VAO Symposium Kaprun
02. – 04. April 2025
Abstract booklet
Only submissions that include an abstract are considered

Isotopic measurements of greenhouse gases at mountain sites: Opportunities and challenges

Presenting author: Associate Professor Dr. Eliza Harris, University of Bern
(please refer to the presentation for potential co-author names)

Climate change is a major environmental problem requiring collaborative solutions from scientific, technological and societal partners. Greenhouse gas (GHG) measurements play a pivotal role in understanding and quantification of emissions, providing the basis to develop and assess mitigation measures. Mountain sites are a key part of measurement programs as they provide an estimate of background concentrations - far from pollution sources - and offer an integrated view of emissions across large geographical regions. While GHG mixing ratio measurements are effective for estimating total emissions, isotopic composition analysis offers a deeper understanding by enabling the differentiation of various sources and processes. However, isotopic measurements at background and mountain sites are challenging. The signals detected are often near the sensitivity limits of current instrumental techniques, necessitating advancements in precision and methodology. Furthermore, ensuring comparability between sites requires highly accurate measurements, inter-laboratory comparisons, and the development of isotopic standards—many of which remain unavailable for certain species and isotopocules. The interpretation of data also brings challenges, as isotopic composition is not yet incorporated into most bottom-up and top-down modelling methods. Despite these challenges, isotopic measurements at mountain sites offer a unique opportunity to increase our understanding of greenhouse gas emissions and processes, and we expect that this field will deliver exciting advances in the coming years.

Snow in the European Alps: Observations, changes and opportunities

Presenting author: Prof. Michael Lehning, EPFL, Laboratory of Cryospheric Sciences
(please refer to the presentation for potential co-author names)

Switzerland, as an Alpine country with an economy reliant on hydropower, tourism, and effective natural hazard management, has a long-standing tradition of snow monitoring and operates a unique network of high-altitude automatic weather stations. These extensive observations enable detailed analyses of past climate trends and future projections, revealing a significant decline in snow cover, particularly at mid-elevations. This shift poses challenges for many ski resorts, while higher-altitude areas may benefit. Reduced snowfall and increased rainfall are expected to lower avalanche risks but heighten the likelihood of flooding, as well as more severe mud and debris flows. Conversely, greater winter hydropower availability—complemented by wind and solar energy—could help mitigate electricity shortages during low-flow winter periods. Adapting to these changes requires strategic infrastructure planning, where high-quality data and predictive models are essential tools.

Ethical and Cultural Dimensions of Adaptation Strategies in a Changing Alpine Environment

Presenting author: Prof. Dr. Dr. Johannes Wallacher, Munich School of Philosophy
(please refer to the presentation for potential co-author names)

Strategien der Anpassung an den Klimawandel in sich schnell verändernden Alpinen Räumen haben unvermeidliche ethische und kulturelle Dimensionen, die häufig vernachlässigt werden. Für gerechte, wirksame und effiziente Anpassungsmaßnahmen sollten diese aber unbedingt berücksichtigt werden. In der keynote soll dies anhand von drei Themen verdeutlicht werden.
1. Der Tatsache, dass nicht nur die Begrenzung des Klimawandels (mitigation), sondern auch die Anpassung an die schon nicht mehr vermeidbaren Folgen mit Fragen inter- und intragenerationeller Gerechtigkeit verbunden sind, die möglichst integriert zu betrachten sind.
2. Ganz allgemein und im Besonderen für verwundbare Alpenregionen stellt sich die Fragen nach den Werten, die unser Verhältnis und unser Verhalten gegenüber der Natur leiten.
3. Ethik und Kultur sind eng miteinander verbunden. Dies ist vor allem bedeutsam, um die Notwendigkeit von Anpassungsmaßnahmen nicht nur zu begründen, sondern auch konkret umzusetzen und mögliche Widerstände zu überwinden.

Strategies for adapting to climate change in rapidly changing Alpine regions have inevitable ethical and cultural dimensions that are often neglected. For fair, effective, and efficient adaptation measures, these must be taken into account. The keynote will illustrate this through three themes:
1. The fact that not only the limitation of climate change (mitigation), but also adaptation to the already unavoidable consequences are associated with questions of inter- and intragenerational justice, which should be considered as integrated as possible.
2. In general and especially for vulnerable Alpine regions, the question arises about the values that guide our relationship and behavior towards nature. In this sense, ethics and culture are closely linked.

3. The linkage between ethics and culture is particularly important not only to argue for urgency of adaptation measures but also to implement them concretely and overcome possible resistance.

Alpine rivers and their extreme events in a changing climate

Presenting author: Prof. Dr. Manuela Brunner, WSL Institute for Snow and Avalanche Research SLF
(please refer to the presentation for potential co-author names)

Climate change leads to changes in Alpine rivers including changes in water availability and extreme events, namely droughts, floods, and riverine heatwaves. Using observational data and hydrological model simulations generated with different types of climate ensembles, I highlight what changes society needs to expect and prepare for. I show that increases in temperature and precipitation variability lead to seasonal shifts in flow seasonality. Further, I discuss changes in different types of extreme events including (1) increases in drought frequency, and magnitude as a result of changes in drought generation processes; (2) increases in flood frequency in many regions, in particular for the most extreme events as a results of precipitation intensification; and (3) increases in mean and extreme water temperatures.

Permafrost degradation and alpine hazards in the Alps

Presenting author: Prof. Dr. Michael Krautblatter, Technical University Munich
(please refer to the presentation for potential co-author names)

Understanding and modelling instable permafrost bedrock is a key requirement to anticipate magnitudes and frequency of rock slope failures in a changing climate but also to forecast the stability of high-alpine infrastructure throughout its lifetime.

The last 5-10 years have brought upon significant advances in the (i) knowledge of relevant hydrostatic pressures in permafrost rock, (ii) the brittle-ductile transitions of ice relevant for larger permafrost rock slope failures and (iii) techniques that can help to decipher the preparation phase of large rockslides also (iv) many new examples have delivered additional insight into multi-phase failure.

High-alpine rock faces witness the past and present mechanical limit equilibrium. Rock segments where driving forces exceed resisting forces fall of the cliff often leaving a rock face behind which is just above the limit equilibrium. All significant changes in rock mechanical properties or significant changes in state of stress will evoke rock instability which often occurs with response times of years to 1000 years. Degrading permafrost will act to alter (i) rock mechanical properties such as compressive and tensile strength, fracture toughness and most likely rock friction, (ii) warming subcero conditions will weaken ice and rock-ice interfaces and (iii) increased cryo- and (iv) hydrostatic pressures are expected. Laboratory experiments provide estimations of the serious impact of thawing and warming rock and ice-mechanical properties (ad i and ii), which often lose 25-75% of their strength between -5°C and -0.5°C. Approaches to calculate cryostatic pressure (ad iii) have been published and are experimentally confirmed. However, the importance and dimension of extreme hydrostatic forces (ad iv) due to perched water above permafrost-affected rocks has been assumed but has not yet been quantitatively recorded.

This talk presents data and strategies how to obtain relevant (i) rock mechanical parameters (compressive and tensile strength and fracture toughness, lab), (ii) ice- and rock-ice interface

mechanical parameters (lab), (iii) cryostatic forces in low-porosity alpine bedrock (lab and field) and (iv) hydrostatic forces in perched water-filled fractures above permafrost (field).

We demonstrate mechanical models that base on the conceptual assumption of the rock ice mechanical (Krautblatter et al. 2013) and rely on frozen/unfrozen parameter testing in the lab and field. Continuum mechanical models (no discontinuities) can be used to demonstrate permafrost rock wall destabilization on a valley scale over longer time scales, as exemplified by progressive fjord rock slope failure in the Lateglacial and Holocene. Discontinuum mechanical models including rock fracture patterns can display rock instability induced by permafrost degradation on a singular slope scale, as exemplified for recent a recent ice-supported 10.000 m^3 preparing rock at the Zugspitze (D). Discontinuum mechanical models also have capabilities to link permafrost slope stability to structural loading induced by high-alpine infrastructure such as cable cars and mountains huts, as exemplified for the Kitzsteinhorn Cable Car and its anchoring in permafrost rocks (A).

Over longer time scales the polycyclicity of hydro- and cryostatic forcing as well as material fatigue play an important role. We also introduce a mechanical approach to quantify cryo-forcing related rock-fatigue. This paper shows benchmark approaches to develop mechanical models based on a rock-ice mechanical model for degrading permafrost rock slopes and how a virtual alpine observatory could help to better anticipate future failures in the Alpine Domain.

