonally unfrozen layer (i.e. active layer). Such regions are addressed as permafrost areas. Further ca. 1.5 % of Austria are affected by deep seasonal frost which has similar impacts on weathering processes. 23 skiing resorts, 31 reservoirs and 42 mountain huts are directly or indirectly influenced by permafrost and associated processes. Ground stability and thus infrastructure (water dams, supporting infrastructure, buildings) can be affected by ground temperature increase and permafrost thawing due to climate change. Furthermore, there is also a substantial impact on hydrology related to permafrost degradation. The modification of permafrost affected regions is therefore of ecological but also economic importance. A range of institutions are interested in systematic permafrost monitoring, e.g. several Austrian universities, geological surveys at national and regional scale, the Austrian Federal Service for Torrent and Avalanche Control, or several different alpine clubs. To date, no coordinated monitoring network has been established at the national level and a strategy for long-term observations is not implemented. This impedes the evaluation of the existing sparsely distributed measurements as well as the development of an understanding of underlying processes.

It is recommended to increase the number of monitoring sites based on the analyses of the current situation and exchange with stakeholders. This should include temperature measurements in deep boreholes and shallow boreholes close to the surface, geophysical surveys and ground movement measurements (rock glaciers, instable rock faces) as well as hydro(geo)logical measurements. In addition, a spatially continuous observation of surface movements with remote sensing methods is required. Demand is highest for entire Tyrol, the district of Zell am See, north-western Carinthia and south-eastern Vorarlberg.



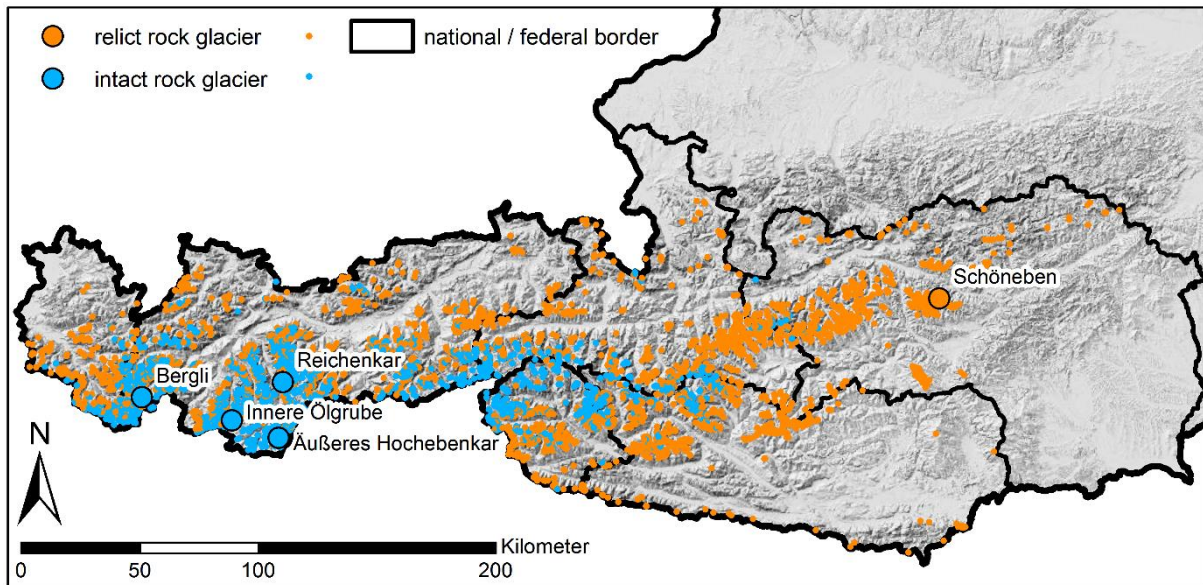
**Figure 41** Permafrost monitoring sites in Austria currently listed in our permafrost monitoring inventory as listed in Table 1. Permafrost extent indicated in the map is based on Boeckli et al. (2012)

Currently, there are five deep boreholes at Kitzsteinhorn, four at Hoher Sonnblick (all sites are located in the Hohe Tauern Range) and one deep borehole at the Dachstein Massif (Northern Calcareous Alps). The borehole at the Dachstein Massif is currently not working and needs a major repair. The ground temperature records from the other two sites are either submitted on an annual basis to GTN-P (Global Terrestrial Network on Permafrost) or metadata is provided. Related permafrost/periglacial monitoring with other methods, including ground surface temperature (GST) measurements, geophysical observations, terrain movements and hydrology has been conducted at about 20 other sites in Austria.

**Table 1** List of permafrost monitoring sites (#=number of sites; d=maximum borehole depth in m; a=active monitoring; m=continuous monitoring; s=single measurements, \* measurements stopped, \*\* severe problems with borehole, † contributes to GTN-P)

Location	Borehole		GST/GT		Geophysics			Movements		Hydrology	
	#	d	a	#	a	m	s	a	m	a	m
Äußeres Hochebenkar				2			X	X	X	X	X
Dachstein †**	1	7	X	1			X				
Dösen			X	12			X	X	X	X	X
Hintereggen-graben			X	8							
Hinteres Langtalkar			X	15			X	X	X	X	X
Hochreichart-Schöneben			X	16			X			X	X
Hochtor-Fallbichl			X	3			X	X			
Innerer Knorrkogel			X	18							
Innere Ölgrube							X		X	X	X
Kaiserberg *							X		X	X	X
Kitzsteinhorn †	5	30	X	29	X	X	X	X	X	X	X
Krummgampen							X			X	X
Leibnitzkopf			X	2				X	X		
Pasterze-Burgställe			X	7				X	X		
Reichenkar *							X		X	X	X
Rofenberg			X	5			X	X	X		
Rosskar				≤1							
Schrankar				≤1							
Sonnblick †	4	20	X	10	X	X	X				
Tschadinalm			X	2				X	X		
Weissenkar			X	3			X	X	X		
Wintergasse			X	28							

