

# Alpine research in the region of Obergurgl



## **Alpine research in the region of Obergurgl**

The area around Obergurgl is one of the main regions of high alpine research in Tyrol and a perfect location for courses and excursions of the University of Innsbruck and other international institutions and organisations. Since the Alpine Research Centre Obergurgl was founded by Prof. Wolfgang Burger in 1951, numerous research projects of different disciplines have been carried out and several investigations are still in progress.

The individual projects range from studies of weather conditions in the high alpine region, habitat characteristics of glaciers, glacier forelands, bogs and meadows to studies in cultural heritage and alpine history. The Alpine Research Centre compiled all of these data with the help of numerous experts and has published three books.

This booklet wants to give some basic information on the centre and the research performed in it and can also work as an overview for the book publications.



**Volume 1: *Glaziale und periglaziale Lebensräume im Raum Obergurgl***

Eva Maria Koch, Brigitta Erschbamer (eds.)  
ISBN 978-3-902719-50-8

**Volume 2: *An den Grenzen des Waldes und der menschlichen Siedlung***



Eva Maria Koch, Brigitta Erschbamer (eds.)  
ISBN 978-3-902811-40-0

**Volume 3: *Klima, Wetter, Gletscher im Wandel***

Eva-Maria Koch, Brigitta Erschbamer (eds.)  
ISBN 978-3-902811-89-9



All three books are available through *innsbruck university press (iup)* and amazon. They can also be purchased at the University Centre Obergurgl, the office of the Ötztal Tourism in Obergurgl and at local shops. To this point the books have been written in German. However, all chapters include abstracts in English.

For further information on books, research, events or contact address please visit the homepage of the Alpine Research Centre Obergurgl:

<http://www.uibk.ac.at/afo/>



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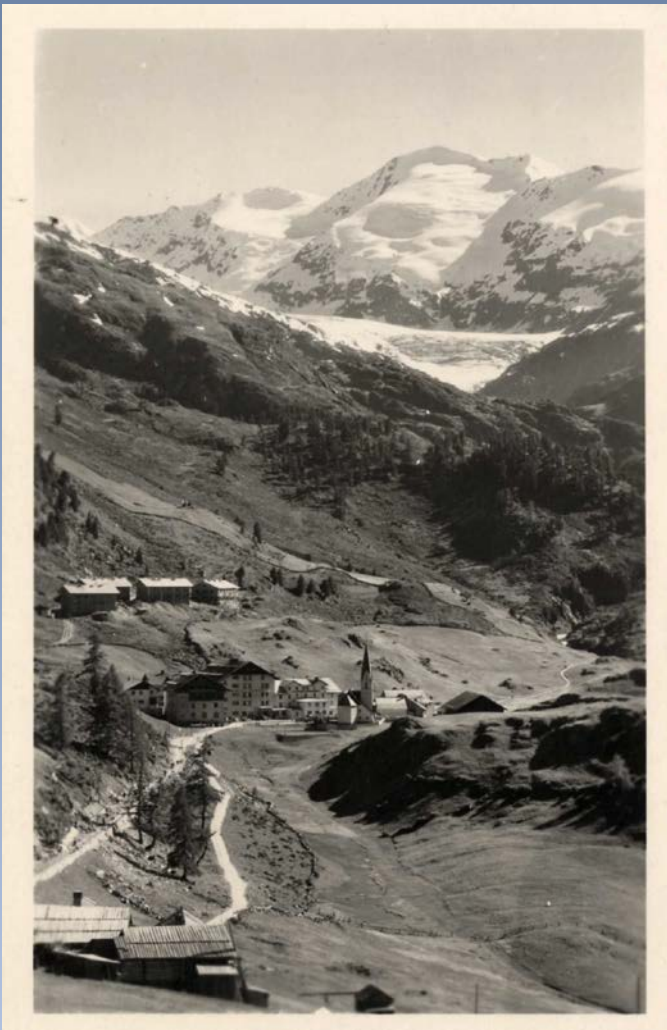
## **History of Obergurgl**

Obergurgl is a district of the municipality of Sölden in the inner Ötz Valley. It is situated at 1927 m a.s.l., being the highest village with a church in Austria.

The first documented reference of the toponym 'Gurgl' dates back to 1250 and can be traced to "Heberhardus von Gurgele", a vassal of the lords of 'Montalban' from South Tyrol.