Air Quality, Climate, and Health in the Anthropocene

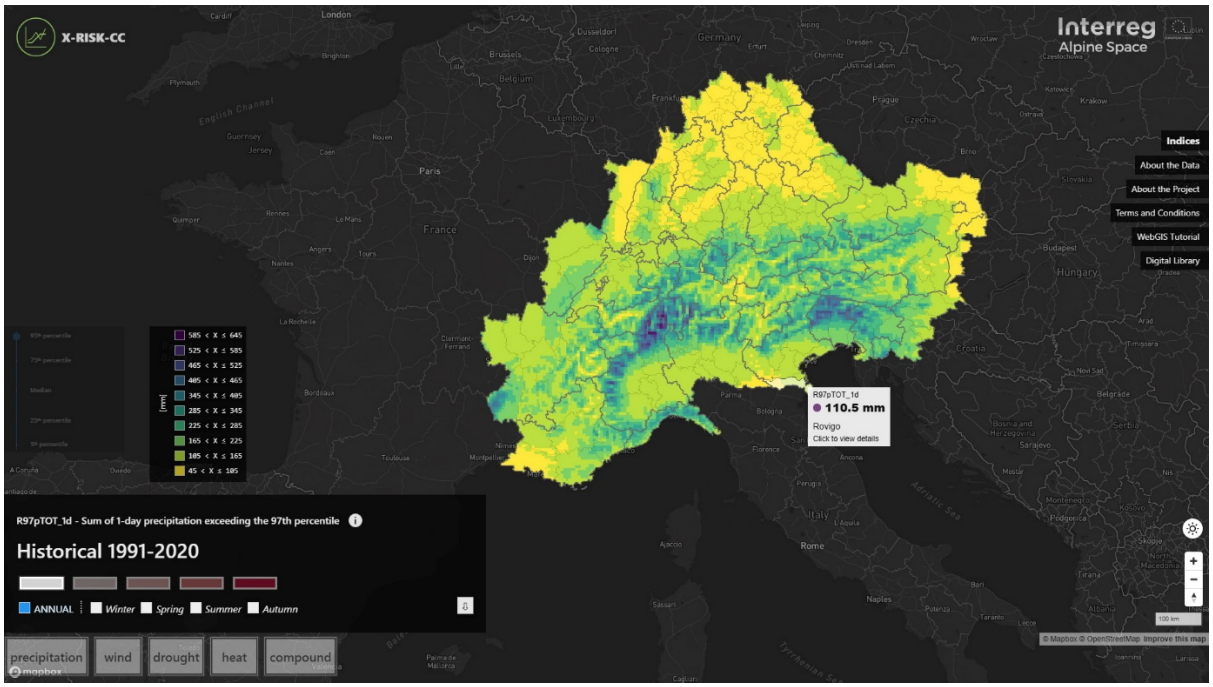
Presenting author: Prof. Dr. Ulrich Pöschl, Max Planck Institute for Chemistry
(please refer to the presentation for potential co-author names)

The Anthropocene as the current period of Earth history is characterised by a globally pervasive and rapidly increasing influence of human activities on the planet - from the equator to the poles and from the land surface, atmosphere and biosphere to the oceans and deep sea. The intensive use of land and water as well as the emission of greenhouse gases and pollutants lead to climate change and put pressure on ecosystems, biodiversity, and human health. Recent scientific advances and future perspectives concerning air quality, climate, and health in the Anthropocene will be outlined and discussed.

The X-RISK-CC webGIS of alpine-wide climate extremes

Presenting author: Dr. Piero Campalani, Eurac Research
(please refer to the poster for potential co-author names)

European scale research is not limited to collaborative scientific advancements, but also requires joint trans-national development and operationalization of the results. The X-RISK-CC project (https://www.alpine-space.eu/project/x-risk-cc/) brings together partners from five Alpine countries (Italy, Slovenia, Austria, Germany, France) in a joint effort to produce tangible impact in the support to climate risk managers and policymakers, motivated by the steadily increasing hazardous weather events that have been experienced in the Alps in recent decades. To promote climate-informed decision making and the transferability of local results, the X-RISK-CC WebGIS offers an interactive and accessible way to visualize maps and NUTS3 level aggregations of 20 specifically selected climate indices, including heavy rain, heatwaves, drought and compound processes, over the Alpine Space. The data catalogue includes both historical observations from model reanalyses and future climate projections (EURO-CORDEX) under different Global Warming Levels. The WebGIS is complemented by a digital archive including in-depth technical documentation, scientific syntheses and detailed reports of both Alpine and local analyses. The research leading to these results has received funding from Interreg Alpine Space Program 2021-27 under the project number ASP0100101, "How to adapt to changing weather eXtremes and associated compound and cascading RISKs in the context of Climate Change" (X-RISK-CC).


X-RISK-CC
Interreg
Alpine Space
Indices
About the Data
About the Project
Terms and Conditions
WebGIS Tutorial
Digital Library
R97pTOT_1d
110.5 mm
Rovigo
Click to view details
R97pTOT_1d - Sum of 1-day precipitation exceeding the 97th percentile
Historical 1991-2020
ANNUAL
Winter
Spring
Summer
Autumn
precipitation
wind
drought
heat
compound

Determination of emerging pollutants at Zugspitze and Schauinsland: Overview on current projects by the UBA Germany

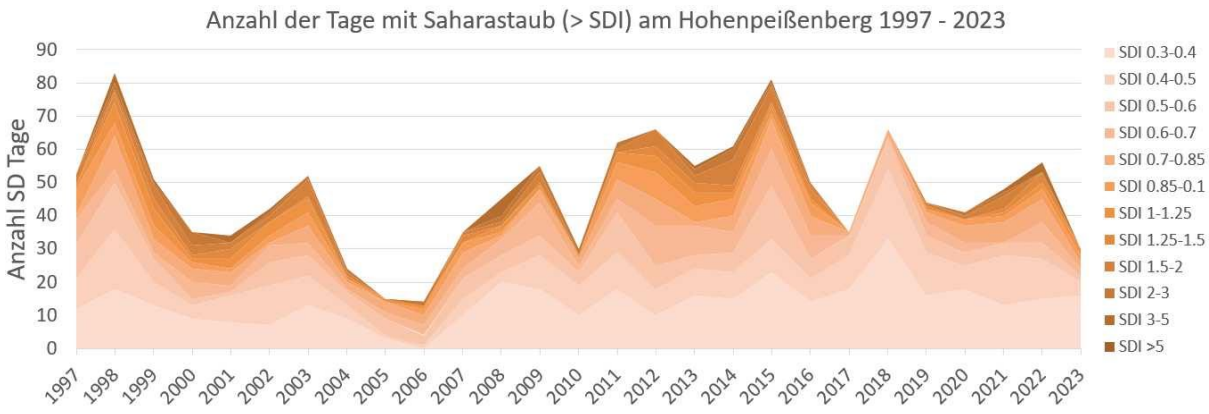
Presenting author: Dr. Julian Rüdiger, Umweltbundesamt - Germany
(please refer to the poster for potential co-author names)

Within multiple international conventions, Germany like other states is committed to monitor the air quality in the atmospheric background. Therefore, atmospheric measurements are realized by the German Environment Agency -(UBA) at its 7 remote stations throughout the rural background of Germany including Schauinsland and Zugspitze. These stations contribute data on pollutant deposition and transboundary long-range transport to various monitoring programs like GAW and EMEP. Some pollutants are measured continuously since the late 1960s, while other pollutants especially metals and semi-metals are monitored since the early 1990s. Organic pollutants such as PAHs and POPs are regularly monitored as well starting in the mid-1990s in precipitation and since the mid-2000s also in air and aerosols. Therefore, the UBA air monitoring network contributes to the supervision of the Stockholm convention and the respective EU Regulation. Recently, further emerging pollutants were included to the list of substances that are measured at the UBA air monitoring stations. Within a multi-year project period, fluorinated organics such as per- and polyfluorinated substances (PFAS), a range of more than 100 current used pesticides (CUP) and the presence of microplastics is studied in precipitation, air and other matrices. This work will present an overview on the studied emerging pollutants as well as sampling and analysis techniques at the two mountain site stations Schauinsland and Zugspitze.