During the last years rock glaciers in the Austrian Alps were intensely investigated related to their hydro(geo)logical impact on alpine head waters. A process-based understanding of the storage and runoff behaviour of rock glaciers was developed as a fundamental base for further discussion of runoff behaviour in alpine catchment in the light of climate change. Parallel the first Austrian-wide consistent and homogenized polygon-based inventory of rock glaciers (and their topographic catchments, see Fig. 42) has been compiled using high resolution digital elevation model (1x1m spatial resolution). In total, 5769 rock glaciers were mapped, of which ~40 % are interpreted to be intact rock glaciers (containing permafrost); the remaining 60 % are interpreted to be relict (containing no permafrost).



**Figure 42: Overview of rock glaciers mapped in the Austrian Alps and the five test sites where discharge patterns were analysed. Rock glaciers are shown as centroid points within the Austrian national border distinguishing between relict and intact rock glaciers. Bergli (Silvretta Mountain Group), Innere Ölgrube and Äußeres Hochebenkar (Ötztal Alps); Reichenkar (Stubai Alps) and Schöneben rock glacier (Seckauer Tauern Range). From Wagner et al. (2020)**

A monitoring network of rock glaciers was developed by continuous measurements at already existing test sites and by the installation of new ones. Research goals ranged from hydrogeological issues such as storage behaviour and runoff characterization to the thermal regime on the surface and in the subsurface as a base for a better understanding of rock glacier evolution. An overview of the test sites, the performed investigations and the installed measurement devices is given in Table 2. Runoff data from rock glaciers is partly derived from official gauging stations of the Hydrographic Services of Styria and Tyrol (Schöneben, Bergli, Äußeres Hochebenkar).



**Table 2:** A detailed overview of rock glaciers and applied measurements where data can be provided. Electrical conductivity of the water (EC), water temperature (WT), discharge of the spring (Q), precipitation (P), air temperature (AT), air humidity (AH), wind direction (WD), wind velocity (WV), global radiation (GR) und radiation balance (RB), digital automatic camera for snow cover dynamics (RDC).

	Schöneben	Dürrtal	Ölgrube Nord	Innere Ölgrube	Krummgampen	Inneres Hochebenkar	Äußeres Hochebenkar	Hochschober	Bergli (Galtür)	Tuxer Hauptkamm	Dösen	Hinteres Langtalkar	Tschadinhorn	Leibnitzkopf	Weißekar	Reichartkar
Geologic/geomorphologic mapping	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Monitoring of spring WT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-
Monitoring of spring EC	X	X	X	X	X	X	X	-	X	-	-	-	-	-	-	-
Monitoring of measuring gauge Q	X	-	X	X	X	X	X	X	X	-	-	-	-	-	-	-
Hydrochemical analysis	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-	-
Isotope hydrological analysis	X	X	X	X	X	-	-	X	X	X	-	-	-	-	-	-
Heavy metal analysos	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-	-
Artificial tracer tests	X	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-
Meteorological station (P, AT, AH, WD, WV, GR, RB)	X	-	-	-	-	X	X	-	-	-	X	X	-	-	-	-
AT/AH station	X	X	-	-	-	X	X	-	-	-	X	X	X	-	-	X
Isotope signature precipitation	X	-	X	X	-	-	-	X	X	-	-	-	-	-	-	-
Monitoring ground temperature	X	X	-	X	X	-	-	x	X	X	X	X	X	X	X	X
Snow cover dynamics (RDC)	X	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-
Geophysical investigations - geometry	X	-	X	X	-	-	-	-	-	-	X	X	-	-	-	X
Flow velocity measurements	-	-	-	X	-	-	X	-	-	-	X	X	X	X	X	-

Essential Climate Variables - Terrestrial Observations - Cryosphere

Parameter measured/observed	Ground temperature
Starting date	2007
Temporal Resolution	hourly (or at 10-minute intervals)
Observational Network	Sonnblick Observatory, Open Air Lab Kitzsteinhorn, GTN-P
Stations	Sonnblick Observatory (Hoher Sonnblick 1-3) Kitzsteinhorn (Kitzsteinhorn 1-5) Dachstein Massif (Koppenkarstein North Face)
Data Portal	<a href="http://www.gtnpdatabase.org">www.gtnpdatabase.org</a>
Supervising Organization	Georesearch, University of Graz, ZAMG
National and/or international Networks or Programs	AlpHaz (Munich Alpine Hazards and Mitigation Cluster), GTN-P (Global Terrestrial Network on Permafrost), IPA (International Permafrost Association)
Data Submission	partial annual upload to GTN-P database
Licenses	CC BY-NC
Use Limitation	For research only
Data Format	csv
Data Access	restricted
Data Quality	raw data
Performance Monitoring	systematic check
Publications	<p>Wagner, T., Pleschberger, R., Kainz, S., Ribis, M., Kellerer-Pirklbauer, A., Krainer, K., Philippitsch, R., &amp; Winkler, G. (2020). The first consistent inventory of rock glaciers and their hydrological catchments of the Austrian Alps, Austrian Journal of Earth Sciences, 113(1), 1-23. doi: <a href="https://doi.org/10.17738/ajes.2020.0001">https://doi.org/10.17738/ajes.2020.0001</a></p> <p>Kellerer-Pirklbauer, A.; Lieb, G.K. (2017): Permafrost-Monitoring in den österreichischen Alpen: Ein Arbeitsbereich am Institut für Geographie und Raumforschung. In: GEOGRAZ. Grazer Mitteilungen der Geographie und Raumforschung. 60. 2017. 11-16.</p> <p>Kellerer-Pirklbauer A., Lieb G.K. (2016): Permafrost in Österreich 2014/15 – Ein erster nationaler Kurzbericht. In: Bergauf 03/2016, 51-53.</p> <p>Kellerer-Pirklbauer, A., Bartsch, A., Gitschthaler, C., Reisenhofer, S., Weyss, G., Riedl, C., Avian, M. (2015). permAT – Long-term monitoring of permafrost and periglacial processes and its role for</p>

	<p>natural hazard prevention: Possible strategies for Austria (in German). 10.13140/RG.2.1.1115.4807.</p> <p>Boeckli, Lorenz; Brenning, A; Gruber, A; Noetzli, Jeannette (2012): Alpine permafrost index map. PANGAEA, <a href="https://doi.org/10.1594/PANGAEA.784450">https://doi.org/10.1594/PANGAEA.784450</a> Supplement to: Boeckli, L et al. (2012): Permafrost distribution in the European Alps: calculation and evaluation of an index map and summary statistics. The Cryosphere, 6, 807-820, <a href="https://doi.org/10.5194/tc-6-807-2012">https://doi.org/10.5194/tc-6-807-2012</a></p> <p>StartClim2014:  <a href="http://www.startclim.at/fileadmin/user_upload/StartClim2014/StCl2014_en_final_report.pdf">http://www.startclim.at/fileadmin/user_upload/StartClim2014/StCl2014_en_final_report.pdf</a>  <a href="http://www.startclim.at/projektliste/">http://www.startclim.at/projektliste/</a></p>
<p>Contact (National correspondent, focal point)</p>	<p>Claudia Riedl: <a href="mailto:claudia.riedl@zamg.ac.at">claudia.riedl@zamg.ac.at</a>  Ingo Hartmeyer: <a href="mailto:ingo.hartmeyer@georesearch.at">ingo.hartmeyer@georesearch.at</a>  Andreas Kellerer-Pirklbauer: <a href="mailto:andreas.kellerer@uni-graz.at">andreas.kellerer@uni-graz.at</a></p>
<p>Remarks</p>	<p>Satellite data based, modelled ground temperature data are made openly available through the ESA initiative GlobPermafrost  <a href="http://www.globpermafrost.info">http://www.globpermafrost.info</a></p>

## ARGE LWD

### Austrian snow station network

Christoph Mitterer (LWD-Tirol), Patrick Nairz (LWD-Tirol),  
Michael Butschek (ZAMG), Alexander Podesser (ZAMG)

The consortium of regional avalanche warning services in Austria (ARGE LWD ) operates an intensive automated snow and weather station network to record snow and weather parameters relevant for high-quality avalanche danger assessments. The network consists of 186 snow stations (Figure 42) and represents one of the most sophisticated and densest automated station networks worldwide.

The objectives of the measurements:

- Provide information on snow and weather properties at a high temporal resolution to local and regional avalanche warning services and avalanche commissions.
- Provide the basis for daily local and regional avalanche danger assessments and/or forecast throughout various warning products and advisories.
- Provide the input for operational snow cover modelling.
- Provide the background for long-term statistical tools based on nearest-neighbor methods (e.g. NxD).

The network is partly owned by the Provincial Governments, communities and/or third party NGO's or companies such as e.g. the Austrian Railways (OEBB). Most measurement sites include two automated stations: a snow station and a wind station (not shown on the map below). While the wind station is mostly placed on exposed ridges or summits, snow stations are built in wind sheltered areas such as e.g. bowls. The name of the station speaks for its sensor equipment: Wind stations record parameters of wind and air temperature, while snow station focus on recording snow height, snow surface temperature and other relevant snow parameters (e.g. snow temperature and liquid water content).

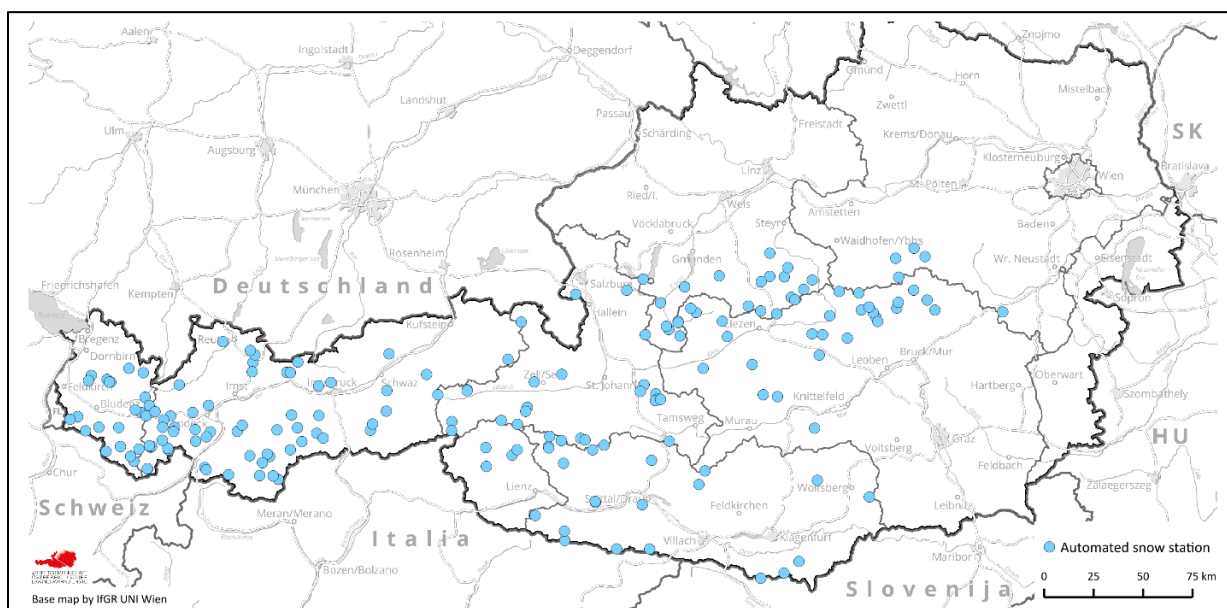


Figure 43 Network of snow stations operated by the consortium of regional Avalanche Warning Services in Austria (N = 186)