Identification and Monitoring of Saharan Dust

Presenting author: Dr. Harald Flentje, Deutscher Wetterdienst
(please refer to the poster for potential co-author names)

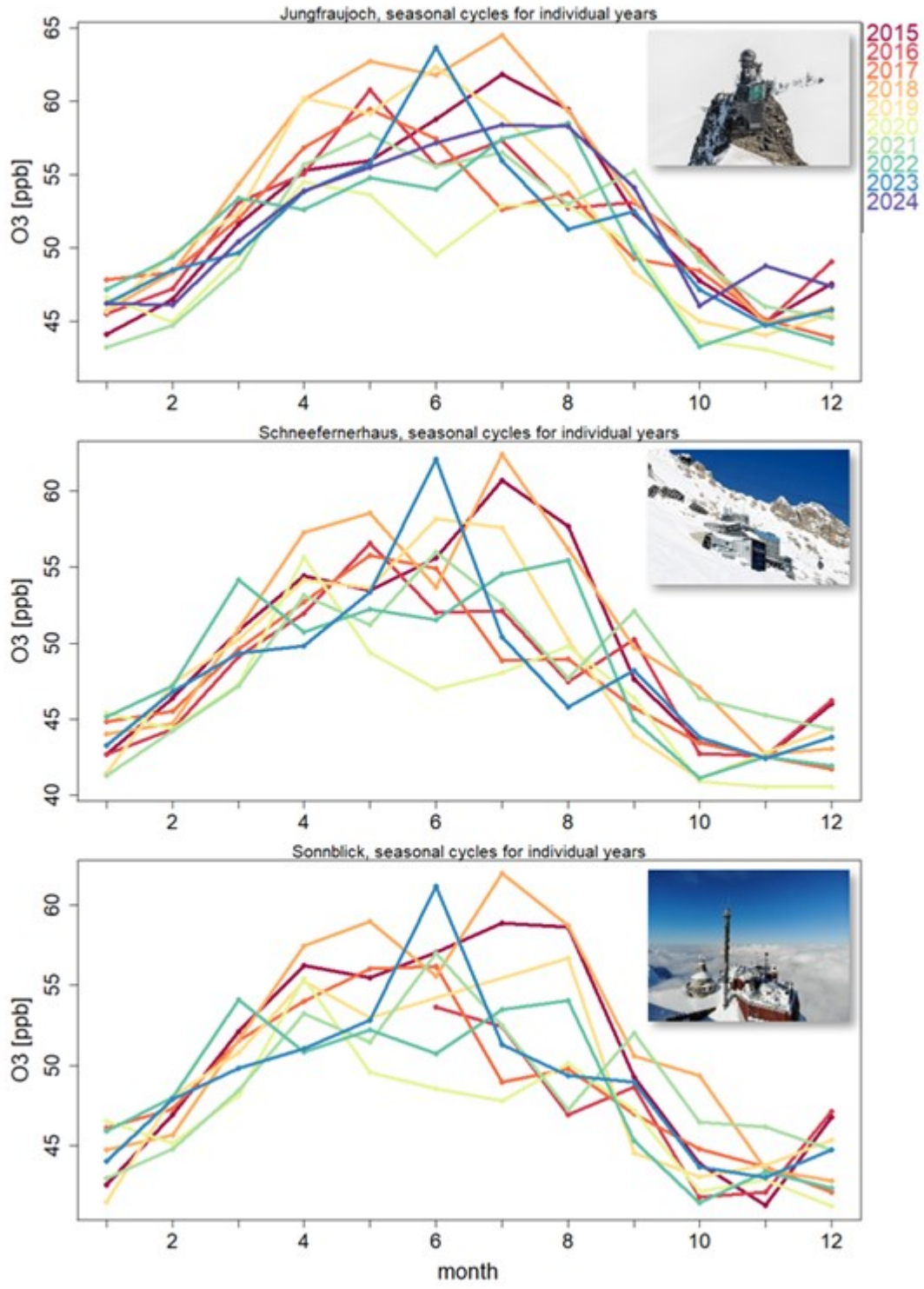
Long-term monitoring and quantification of mineral dust in the atmosphere helps understanding it's impact on climate, weather and health, as well as forecasting and reducing perturbations of traffic and solar power production by dust-induced turbidity and deposition. Central Europe is reached by Saharan Dust (SD) on roughly 50-100 days per year, but less than ~¾ of the events penetrate down and can be identified at lowland in-situ stations. SD typically arrives in central Europe as coarse (0.5-15 µm) iron- and Ca2+-rich particles with characteristic absorption and refractory properties. In the mixing layer, however, no specific individual indicator proves the presence and load of SD, but several parameters must be considered, whereby the loose relationship between concentration and purity suggests to use a combined 2-tuple made of a SD-proxy (load in µg/m³) and a qualitative SD-index (ambiguity). Since 1997, neither frequency nor strength of SD events did change significantly, but their occurrence in the last years tends to increasingly cover late autumn and winter months as well.



Atmospheric cycles at high-altitude stations

Presenting author: Dr. Martin Steinbacher, Empa
(please refer to the poster for potential co-author names)

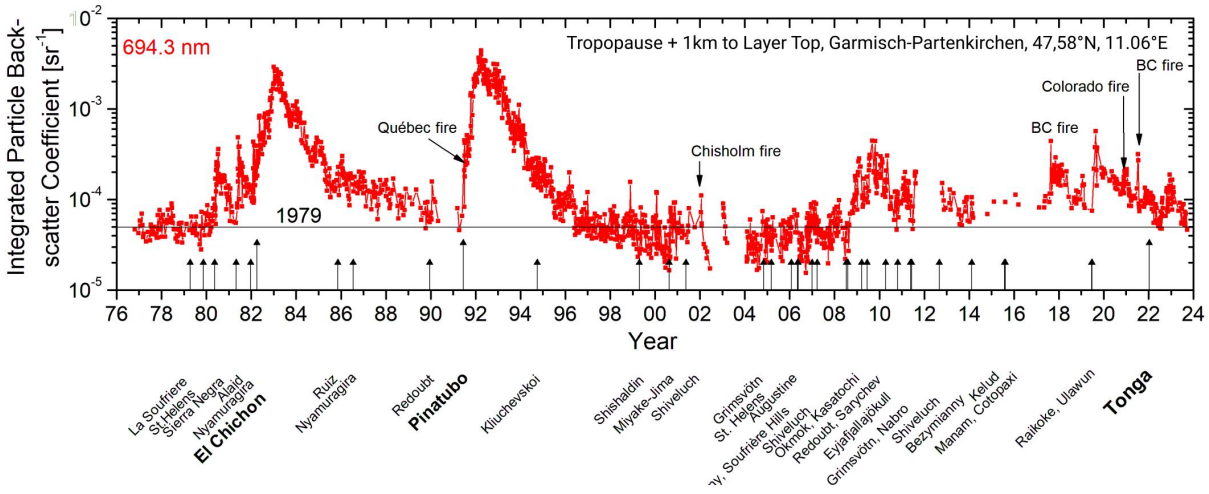
Atmospheric cycles at high-altitude stations Martin Steinbacher1, Cedric Couret2, Elke Ludewig3, Wolfgang Spangl4, Lukas Emmenegger1 1 Laboratory for Air Pollution/Environmental Technology, Empa, Dübendorf, Switzerland 2 Umweltbundesamt, Zugspitze, Germany 3 GeoSphere Austria, Salzburg, Austria 4 Umweltbundesamt, Vienna, Austria The present study investigates diurnal and seasonal cycles of O3, CO, CO2, and CH4 and their interannual variability measured at the high-altitude stations Jungfraujoch (3'580 m asl), Zugspitze - Schneefernerhaus (2'666 m asl) and Sonnblick Observatory (3'106 m asl) over the last 10 years. The diurnal and seasonal cycles at all three observatories reveal systematic recurrent patterns due to the remoteness of stations and the low influence of sporadic, short-term events. However, some year-to-year variability in the cycles can be attributed to large scale phenomenon like the effects of widespread emission reductions due to Covid-19 pandemic restrictions. Moreover, the analysis of the diurnal patterns of the different trace gases allows to deduce qualitative information about the advection of air masses from the planetary boundary layer reaching the monitoring sites. The figure below shows mean seasonal cycles of surface ozone observed at Jungfraujoch, Schneefernerhaus and Mt. Hoher Sonnblick for the 2015 to 2024 period. Different colors represent different years.


Jungfraujoch, seasonal cycles for individual years
Schneefernerhaus, seasonal cycles for individual years
Sonnblick, seasonal cycles for individual years
O3 [ppb]
month
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

Aerosol Remote Sensing with Lidar at Zugspitze

Presenting author: Dr. Hannes Vogelmann, Schneefernerhaus
(please refer to the poster for potential co-author names)