Essential Climate Variables - Terrestrial Observations - Cryosphere

Parameter measured/observed	<p>10-minute-mean: air temperature, relative humidity, wind speed, wind direction, global radiation, snow height, snow temperature, snow surface temperature</p> <p>10-minute-maximum: wind speed, wind direction</p> <p>10-minute-total: precipitation</p> <p>Actual value: snow water equivalent, snow liquid water content, snow ice content</p>
Starting date	Considerable variation within the various avalanche warning services, but mostly starting from mid to end 1990s.
Temporal Resolution	10 minute
Observational Network	Observational network of the corresponding regional avalanche warning service grouped within the ARGE Lawinenwarndienste Österreich
Stations	<p>Vorarlberg: N = 23</p> <p>Tyrol: N = 68</p> <p>Salzburg: N = 23</p> <p>Upper Austria: N = 19</p> <p>Styria: N = 28</p> <p>Carinthia: N = 35</p> <p>Lower Austria: N = 10</p>
Data Portal	No explicit and uniform data portal available, but data can be obtained upon request or through various OGD interfaces of the Provincial Governments.
Supervising Organization	The Provincial Governments of the correspondent regional avalanche warning service.
National and/or international Networks or Programs	ARGE Lawinenwarndienste Österreich
Data Submission	Automatic data transfer via HTTP
Licenses	Free raw data
Limitation of Use	For research purposes and operational warning only, non-commercial
Data Format	CSV, ASCII, ZRXP
Data Access	Open access on request or OGD interfaces

Data Quality	Data quality is evaluated by the correspondent regional avalanche warning service
Performance Monitoring	Data availability is monitored by the correspondent regional avalanche warning service
Publications	<p>Vorarlberg: Various graphs on <a href="http://www.lawis.at">www.lawis.at</a></p> <p>Tyrol: Various graphs on <a href="http://www.lawis.at">www.lawis.at</a></p> <p>Salzburg: Various graphs on <a href="http://www.lawis.at">www.lawis.at</a></p> <p>Upper Austria: Current 3-day graphs <a href="http://www.land-oberoesterreich.gv.at/was_lnw.htm">www.land-oberoesterreich.gv.at/was_lnw.htm</a></p> <p>Styria: Various graphs on <a href="http://www.lawis.at">www.lawis.at</a></p> <p>Carinthia: Current 3-day graphs on <a href="http://www.lawine.ktn.gv.at">www.lawine.ktn.gv.at</a></p> <p>Lower Austria: Various graphs on <a href="http://www.lawis.at">www.lawis.at</a></p>
Contact (National correspondent, focal point)	<p><a href="mailto:lawine@tirol.gv.at">lawine@tirol.gv.at</a>,</p> <p><a href="mailto:lawine@lawine-steiermark.at">lawine@lawine-steiermark.at</a></p> <p><a href="mailto:lawine@ktn.gv.at">lawine@ktn.gv.at</a></p> <p><a href="mailto:post.bd3@noel.gv.at">post.bd3@noel.gv.at</a></p> <p><a href="mailto:lawine@salzburg.gv.at">lawine@salzburg.gv.at</a></p>
Remarks	





# Terrestrial Observations

Biosphere

## National Forest Inventory of Austria

Alexandra Freudenschuß (BFW)

The National Forest Inventory (NFI) of Austria is a large-scale forest monitoring programme covering the federal territory of Austria. The Austrian NFI is the main data provider for national and international reporting on Austria's forest resources. The results serve as basis for decisions in forest and environmental policy and are a valuable data source for numerous scientific projects. The planning, execution and evaluation is carried out by the Department of Forest Inventory of the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW).

Until today, seven sample-based inventories have been carried out. The field assessments of the most recent inventory are ongoing and cover the sampling period 2016 to 2021. The first inventory was conducted in the years 1961 - 1970, and was followed by the assessments in 1971 - 1980, 1981 -1985, 1986 - 1990, 1992 - 1996, 2000 - 2002 and 2007 - 2009. While the first two NFIs were based on a temporary sampling grid, the subsequent inventories were carried out on a permanent grid consisting of approximately 5,500 clusters and 11,000 forest plots. The distance between the clusters is 3.89 km. The clusters have the shape of a square with 200 m side-length where the sample plots are located at the corners. At the sample plots numerous stand-, site- and tree-specific variables are assessed and form the basis for the periodic results of the Austrian NFI.

Furthermore remote sensing techniques are used and continuously improved to supplement and enlarge the information about Austrian forests. With the help of Aerial Images and Orthophotos, Satellite Imagery and Airborne Laserscanning forest parameters like volume, biomass, forest area, forest types, increment, harvest and disturbances are determined (<https://bfw.ac.at/rz/wi.home>).

### Essential Climate Variables – Terrestrial Observations - Biosphere

<b>Parameter measured/observed</b>	Terrestrial data – 200 different stand-, site- and tree-specific parameters like e.g. land use, tree species, forest structure, above-ground biomass, elevation, slope, soil type, forest vegetation type, tree diameter and height.
<b>Starting date</b>	Inventory cycles started in 1961, since then seven NFIs had been conducted, the most recent NFI started in 2016.
<b>Temporal Resolution</b>	periodical assessments in 1961-1970, 1971-1980, 1981-1985, 1986-1990, 1992-1996, 2000-2002, 2007-2009 and 2016-2021.
<b>Observational Network</b>	Large-scale inventory with a sampling grid of 3.89 km x 3.89 km covering all federal territory.
<b>Stations</b>	5,500 clusters with approximately 11,000 plots located on forest land.
<b>Data Portal</b>	Results are available at the homepage <a href="https://bfw.ac.at/rz/wi.home">https://bfw.ac.at/rz/wi.home</a> for national and sub-national levels for different topics (e.g. forest area, standing volume, increment, harvest). Plot data accessibility restricted.

<b>Supervising Organization</b>	Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW), Department of Forest Inventory
<b>National and/or international Networks or Programs</b>	The Austrian NFIs represents large-scale forest monitoring at national level. It is member of ENFIN – the European National Forest Inventory Network which promotes the harmonisation of forest information ( <a href="http://enfin.info/">http://enfin.info/</a> ).
<b>Data Submission</b>	Periodical update following each inventory cycle.
<b>Licenses</b>	Credits and attribution to BFW. No data sharing with others. No commercial use. No modification of data and results.
<b>Use Limitation</b>	Research projects and non-commercial uses.
<b>Data Format</b>	Stored in an Oracle® database. Data excerpts as xls or csv. Download of results as xls files.
<b>Data Access</b>	Open access download of results at the BFW homepage <a href="https://bfw.ac.at/rz/wi.home">https://bfw.ac.at/rz/wi.home</a> . Availability of plot data is restricted.
<b>Data Quality</b>	Data undergo comprehensive quality checking in several steps. Data quality checks are performed by the BFW.
<b>Performance Monitoring</b>	Data availability is supervised by BFW.
<b>Publications</b>	The Department of Forest Inventory publishes and contributes to publications within the thematic frames: inventory methods, harmonization of NFIs, use of remote sensing, uncertainty, climate change, biodiversity, and wood availability.
<b>Contact (National correspondent, focal point)</b>	<a href="mailto:klemens.schadauer@bfw.gv.at">klemens.schadauer@bfw.gv.at</a> <a href="mailto:richard.buechsenmeister@bfw.gv.at">richard.buechsenmeister@bfw.gv.at</a>
<b>Remarks</b>	

## Monitoring hydrological data of forest ecosystems

*Karl Gartner (BFW)*

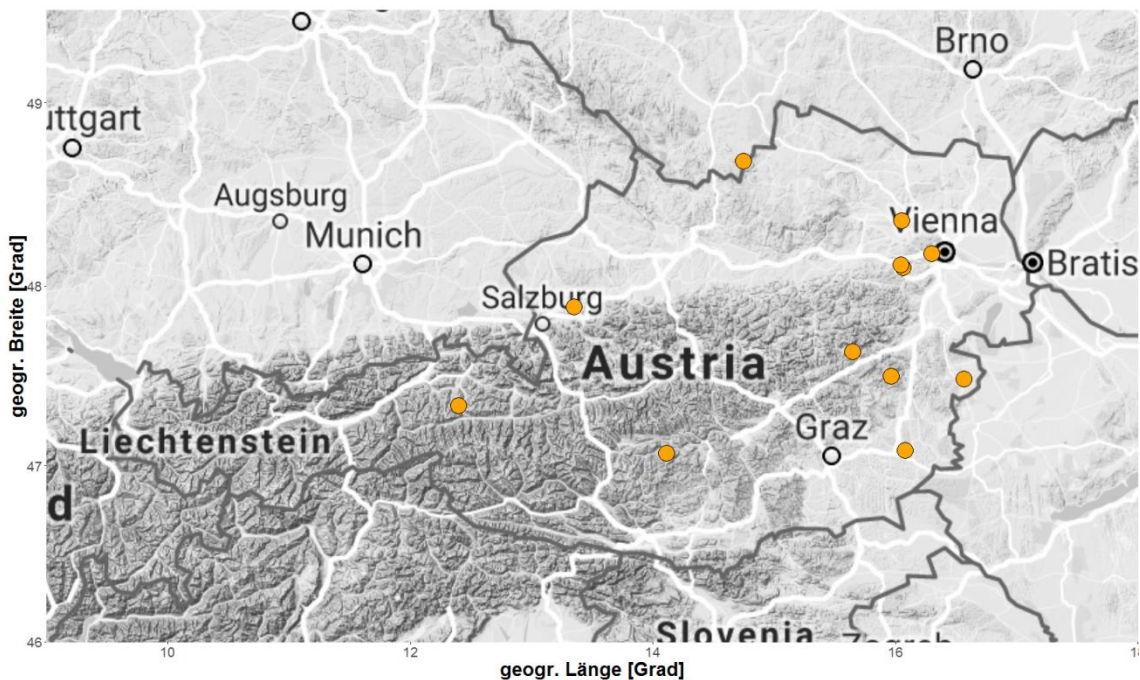
The web portal WALDÖKODATEN was developed by the department of Forest Ecology and Soils of the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW). It provides - daily updated - a large part of the ongoing ecological relevant measurements of the department, which belong to different ongoing projects of the department.

The web portal includes data, which come from the stations via remote access. The data are roughly checked and imported into a POSTGRESQL data base system. The data are aggregated to daily values and exported from this database to be shown in form of graphical form or to be downloaded in the form of CSV-files. Except for the data on changing stem circumferences, all data are shown and

available online only for the last thirty days. A Google-map with the exact position of the measurement station completes the web site.

A simple quality control of the data is done before the data come into the data base. For this reason the data available from the web-portal are not final data sets. They can be changed by data analysis which is done to get the corresponding results for the different projects. The use of the data for commercial use is not permitted.