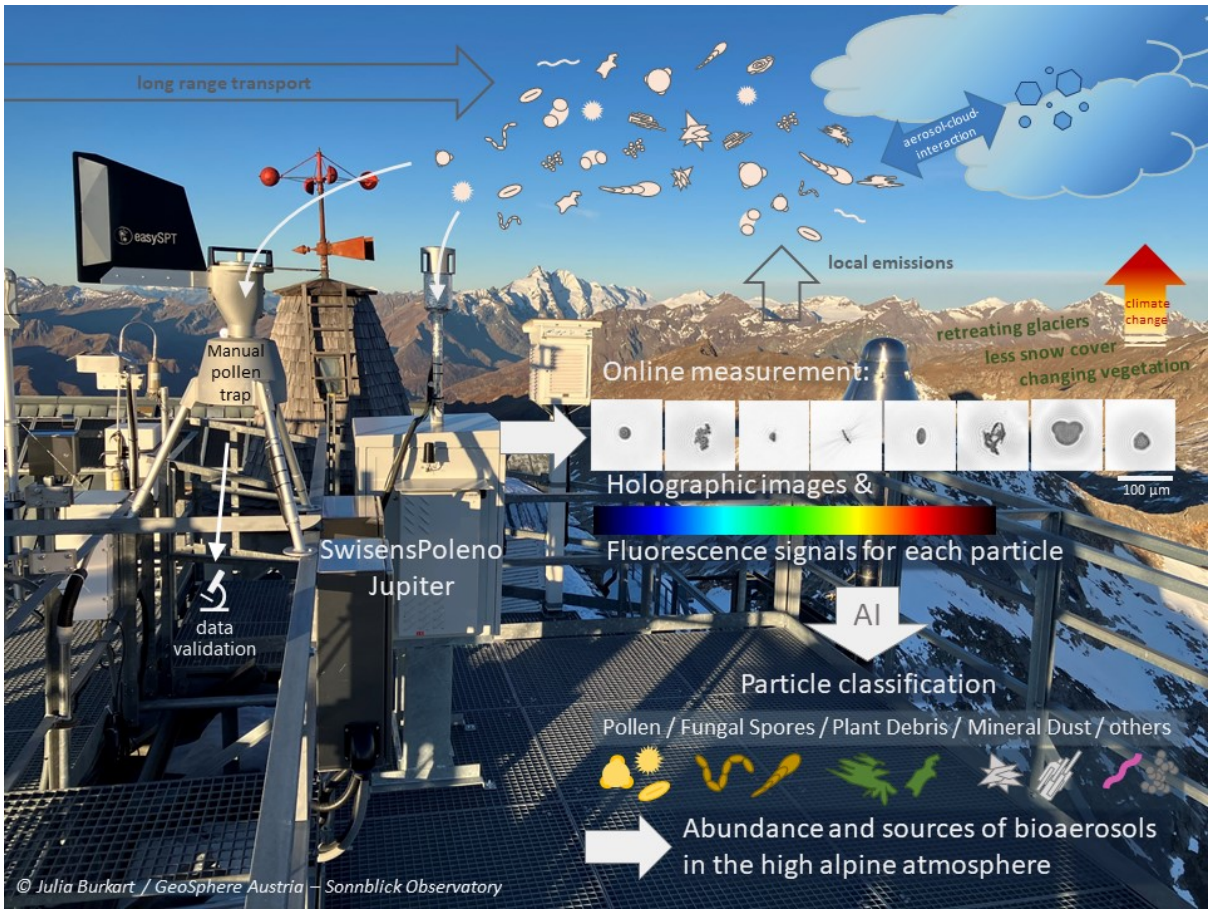
The high-altitude research station Schneefernerhaus (UFS) near Zugspitze (2,650 m a.s.l.) provides a unique environment for aerosol remote sensing. Its location, most of the time above the planetary boundary layer, allows for the study of free tropospheric aerosols while also capturing long-range transported pollution and Saharan dust events. In this study, we present results from long-term aerosol observations at UFS using ground-based remote sensing techniques, including sun photometry (AERONET) and lidar measurements (NDACC). These datasets provide insights into aerosol optical properties, vertical distributions, and seasonal variations. We analyze selected case studies of long-range transport events, such as vulcanic eruptions, wild fires and saharan dust outbreaks. Comparisons with satellite observations (e.g. MODIS, CALIPSO) and backward trajectory caclulations (HYSPLIT) are used for classification, investigation of the underying processes and understanding of aerosol dynamics in the Alpine region. The synergy of different remote sensing techniques enables a comprehensive characterization of aerosols at UFS, contributing to climate and air quality research. Our findings underline the importance of long-term monitoring in high-altitude environments to assess trends and enhance atmospheric models. This work supports European and world wide aerosol observation networks such as ACTRIS and NDACC, respectively.



Bioaerosol monitoring and research at the Sonnblick Observatory

Presenting author: Dr. Julia Burkart, GeoSphere Austria
(please refer to the poster for potential co-author names)

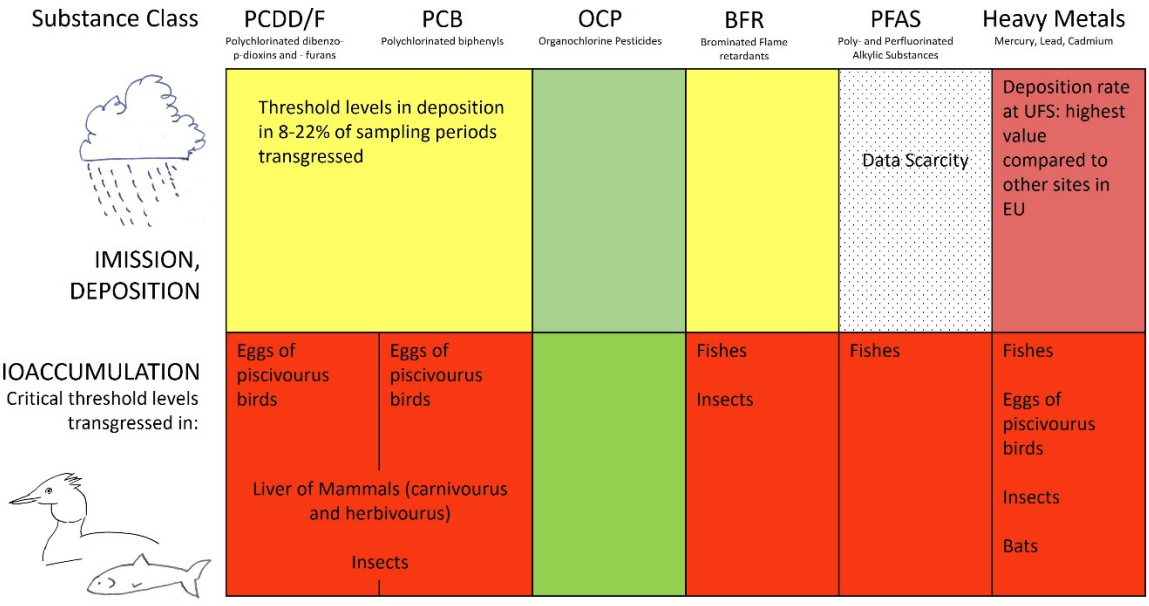
Bioaerosols are an integral and ubiquitous component of the atmospheric aerosol. Despite this, they have received little attention in the atmospheric sciences for many years. The growing evidence that bioaerosols are not only a health concern, but also essential to cloud formation, and the recent emergence of automatic and on-line instrumentation for bioaerosol research, has stimulated interest in bioaerosols. However, very little is known about the abundance of bioaerosols at altitudes where clouds actually form, such as in high alpine mountain regions. At the Sonnblick Observatory we have started with on-line bioaerosol measurements in April 2022 as part of the VINAR framework (https://vinar.univie.ac.at/). We have installed a SwisensPoleno Jupiter next to a manual Hirst-type pollen trap. The SwisensPoleno Jupiter is an on-line and automatic (bio)aerosol monitor that obtains scattered light, two holographic images and fluorescence signals of individual aerosol particles. With the Hirst-type pollen trap, the particles are collected on a sticky tape and are later examined manually under a microscope to identify and count pollen and fungal spores by visual inspection. These data are used to validate the automatic measurements. In my poster I will explain the data analysis approach, show first results and discuss challenges of monitoring bioaerosols at a high alpine station.


long range transport
aerosol-cloud-interaction
local emissions
climate change
retreating glaciers
less snow cover
changing vegetation
easySPT
Manual pollen trap
Online measurement:
Holographic images &
100 µm
Fluorescence signals for each particle
SwisensPoleno Jupiter
data validation
AI
Particle classification
Pollen / Fungal Spores / Plant Debris / Mineral Dust / others
Abundance and sources of bioaerosols in the high alpine atmosphere
© Julia Burkart / GeoSphere Austria – Sonnblick Observatory

From Deposition to effects: The Alpine Ecosystems are prone to impacts of Persistent, Bioaccumulative and Toxic Substances

Presenting author: Dr. Korbinian Freier, Bavarian Environment Agency
(please refer to the poster for potential co-author names)

Our research shows for the Alps that input of PBTs is of a magnitude at which detrimental effects in ecosystems must be expected. Several studies1-5 were performed in the surroundings of the Environmental Research station Schneefernerhaus at Zugspitze/Germany and Sonnblick Observatory at Hoher Sonnblick/Austria. Data on ambient air concentrations and deposition of PBTs are available at both sites from 2005 to present. Between 2016 and 2020, samples from biota have been gathered which encompass insects, fishes, birds and mammals in aquatic as well as terrestrial environments. High deposition rates above international guidance values or EU-benchmark levels are measured for Polychlorinated Dibenzo-p-Dioxins and -Furans (PCDD/Fs), Polychlorinated Biphenyls (PCBs) and mercury. Concentrations of several PBTs in biota surpass a variety of relevant thresholds. This is valid for aquatic species for PBFRs, PCDD/F, Dioxin like PCBs (DL-PCBs) and mercury. For the terrestrial components PCDD/F+DL-PCBs, PBFR, lead, cadmium and mercury showed levels above relevant thresholds.