The data comprise meteorological data of open field stations, air temperature and air humidity within the stand, soil temperature and soil moisture and measurements of changing stem circumference with the help of electronic girth bands.



**Figure 44** Location of the WALDÖKODATEN - stations. Also shown are the stations in Tulln and Weitra, which are at the moment not part of the WALDÖKODATEN-portal.

### Essential Climate Variables – Terrestrial Observations - Biosphere

<b>Parameter measured/observed</b>	meteorological data (air temperature, air humidity, global radiation, wind speed, wind direction, precipitation) together with soil temperature and soil moisture
<b>Starting date</b>	earliest dataset starts at 06/1998
<b>Temporal Resolution</b>	differs from 15 to 60 minutes
<b>Observational Network</b>	long term monitoring of forest sites
<b>Stations</b>	about 10 stations distributed across Austria
<b>Data Portal</b>	<a href="http://bfw.ac.at/rz/bfwcms2.web?dok=8658">http://bfw.ac.at/rz/bfwcms2.web?dok=8658</a> partly national data centres of the participating countries

<b>Supervising Organization</b>	Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW)
<b>National and/or international Networks or Programs</b>	ICP Forests
<b>Data Submission</b>	daily update
<b>Licenses</b>	CC BY-NC-SA
<b>Use Limitation</b>	for non-profit research
<b>Data Format</b>	Download of the data as csv
<b>Data Access</b>	Download via the Waldökodaten-homepage ( <a href="http://bfw.ac.at/rz/bfwcms2.web?dok=8658">http://bfw.ac.at/rz/bfwcms2.web?dok=8658</a> ) Open access to the last 30 days of data (otherwise see contact below)
<b>Data Quality</b>	Data quality is done by BFW.
<b>Performance Monitoring</b>	Data availability is supervised by BFW (see contact).
<b>Publications</b>	
<b>Contact (National correspondent, focal point)</b>	Contact: <a href="mailto:karl.gartner@bfw.gv.at">karl.gartner@bfw.gv.at</a>
<b>Remarks</b>	

## Phenology ZAMG

*Thomas Hübner (ZAMG)*

### Insight Phenology

The roots of the Phenological Observation Network of Austria reach back to 1851 when ZAMG was founded. An uninterrupted series of phenological observations extend back to 1946. The start of the longest observation series dates back to 1457, which is the date of grape harvest in the vineyards of Klosterneuburg (NÖ). Digitized data of phenological development of crop, vine, fruit plants, trees, shrubs, herbaceous and some animals is available from 1926 until today. Earlier years are still under digitization.





Phenological observations are done by volunteering Citizen Scientists. By now there are about 100 observers per year who either enter their observations online on [www.phenowatch.at](http://www.phenowatch.at) or still use the traditional paper pen method and mail the completed form to ZAMG.

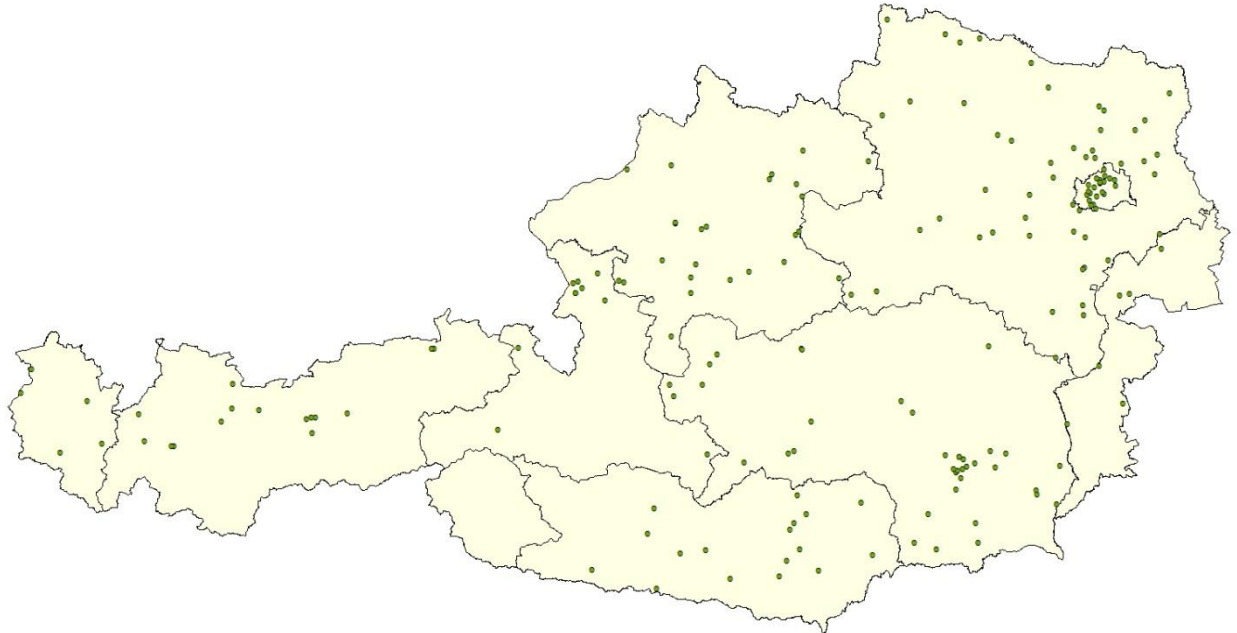


Figure 45 Active stations for phenological observation between 2014 and 2017.

### New tool for new Citizen Scientists

In addition to observation at the classic phenology stations, there is also the possibility for the general population to actively support the phenology as a citizen scientist. The smartphone app "nature calendar ZAMG" was developed to involve interested laypersons in the work of ZAMG.

In this way, the Citizen Scientists become contributors in climate change research and can understand it more easily through their own observations in their own environment. In this way they also become multipliers and ambassadors for phenology.

The app for Android and iOS can be downloaded from the website [www.naturkalender.at](http://www.naturkalender.at). There is also information about phenology and fact sheets about phenological pointer plants.



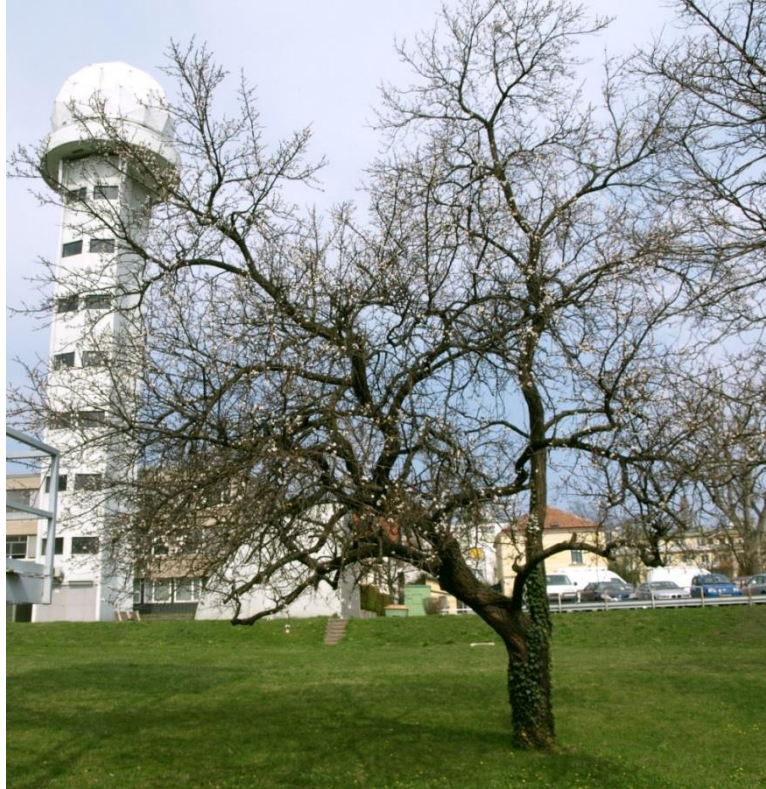
### Europe-wide network

ZAMG is the host of the Pan European Phenological database (PEP725) where all major phenological networks in Europe store their data for scientific research. The access is open to all interested parties and the download or support by ZAMG is free. [www.pep725.eu](http://www.pep725.eu).



## Terrestrial Observations - Biosphere

ZAMG is also a partner of the international Plant Gardens (IPG). This phenological network works with cloned plants to avoid influences of genetic predetermination. In Austria there are two locations for observation which are the only institutionalized sites for phenological observation in general: ZAMG Wien und ZAMG Salzburg.



---

### Essential Climate Variables – Terrestrial Observations - Biosphere

---

<b>Parameter measured/observed</b>	occurrence of certain states of development of plants, like first flowering or leaf colouring in DOY (day of year)
<b>Starting date</b>	1926 with interruptions and changing number of observation stations (not digitised before 1926, extend back to 1851)
<b>Temporal Resolution</b>	yearly occurrence per species, phase and location
<b>Observational Network</b>	National phenological network of Austria including their collaborations
<b>Stations</b>	all phenological stations in Austria (number species and phases may vary yearly)
<b>Data Portal</b>	portal for data entry and meta data <a href="http://www.phenowatch.at">www.phenowatch.at</a> and <a href="http://www.naturkalender.at">www.naturkalender.at</a> (starting in 2018) data portal for download etc. <a href="http://www.pep725.eu">www.pep725.eu</a>

## Terrestrial Observations - Biosphere

<b>Supervising Organization</b>	Zentralanstalt für Meteorologie und Geodynamik (ZAMG)
<b>National and/or international Networks or Programs</b>	Paneuropean Phenological Database - PEP725 National Phenological Network of Austria (Phenowatch, Naturverrückte, Naturkalender Steiermark, etc.) GCOS
<b>Data Submission</b>	Online submission via website continuously (50 %) Annual data submission on posted paper form (50 %)
<b>Licenses</b>	CC-BY-NC
<b>Use Limitation</b>	Non-commercial, non-profit research
<b>Data Format</b>	download of the data as csv
<b>Data Access</b>	download via <a href="http://www.pep725.eu">www.pep725.eu</a> access by registration
<b>Data Quality</b>	First data quality control is done by boundary values during data entry and by review of the members of the phenology team at ZAMG. Other mechanisms are under development.
<b>Performance Monitoring</b>	Data availability is supervised by ZAMG.
<b>Publications</b>	annual report of ZAMG
<b>Contact (National correspondent, focal point)</b>	Paneuropean Phenological Database - PEP725 Markus Ungersböck <a href="mailto:markus.ungersboeck@zamg.ac.at">markus.ungersboeck@zamg.ac.at</a> National Phenological Network of Austria (Phenowatch, Naturverrückte, etc.)  Helfried Scheifinger <a href="mailto:helfried.scheifinger@zamg.ac.at">helfried.scheifinger@zamg.ac.at</a> Thomas Hübner <a href="mailto:thomas.huebner@zamg.ac.at">thomas.huebner@zamg.ac.at</a>
<b>Remarks</b>	