Climate Change - Persistent Chemicals - Alps

Presenting author: Dr. Korbinian Freier, Bavarian Environment Agency
(please refer to the poster for potential co-author names)

In the course of climate change, alterations in the environmental behavior of persistent, bioaccumulative and toxic substances (PBTs) are expected by changes in: (a) atmospheric transport, (b) precipitation rates, and (c) temperatures in the atmosphere and on the ground. In general, with rising temperatures in source regions it is assumed that atmospheric concentrations of more volatile pollutants increase and thus also the transport to more remote regions can be increased. At the same time, changing precipitation regimes with more intense precipitation events can contribute to increased input into cooler regions such as the Alps. The project Climate Change - Chemicals - Alps (CCCA) funded by the Bavarian State Ministry of Consumer Protection and the Environment aims at investigating the influence of meteorological parameters between 2005 and 2026 to assess future deposition and accumulation of PBTs in the Alps. Within the study meteorological parameters will be correlated to air concentrations and deposition of PBTs such as Polychlorinated-p-Dioxins and Furans (PCDD/F), Polybrominated Flame Retardants, Mercury (Hg) and Per- and Polyfluorinated Alkylic Substances (PFAS). The study is additionally investigating if levels of legacy-PBTs in soil and biota have already changed since 2005 due to climate change in the Alps.

Structural shifts in plant functional diversity during biogeomorphic succession: Moving beyond taxonomic investigations in an alpine glacier foreland

Presenting author: Dr. Stefan Haselberger, University of Vienna
(please refer to the poster for potential co-author names)

The concept of biogeomorphic succession describes the interplay between plants and geomorphic processes. While ecological research has shifted towards functional approaches, studies on functional diversity in glacier forelands remain scarce. This study analyzed vascular plant abundance and functional traits across 199 plots in an alpine glacier foreland to assess how functional diversity develops during biogeomorphic succession. We investigated whether structural shifts in functional diversity align with stability thresholds defined by plant cover and geomorphic activity and examined trait spectra across succession stages. Functional diversity followed a non-linear pattern along the plant cover gradient, with two structural shifts at 30% and 74% cover, reflecting stability thresholds. Along the geomorphic activity gradient, diversity increased up to 54% plot disturbance, then declined. Trait analysis across four biogeomorphic succession stages revealed shifts from above-ground adaptations and reproductive traits to dominance of competitor species and below-ground structures. Our findings advance the understanding of plant succession under geomorphic influence, emphasizing functional traits over taxonomic approaches. The functional trait dataset is publicly available as a template for future (bio)geomorphological research.

Wildfire plumes reaching Jungfraujoch in 2023

Presenting author: Dr. Leïla Simon, Paul Scherrer Institut (PSI)
(please refer to the poster for potential co-author names)

The frequency and intensity of large-scale wildfires have increased in recent years likely as a result of climate change. Aerosols emitted from these biomass burning events can reach the free troposphere (FT) and be transported over long distances, e.g. as far as Europe. The resulting aerosol loadings in the FT and their properties remain poorly understood. In this work, we characterize the chemical, physical and optical properties of particles from wildfire plumes that reached the Jungfraujoch (JFJ, 3571 m asl, Switzerland) High Alpine Research Station in the year 2023. In particular, Canadian fires made headlines and several plumes were observed at JFJ between May and October. Markers for biomass burning both in the gas- (CO, benzene) and particle phase (equivalent black carbon) increased on June 28th and 29th (Figure 1). On June 28th, the concentration of PM1 organic matter increased up to 20 µg m-3, corresponding to the highest concentration recorded by the TOF-ACSM over 2022-2024. Fragments of levoglucosan and other anhydrous sugars emitted by biomass combustion are measured at ACSM mass-to-charge ratios m/z 60 and 73. The contribution (in %) of these m/z to organic aerosol also increased on June 28-29, and peaked on July 1st. Other properties such as optics, size distribution and mass spectral features will be investigated. The analysis will be further extended to other wildfire plumes reaching JFJ between 2022 and 2024 for which we have chemical composition data.

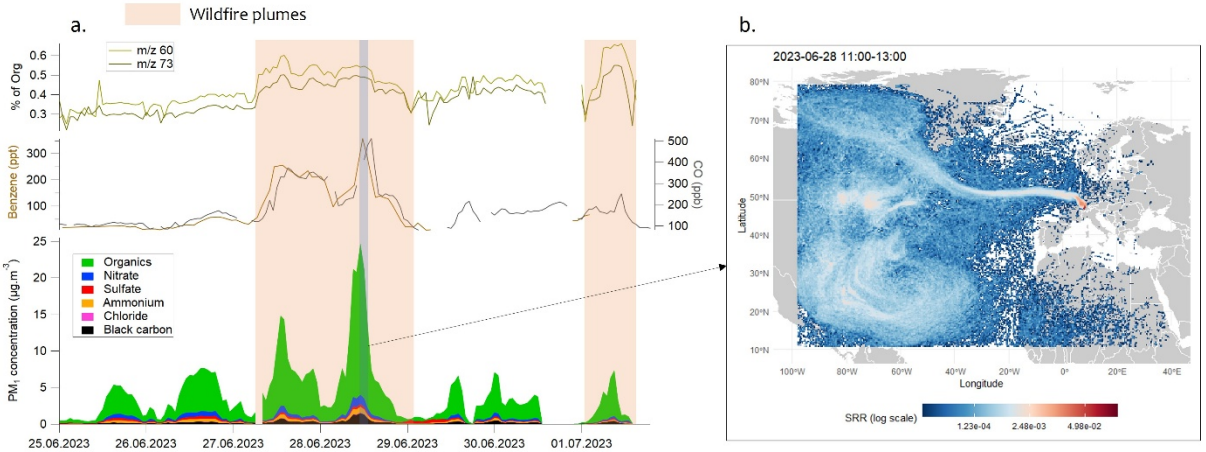


Figure 1: a) PM_1, CO and benzene concentrations, contribution of m/z 60 and 73 to organics between June 25th & July 2nd, 2023. b) Source-receptor relationship calculated from FLEXPART backtrajectories on June 28th between 11am and 1pm UTC.

Reducing propagation of uncertainty for photogrammetry derived snow height measurements in high alpine terrain

Presenting author: Prof. Dr. Karl-Friedrich Wetzel, University of Augsburg
(please refer to the poster for potential co-author names)

Precise data of snow storage is important for runoff estimations in high alpine areas. Photogrammetry with UAVs is often used to capture local snowpack distributions. In this study, we used this technique in the high alpine area at the Zugspitze in Germany. The calculation of snow depth by photogrammetry, a digital winter snow surface model is created from point clouds via image processing. The snow depth is determined by subtracting a summer terrain model. Despite the use of precise GNSS post-processing data, errors exist in all three spatial directions (xyz). This leads to incorrect snow depths in the case of pure subtraction. While a shift between the summer and winter models in the z-direction generally leads to errors for flat areas, errors in the xy-direction are of minor importance. Due to the gradient of the terrain on slopes, xy-shifting between the models leads to a change in vertical distance and thus to an additional error. To improve the calculation, it is necessary to minimize the shift in both the z and xy directions. Collecting control points requires an increased workload. Our approach is to conduct a co-registration of point clouds. For that, we collocate the summer and winter point clouds at snow-free features as rocks, or manmade structures, as the terrain in these areas matches in both winter and summer. Similar approaches have been successfully applied for lidar-based point clouds.

Permafrost research at the Zugspitze

Presenting author: Dr. Korbinian Freier, Bavarian Environment Agency
(please refer to the poster for potential co-author names)

In 2007 a horizontal borehole, 44.5 meters long, was drilled through the Zugspitze peak and 16 temperature sensors were installed inside. Model calculations based on the measured permafrost temperatures and climate data indicate, that a considerable reduction of the permafrost took place during the last hundred years. And the warming continues! The projected ambient temperature increase will probably result in a disappearance of the permafrost at the Zugspitze until the end of the 21st century. Yet great rockslides like the one 3750 years ago are not indicated by geologic conditions.