---

## Continuation of the measurements ensured for the next years:

---

□ < 5 years

□ 5-10 years

□ > 10 years

Atmospheric Observations – Surface	
Climate monitoring ZAMG	□ > 10 years
VAMES	□ > 10 years
Aerodrome Met stations	□ > 10 years
Sunshine duration	□ > 10 years
UV Radiation	□ 5-10 years
Solar and terrestrial radiation	□ 5-10 years
BSRN	□ 5-10 years
HISTALP	□ > 10 years
Atmospheric Observations – Upper Air	
RASO ZAMG	□ > 10 years
RASO AUSTRO CONTROL	□ > 10 years
Austrian Weather Radar Network	□ > 10 years
Atmospheric Observations - Composition	
Stratospheric Ozone	□ 5-10 years
Air Quality Monitoring Network	□ > 10 years
Air Quality Monitoring of federal states of Austria	□ > 10 years
Sonnblick Observatory	□ > 10 years
Terrestrial Observations - Hydrosphere	
Hydrological Service of Austria (eHYD)	□ > 10 years
Tuxer Alps	□ < 5 years
Torrent Research Areas	□ < 5 years
ISMN - In situ soil moisture observations	□ < 5 years
ASCAT surface soil moisture	□ 5-10 years
Terrestrial Observations - Cryosphere	
Snow	□ > 10 years
Glaciers	□ < 5 years
Permafrost	□ < 5 years
Regional avalanche warning services in Austria	□ > 10 years
Terrestrial Observations - Biosphere	
National Forest Inventory of Austria	□ > 10 years
Monitoring hydrological data of forest ecosystems	□ < 5 years
Phenology ZAMG (sustained through citizen science)	□ < 5 years

## Annex

## Essential Climate Variables from the Global Observing System for Climate: Implementation Needs 2016 (WMO)

Essential Climate Variables (ECVs)		WMO		CEOS & CGMS <sup>1</sup>	Other
		Programmes	Co-Sponsored		
Atmospheric	Surface:				
	Wind speed and direction, Precipitation,	WIGOS		WGClimate	
	Air temperature, Water vapour, Pressure, Surface radiation budget.	WIGOS			
	Upper-air:				
	Lightning	WIGOS			
	Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget.	WIGOS		WGClimate	
	Composition				
Carbon Dioxide (CO <sub>2</sub> ), Methane (CH <sub>4</sub> ), Other long-lived greenhouse gases (GHGs), Ozone, Aerosol, Precursors for aerosol and ozone.	GAW		WGClimate		
Oceanic	Physics:				
	Subsurface Temperature, Subsurface Salinity, Subsurface Currents, Ocean Surface Stress, Ocean Surface heat Flux		GOOS/JCOMM		
	Sea Surface Temperature, Surface Currents, Sea Surface Salinity, Sea Level, Sea State, Sea Ice		GOOS/JCOMM	WGClimate	
	Biogeochemistry:				
	Inorganic Carbon, Oxygen, Nutrients, Transient Tracers, Nitrous Oxide (N <sub>2</sub> O),		GOOS		IOCCP
	Ocean Colour		GOOS	WGClimate	IOCCG
	Biology/ecosystems:				
Plankton, Marine habitat properties		GOOS	TBD	GEOBON	
Terrestrial	Hydrology:				
	River discharge, Groundwater, Soil Moisture	WHYCOS	GTN-H		
	Lakes	WHYCOS	HYDROLARE	WGClimate	
	Cryosphere:				
	Snow, Glaciers, Ice sheets and Ice shelves, Permafrost	GCW		WGClimate	
		GCW			GTN-G, GTN-P
	Biosphere:				
	Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Above-ground biomass, Fire, Land Surface Temperature		BSRN	WGClimate	FluxNet, Others
	Soil carbon,				
Human use of natural resources:					
Water use,				AQUASTAT	
GHG fluxes	GAW		WGClimate	TBD, GCP	

Notes: <sup>1</sup> The WG-Climate works on satellite derived data products

Stakeholders:

AQUASTAT	FAO database and data collection system on water use
GAW	WMO's Global Atmosphere Watch
GCP	Global Carbon Project
GCW	WMO's Global Cryosphere Watch
GOOS	Global Ocean Observing System Sponsored by WMO, IOC of UNESCO, ...
GTN-G	Global Terrestrial Network – Glaciers
GTN-H	Global Terrestrial Network – Hydrology
GTN-P	Global terrestrial Network – Permafrost
HYDROLARE	International Data Centre on Hydrology of Lakes and Reservoirs
JCOMM	WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology
IOCCG	International Ocean Color Coordination Group
IOCCP	International Ocean Carbon Coordination Project
TBD	To be determined
WGClimate	The Joint CEOS/CGMS working group on climate
WHYCOS	World Hydrological Cycle Observing System (a WMO programme)

## GCOS CLIMATE MONITORING PRINCIPLES

*Effective monitoring systems for climate should adhere to the following principles\*:*

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.
2. A suitable period of overlap for new and old observing systems is required.
3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.
4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.
5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.
6. Operation of historically-uninterrupted stations and observing systems should be maintained.
7. High priority for additional observations should be focused on data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.
8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.
9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.
10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

*Furthermore, operators of satellite systems for monitoring climate need to:*

- (a) Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system; and
- (b) Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.

*Thus satellite systems for climate monitoring should adhere to the following specific principles:*

11. Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained.
12. A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations.
13. Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured.
14. Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured.

15. On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored.
16. Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate.
17. Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.
18. Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on decommissioned satellites.
19. Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation.
20. Random errors and time-dependent biases in satellite observations and derived products should be identified.

---

*\*The ten basic principles (in paraphrased form) were adopted by the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) through decision 5/CP.5 at COP-5 in November 1999. This complete set of principles was adopted by the Congress of the World Meteorological Organization (WMO) through Resolution 9 (Cg-XIV) in May 2003; agreed by the Committee on Earth Observation Satellites (CEOS) at its 17th Plenary in November 2003; and adopted by COP through decision 11/CP.9 at COP-9 in December 2003.*