Coupled Thermal, Hydrological, and Mechanical Responses in Permafrost Rockwalls in a Changing Climate

Presenting author: M.Sc. Maike Offer, GEORESEARCH
(please refer to the poster for potential co-author names)

As climate change progresses, permafrost rockwalls continue to warm, increasing the risk of alpine hazards. While many studies focus on permafrost evolution or individual processes, the complex interactions between thermal, hydrological, and mechanical factors remain poorly understood. At the Open-Air-Lab Kitzsteinhorn, part of the VAO network, we combine multiple observational datasets, including electrical resistivity tomography, piezometric pressure, borehole temperature, weather data, and anchor load. This interdisciplinary approach enables us to identify five distinct seasonal phases of rockwall conditions, each defined by variations in water levels, active layer thickness, and stress loads. These insights enhance our understanding of critical time periods for rock slope failures, contributing to improved hazard assessment and risk management in high-alpine environments.

Progress in Modeling Large-Scale Failure of Rock-Ice Joints

Presenting author: M.Sc. Simon Mühlbauer, Technical University of Munich
(please refer to the poster for potential co-author names)

In recent years, frequent rock slope failures in permafrost regions exceeding 1 Mio m³ have been documented on a regional (European alps) and global (Andes, Caucasus) scale. Yet, the fracture behaviour of ice-filled joints under high loads remains insufficiently understood. This study presents novel data to extend the Mohr-Coulomb failure criterion for rock-ice interfaces (Krautblatter et al. 2013, Mamot et al. 2018) for rock overburden exceeding 16 m. More than 100 shear experiments were conducted simulating rock overburden of up to 65 m (1600 kPa) at temperatures ranging from -0.5 °C to -4 °C, and with strain rates consistently maintained in the range of 10^{-3} s^{-1}. Ductile ice deformation occurs within the temperature range of -1 °C to -0.5 °C and exhibits marginal dependence on normal stress. Below -1 °C and at normal stresses below 800 kPa, the rock-ice interface undergoes single brittle fracture. At higher stress levels, ice healing mechanisms are activated, leading to periodic stick-slip fracture behaviour. This study refines the Mohr-Coulomb failure criterion for ice-filled rock fractures by incorporating high-load mechanisms and defining the brittle-ductile transition as a function of stress and temperature, providing valuable insights to improve mechanical models of large-scale permafrost rock slope instabilities.

A forecasting framework for mountain glacier evolution

Presenting author: Dr. Johannes Fürst, FAU Erlangen-Nürnberg
(please refer to the poster for potential co-author names)

Worldwide glacier retreat outside the two large ice sheets is increasingly tangible and the associated ice-loss has dominated the cryospheric contribution to sea-level change for many decades. This ice loss has also become symbolic for the effects of rising temperatures. In addition to the anticipated importance for future sea-level rise, continuing glacier mass loss will affect seasonal freshwater availability and might add to water-stress in this century in many regions. Here, we present a self-consistent, ice-dynamic forecasting framework for glacier evolution. For the first time, each glacier on Earth can be treated as a three-dimension body within its surrounding topography without the severe geometric simplifications typical on regional and global scales. The heart of the framework is the systematic utilisation of the rapidly growing body of information from satellite remote sensing. For this purpose, we passed on to ensemble assimilation techniques that transiently consider measurements as they become available - increasing the total information flow into glacier system models. The 3D modelling framework also allows a direct integration of iceberg calving, which is, on regional scales, an important but often unconsidered ice-loss term. Finally, we refined the representation of the local energy balance at the glacier surface improving the multi-decadal stability in the melt formulation.

UAV-based monitoring of the mountain cryosphere: Recent advances and future prospects

Presenting author: Dr. Alexander Raphael Groos, FAU Erlangen-Nürnberg
(please refer to the poster for potential co-author names)

Unoccupied aerial vehicles (UAVs) equipped with cameras or geophysical and meteorological instruments have been increasingly deployed for detailed mapping and monitoring of the mountain cryosphere in recent years. UAVs facilitate a wide range of geoscientific applications and are particularly useful for surveying areas in alpine terrain that are difficult to access. They also have great potential for the spatial study of small-scale and dynamic processes. Using high-resolution digital elevation models or dense point clouds from (repeated) UAV surveys has become a widespread method for mapping snow depth and quantifying glacier volume loss. The ongoing miniaturisation of electronic sensors and the specific development of multispectral and thermal infrared cameras, GPR and LiDAR systems and other geophysical instruments for UAV-based surveys have opened up new opportunities for cryospheric research in complex terrain. Recent advances include measurements of glacier thickness and snow depth using UAV-borne GPR, high-resolution mapping of supraglacial debris thickness and permafrost distribution using UAV-based thermal infrared thermography, albedo mapping of snow and ice using UAV-based multispectral imaging, and UAV-based atmospheric sounding over ice and snow. Here I briefly discuss the potential and limitations of recent advances in UAV technology for cryospheric research and outline future prospects for monitoring mountain snow, glaciers and permafrost.

Zugspitze Geology and the Eibsee Rockslide

Presenting author: Dr. Korbinian Freier, Bavarian Environment Agency
(please refer to the poster for potential co-author names)

3.750 years ago a huge rockslide of 200 million cubicmeters occurred at the North side of Zugspitze massif in the Bavarian Schneekar. Probably the former mountain peak - altitude above 3.000 m - plummeted during the rockslide as well. The debris of this event can still be spotted in the denounced area between Eibsee and Grainau. At the end of a longer warm period the decrease of permafrost may have triggered this rockslide.

Erosive power of debris flows: predictive modelling by a simple empirical approach

Presenting author: M.Sc. Verena Stammberger, Technical University of Munich
(please refer to the poster for potential co-author names)

Debris flows are massively erosive mass movements that pose an increasing threat to infrastructure and settlements in mountainous areas due to more intense heavy rainfall events in the future. A major contributor to the magnitude for runoff generated debris flow is the parameter of effective erosion. It directly translates to the hazard potential of debris flows, but it is yet to be sufficiently implemented in models to achieve a predictive performance. We developed a simple predictive erosive debris-flow model calibrated on active channels in the northern Bavarian Alps with recent events in 2015 and in 2021. In all cases more than 80% of their final volume was entrained from the sediment channel bed. Geomorphic change was calculated from pre- and post-event LiDAR data and the total volume of the flow was then compared to catchment characteristics. For a detailed analysis we compared the eroded volume to simulated flow parameters in individual sections of the channel. The initiation volume was estimated by a runoff calculation from the respective heavy precipitation events recorded with radar data. We were able to obtain a correlation that can be used in a predictive debris-flow model to iteratively calculate the erosion for runoff-generated debris flows that are triggered by intense rainstorms. This model allows improved predictions of the magnitude of debris-flow prone channels through a forward-modelling approach.

Increased debris flow activity as a composed signal of 54 contributing catchments at Plansee, AT

Presenting author: MSc. Carolin Kiefer, TUM
(please refer to the poster for potential co-author names)

Debris flow activity is expected to show a nonlinear response under different climate change scenarios. The 54 alluvial fans bordering the Plansee (Tyrol, Austria) are connected to heavily jointed Dolostone catchments with constant debris production and form an archive for the evolution of debris flow activity over the Holocene. This is one of the few catchments where the strong increase in debris flow activity could be evidenced over the last 70 years (terrestrially) and 4000 years (lake sediments). The latter study (Kiefer et al. 2021) shows a 9-fold recent (since 1920) increase in debris flow volumes, with a total of 138 debris-flow induced turbidites over the last 4000 years. This increase in debris flow activity since 1920 coincides with a 2-fold increase in heavy rainstorm activity (&gt,35 mm/day) over the same period (Dietrich and Krautblatter, 2017). By photogrammetric analysis of historical and digital aerial images starting in 1952, we capture a 7-decade period of terrestrial hillslope erosion. An increase in rainfall days since the 1980s corresponds to an increase in mean erosion over all catchments.

Challenges of scoring landslide susceptibility models

Presenting author: Dr. Alexandre Dunant, EURAC
(please refer to the poster for potential co-author names)

Impact-based landslide susceptibility models are crucial for risk assessment in Alpine environments. However, the development and evaluation of these systems face challenges, particularly in the realm of model scoring. This poster was set to discuss two critical issues: the prevalence of unbalanced datasets and the limitations of commonly used evaluation metrics such as the Receiver Operating Characteristic Area Under the Curve (ROC AUC) score. In Alpine regions, landslide events are relatively rare compared to stable periods, resulting in highly unbalanced datasets. This imbalance poses difficulties in model training and validation, potentially leading to biased predictions and unreliable performance assessments. We argue that we need to explore various strategies to address this issue, including changing standard scoring method in line with Protection agencies needs, data augmentation techniques and the use of synthetic data generation.

Deciphering controls of periglacial and cryogenic debris flows at Chimborazo volcano, Ecuador

Presenting author: M.Sc. Theresa Frimberger, TU Munich
(please refer to the poster for potential co-author names)

Volcanic debris flows (lahars) pose a major threat to surrounding areas and commonly occur during volcanic eruptions or heavy precipitation in post-eruptive periods. However, the unprecedented occurrence of lahars that originate in (peri-)glacial areas of the glacier-capped volcanoes Chimborazo and Cotopaxi is challenging the current understanding of how secondary lahars can be triggered. Ecuadorian glaciers are affected by a rapid decline of up to 50% of surface area within the last 40 years, and the ELA is projected to further rise by 200 m in the next 50 years. We develop a conceptual model and employ meteorological, geophysical and geomorphological reconnaissance and IR UAV-surveys at Chimborazo volcano (EC, 4700-4900 m asl) to investigate starting conditions of cryogenic lahars. Along the debris-covered ice body extending below Glacier Nicolas Martínez, we investigate known starting zone of at least 5 secondary lahars with 2 ERT cross-sections to decipher ice contents, and installed 6 temperature loggers to calibrate IR surveys. We found exposed ice in former debris-covered glaciers but also in former side moraines which are now ice-cored. A systematical comparison with our conceptual model shows that only few generic types comprise a majority of relevant starting conditions for secondary lahars. Here we show how periglacial and cryogenic lahars evolve in degrading debris-covered glaciers, a problem which is gaining importance due to glacier retreat in a warming climate.

Combining Climate, Hazard and Impact Analyses to Explore Future Local Risk Scenarios in the Alpine Region: Insights from the X-RISK-CC Project

Presenting author: Dr Alice Crespi, Eurac Research
(please refer to the poster for potential co-author names)

The Interreg Alpine Space project X-RISK-CC aims to enhance risk management of current and future meteorological extremes in the Alpine region. Understanding these risks requires integrating knowledge of climate trends, their links to hazards, the factors driving impacts and their future evolution. However, data limitations, projection uncertainties and gaps in future vulnerability and exposure hinder detailed risk assessments, limiting the ability to define effective risk management strategies. To address this, X-RISK-CC combined quantitative and narrative-based approaches to develop future risk scenarios in several pilot areas across the Alps. Sequential impact chains were used for a preliminary analysis of past impact dynamics and interconnections. It was followed by a systematic assessment of current and future climate trends and local hazard and risk components. The analysis integrated both quantitative and qualitative methods leveraging available data, identified interconnections, and local expert knowledge. The outcomes were synthesized into climate risk storylines for each pilot area. The storylines present challenging yet plausible future situations—grounded in analysed data—that support decision makers to critically assess risk scenarios based on expected trends, also in situations of high uncertainties. They can be used to stress-test risk management capacity to cope with extreme events under future climate conditions and ultimately improve resilience planning.

Insights into Rock Temperature Variations: A Monitoring Study in Slovenia

Presenting author: Assoc. Prof. Mateja Jemec Auflič, Geological survey of Slovenia
(please refer to the poster for potential co-author names)

This study explores the impact of rock temperature on rock deformation, with a focus on crack initiation and behavior in natural environments. Monitoring was conducted at seven exposed rock faces across the Alpine and Prealpine regions of Slovenia (Eastern Alps). Strain gauges with integrated temperature sensors were installed in boreholes at three different depths to track specific deformations in the rock faces over a four-year period. Both reversible and irreversible rock deformations were observed, driven by temperature fluctuations. Reversible deformations were most prevalent when rock temperatures were near or below 0°C, occurring predominantly between October and May. Rather than thermal shock resulting from extreme temperature changes, thermal fatigue induced by repeated freeze-thaw cycles—combined with the presence of water in pores and microcracks—led to irreversible rock deformation, which was measured and observed in situ. While rock temperature near the surface influenced deeper deformation patterns, the generally low thermal conductivity of rocks limited the effect of air temperature on deeper rock layers. As a result, most thermally induced cracks are expected to form at shallower depths within the rock face. This study was funded by the Slovenian Research And Innovation Agency research project J1-3024. All monitoring sensors were purchased under the project Development of research infrastructure for the international competitiveness of the Slovenian RRI space - RI-SI-EPOS.

Rockfall hazard mitigation in touristically developed alpine gorges: a benchmark study in the Höllental Gorge, Bavaria.

Presenting author: M.Sc. Benjamin Jacobs, TU Munich
(please refer to the poster for potential co-author names)

The Höllental Gorge in Grainau is part of the main hiking route to the Zugspitze and a major tourist attraction in the Bavarian Alps. After several rockfalls in the recent past (up to 300 m^3), we detect, assess and monitor geomorphic hazards in the Höllental Gorge. For the first time, multi-temporal terrestrial laser scanning (TLS) is applied in this extreme topography to (i) detect rockfall, (ii) identify and monitor hazardous objects and (iii) perform event analysis of slope instabilities and hyperconcentrated flows. A 615 m^3 rock tower above the track is equipped with an early warning system. We show that TLS in alpine gorges is well suited for the detection and quantification of rockfalls of several orders of magnitude. Events above a certain size are likely to be detected even before failure. Here we present a benchmark rockfall hazard assessment and safety concept for alpine gorges with high safety requirements, providing several years of data.

50 years of hydrometeorological observations at the Glacier Observatory Vernagtferner

Presenting author: Dr. Florentin Hofmeister, Bavarian Academy of Sciences and Humanities (BAdW)
(please refer to the poster for potential co-author names)

The Bavarian Academy of Sciences has been operating a unique high-alpine environmental laboratory on the Vernagtferner in the Ötztal Alps (Tyrol/Austria) since the early 1970s. Besides seasonal glacier mass balance, continuous and high-resolution meteorological and hydrological variables are measured. The gauging station on the Vernagtbach is at an altitude of 2640 m and is, therefore, probably the highest permanently operated discharge gauge in the Alps. The Glacier Observatory Vernagtferner joined the VAO in 2024. As part of this, interdisciplinary networking and collaboration is further expanded. In this contribution, we show analyses of the long-term observations of the hydrometeorological data in relation to the glacier mass balances. The runoff characteristics and magnitudes have changed considerably since the first observations in the 1970s, not only because of the development towards more negative glacier mass balances but also due to changes in the snow cover characteristics, as well as the glacier coverage in the basin. Extreme years concerning negative mass balance, like 2003 and 2022, seem to change the melt conditions fundamentally, as for the subsequent years. Here, we present an analysis of the hydrometeorological time series compared to fundamental glaciological variables, which help us understand the characteristics of meltwater production and runoff generation of this high-alpine catchment.

25 Years of Lake Evolution and Sediment Dynamics in a Proglacial Environment: The Case of Sulzsee, Obersulzbach Valley, Austrian Alps

Presenting author: Dr. Jan-Christoph Otto, University of Salzburg
(please refer to the poster for potential co-author names)

The study of glacier-fed lakes in proglacial environments provides valuable insights into sediment dynamics and adaptation to climate change in high mountain landscapes. These newly formed lakes influence the sediment cascade by collecting significant amounts of the sediment input transported by the meltwater streams and paraglacial processes around the lake. Proglacial lakes thus represent sediment traps that have a significant impact on sediment budgets and sediment availability in downstream fluvial systems, with implications for river ecology and bedload changes. The Sulzsee lake emerged 25 years ago from the retreating Obersulzbach glacier (Hohe Tauern, Austria) and has since been intensively monitored with respect to lake evolution and sediment dynamics. Here, we document the different phases of lake evolution associated with paraglacial adjustment of the lake shores and lake sedimentation patterns. We combined repeated bathymetric surveys and ground-penetrating radar for lake mapping and lake sediment quantification. Multitemporal surface change detection using high-resolution terrestrial laser scanning data was used to quantify paraglacial sediment dynamics around the lake. Field and remote sensing mapping provided detailed insight into geomorphological processes and ice-melt dynamics. We observed significant sedimentation within this 35 m deep lake mainly in a large delta and along the steep slopes towards the northern shore. After glacier retreat, sediment input is dominated by meltwater streams from the remaining glacier areas, surface erosion by debris and slush flows, and by sliding from the northern lake slopes. Individual large boulders on the lakebed document the deposition of drop stones from the melting glacier. The lake bathymetry and open water area changed significantly recently due to delayed melt of buried ice at the lakebed. We reconstruct the preservation of ice on the lakebed for over 20 y

Superconducting gravimetry at Mt. Zugspitze applied in the field of snow-hydrology

Presenting author: Dr. Franziska Koch, BOKU University Vienna
(please refer to the poster for potential co-author names)

Estimating the amount and the spatiotemporal distribution of snow in complex high-alpine terrain is currently considered as one of the most important challenges in alpine hydrology. In addition, it is extremely difficult to estimate alpine water storage components such as karst water reservoirs, permafrost and glaciers, and to examine the relationship between precipitation, evapotranspiration/sublimation, and discharge. Hydrogravimetry is the method of observing temporal gravity variations after the reduction of all other geophysical signals as the integral of all hydrological mass variations on a wide spectrum from 1 s to several years at footprints up to ~50 km². At the Zugspitze Geodynamic Observatory Germany (ZUGOG) with its worldwide unique installation of a superconducting gravimeter at a high-alpine summit, this method is applied for the first time on top of a well-instrumented, snow-dominated catchment. We investigate to what extent hydrogravimetry can contribute to a better understanding and quantification of cryospheric and hydrological processes and storages and will show the sensitivity of the gravimetric signal regarding the cryo-hydro-gravimetric signal changes since 2019. In this study, we use this unique instrumental setup in synthesis with in situ measured data, detailed physically-based snowpack modelling and satellite-based snow depth maps to reflect for the first time the temporal evolution of snow water equivalent in a few kilometres scale radius.

Swiss Cheese meets Bucket-Model" - Conceptional hydrological modelling of the karstic Zugspitz-Region

Presenting author: Univ. Prof. Karsten Schulz, BOKU University, Vienna
(please refer to the poster for potential co-author names)

As part of the FWF/DFG Weave project G-MONARCH, one of the questions being asked is whether the highly variable dynamics of water storage and, in particular, of runoff in inhomogeneous and alpine karst catchment areas with complex topography can be described with a simple, parsimonious modelling approach. In this study, the GR4J model, a spatially aggregated, conceptual hydrological model with only four hydrological model with only four parameters and a temporal resolution of one day, the discharge and two runoff and two (karst) intermediate reservoirs as well as a possible exchange (e.g. groundwater) between catchment areas were simulated. The study area is located on the Zugspitze in the border region between Germany and Austria, which is characterised by a high density of meteorological stations and a lysimeter-like drainage of the catchment area at the Partnachursprung gauging station and at the Bockhütte with long-term measurement series. With regard to the input parameters and the following analyses were carried out with increasing complexity and compared compared with each other: 1. application with the standard version of the GR4J model with potential evapotranspiration. 2. implementation of CemaNeige in GR4J to simulate snowmelt using the day-degree method. simulate. 3. using the setup of variant 2, but taking into account the actual sublimation and evapotranspiration simulated with Alpine3D 4. coupling of variant 3 with the runoff generation calculated with Alpine3D. 5. increasing the spatial complexity by subdividing into sub-sub-catchments in order to specific characteristics of sub-catchments. Results will be shown at the poster!

Learning from the Past - River Analysis for a Changing Future

Presenting author: M.Sc. Max Rau, Technical University of Munich
(please refer to the poster for potential co-author names)

Rivers shape landscapes over long timescales, reflecting past environmental conditions and responding dynamically to climatic changes. By analyzing fluvial systems and their historical changes, we gain critical insights into future developments under changing climate conditions. This study highlights the importance of combining past river dynamics with modern analytical tools to better understand sediment transport, erosion patterns, and hydrological shifts. Such knowledge is essential for predicting future river behavior and developing sustainable strategies for water management and landscape adaptation.

Modeling of Geothermal Reservoirs in Munich/Bavaria

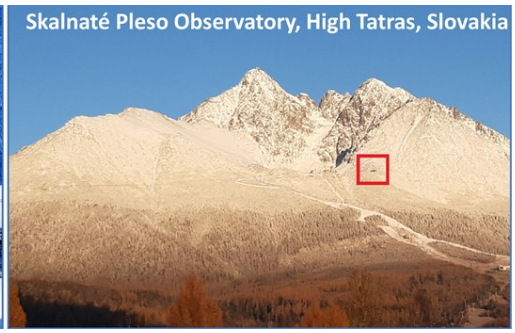
Presenting author: M.Sc. Viktoria Pauw, Leibniz Rechenzentrum
(please refer to the poster for potential co-author names)

The research objective of the projects Geo.KW and BEM-TG is a user-orientated development of an area-wide assessment model for the utilisation of shallow geothermal energy in the city of Munich (Geo.KW) and the deep hydrothermal geothermal energy in the Bavarian part of the Molasse Basin. The aim is to ensure a sustainable assessment of hydrothermal geothermal expansion in Bavaria and to speed up the authorisation and initial planning assessment. Aims are the creation of a holistic data model as a basis for the assessment of the utilisation of the hydrothermal geothermal resource in consultation with the relevant stakeholders (in particular the assessment practice). The consolidation and joint evaluation of all available basic data in the study area as the basis for a regional geological and numerical model for the visualisation and prediction of hydraulic-thermal interactions of existing and planned geothermal appliances.

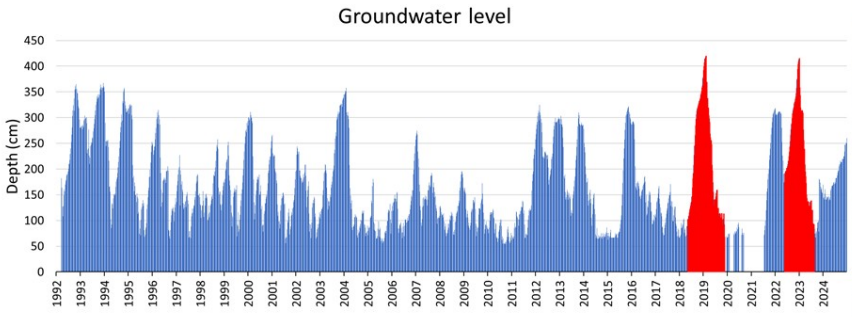
Impact of Climate Change on Groundwater Level

Presenting author: MSc. Ján Krempaský, Dr. Svetlana Varšová, Dr. Veronika Lukasová, Slovak Academy of Sciences
(please refer to the poster for potential co-author names)

The availability of water in adequate quantity and quality has become one of the primary global challenges. Accurate groundwater recharge estimation is essential for sustainable water management and the protection of water resources. In the High Tatra foothill, groundwater recharge depends on climate conditions in the mountains. This study aims to analyse the long-term development of climate characteristics and extremes in the High Tatras (Slovakia) using data from the meteorological observatory at Skalnaté Pleso (49°11'N, 20°14'E, 1788 m a.s.l.) and to investigate their impact on groundwater level fluctuations measured in the foothill. Long-term climate data indicate unprecedented warming and an increase in precipitation in the alpine environment, accompanied by growing precipitation variability and more frequent extreme weather events. Groundwater level records since 1992 reveal multiple low-level episodes, with the lowest levels observed in winter seasons 2018/19 and 2022/23. The occurrence of groundwater fluctuations will be analysed in relation to dry periods and snow cover characteristics, including compound hydrometeorological extremes. The study will also incorporate predictions based on regional climate models. Additionally, the research will consider overall environmental conditions, significant land cover changes during the assessed period, disturbances in forest stands, and socio-economic factors related to water resource supply and utilization in the study area.


Skalnaté Pleso Observatory, High Tatras, Slovakia


Dry periods
Land cover changes
Warming of environment
Low snow cover / Short snow period
Water resources consumption
GROUNDWATER LEVEL


Groundwater level
Depth (cm)
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400
350
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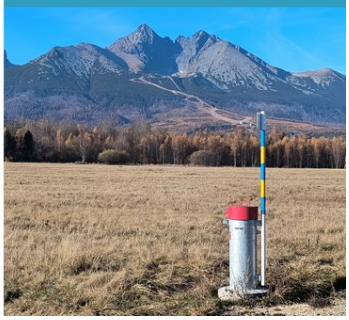

Research of the Space Weather at the Lomnicky stit observatory

Presenting author: Dr. Jan Kubancak, Ronald Langer, Department of Space Physics, SAS
(please refer to the poster for potential co-author names)

The Lomnicky Stit Observatory, situated in the High Tatras, Slovakia, has a long history of cosmic ray observations, providing valuable data for space weather research. Our contribution presents an overview of these observations, focusing on the detection of various cosmic ray components. We describe the instrumentation used, including neutron monitor and SEVAN detector, and their sensitivity to different energy ranges. The poster highlights the importance of Lomnicky Stit`s high-altitude location for minimizing atmospheric effects and enhancing the detection of primary cosmic rays. We showcase examples of observed phenomena, such as Forbush decreases and solar energetic particle events, demonstrating the observatory`s contribution to understanding solar activity and its impact on the near-Earth space environment. The continuous monitoring of cosmic rays at Lomnicky Stit provides crucial data for space weather forecasting and contributes to our understanding of the Sun-Earth connection.

Cosmic ray measurements at Jungfraujoch

Presenting author: Dr. Lukas Bäni, University of Bern, Physics Institute
(please refer to the poster for potential co-author names)

Two neutron monitors, an 18-IGY since 1958 and a 3-NM64 since 1986, are in operation at the High Altitude Research Station Jungfraujoch in Switzerland. Both neutron monitors are located close to each other but with a difference in altitude of about 100 m (IGY: 3570 m asl, NM64: 3475 m asl). Due to their locations in a high alpine environment, the two neutron monitors are exposed to high winds and snow accumulation on and around the detector housing. Updated readout electronics are in operation since end of 2022 at both neutron monitors. In this presentation, we give a status overview of the continuous cosmic ray measurements at Jungfraujoch.