Around 1760 Obergurgl was a community inhabited by about 200 people, most of which lived on agriculture and weaving. An article in the 'Tiroler Boten' from 1821 states that almost all farmers of the Ötz Valley produced linen and loden and traded flax with the 'Passeier' Valley in South Tyrol. However, the demand on these local products decreased in the 19<sup>th</sup> century, leading to a dramatic emigration and leaving the community of Obergurgl with no more than 39 people in 1910.

With the discovery of the Alps as a recreational space the Ötz Valley was put on the map for tourists and mountaineers and the population in the region soon increased.



Above: *"Schönwieshütte 2340m mit Gaisberg- und Rotmoos-Gletscher bei Ober-Gurgl – Tirol"* Mountain lodge 'Schönwieshütte' near Obergurgl at 2340 m a.s.l., with 'Gaisberg'- and 'Rotmoos' glacier in the background.

Postcard published by Lohmann and Aretz, Ötztaler Alpenverlag, (Tyrolean State Museum Ferdinandeum, Postcard collection 'Rotmoostal').

Left: photo from Obergurgl around 1928 (dated by the priest of Gurgl, Dr. Josef Hrbata in 1986); Nowadays, the houses on the upper left side are home of the University Centre and the Alpine Research Centre (Tyrolean State Museum Ferdinandeum, Postcard collection 'Obergurgl').



## The beginning of mountaineering

Two priests were mainly responsible for the establishment of mountaineering in the Ötz Valley: Adolf Trientl (from 1857 to 1864 in Gurgl) and Franz Senn (from 1860 to 1872 in Vent). Both were pioneers in alpine path construction and frequently accommodated mountaineers in their rectories.

Many locals found work as mountain guides and burden bearers and it did not take long until the first mountain lodges were established: the 'Hochjochospitz' in 1871/72 and the 'Samoarhütte' in 1877/78 established by Josef Grüner from Sölden and the 'Ramolhaus' in 1881/83 established by Martin Scheiber from Gurgl.

In 1875 Obergurgl was visited by up to 400 travellers and mountaineers in summer. This led to the first guest houses being opened in the early 1880s. The number of guests steadily increased with more than 2000 visitors in 1904. The first hotel, the 'Edelweiss', was founded by Martin Scheiber, who developed it from an old farm house, which indicates the region's transition from an agriculture- towards a tourism-based economy.



***Gasthaus zum Edelweiss.*** Guest house Edelweiss. Part of a drawing, around 1900, picture provided by Hotel Edelweiss & Gurgl

Excerpt from: "Glaziale und periglaziale Lebensräume im Raum Obergurgl"; chapter 1: "Historisches zum Thema Gletscher, Gletschervorfeld und Obergurgl" by Wolfgang Meixner and Gerhard Siegl

## **Skiing tourism in Obergurgl**

Around 1900 the first skiers visited the Ötz Valley and it did not take long until the 'Ski-Club Gurgl' was founded on 10<sup>th</sup> January 1911 with its first chairman Jakob Gstrein, commonly called 'Krumpns Joggel'.

The region received a boost in publicity after the crash landing of the Swiss scientist and balloonist Auguste Piccard on 27<sup>th</sup> August 1931 at the 'Gurgler Ferner'. This event considerably facilitated the prominence of Obergurgl as a ski resort for it was only five months after the crash that the first international 'Piccard' ski race took place on the 'Festkogel' on 10<sup>th</sup> January 1932.

During World War II tourism in Obergurgl almost completely stopped but only a few months after the war touristic infrastructure was revived and expanded.

On 14<sup>th</sup> March 1948 the first ski lift of the Ötz Valley was opened in Obergurgl. In 1954 a skilift was built from the 'Gaisberg' (2.050 m a.s.l.) to the 'Hohen Mut' (2.669 m a.s.l.). It was the highest one in Austria at the time.

In 2001 around 420 people lived in Obergurgl permanently. Currently about 4.500 guest beds are available in Obergurgl-Hochgurgl and more than 120.000 tourists are accommodated per year. The boom of travelling that set in in the second half of the 20<sup>th</sup> century facilitated Obergurgl's development from a small mountain village to a centre of mountaineering and skiing.



***“Auf dem Rotmoos-Gletscher bei Ober-Gurgl, Abfahrt vom Rotmoosjoch 3135 m, Ötztal – Tirol”***; On the 'Rotmoos' glacier near Obergurgl, downhill run from the 'Rotmoosjoch' 3135 m a.s.l.; Postcard from 1939; published by Lohmann and Aretz, Ötztaler Alpenverlag, private property



## Geology und geomorphology of the area around Obergurgl

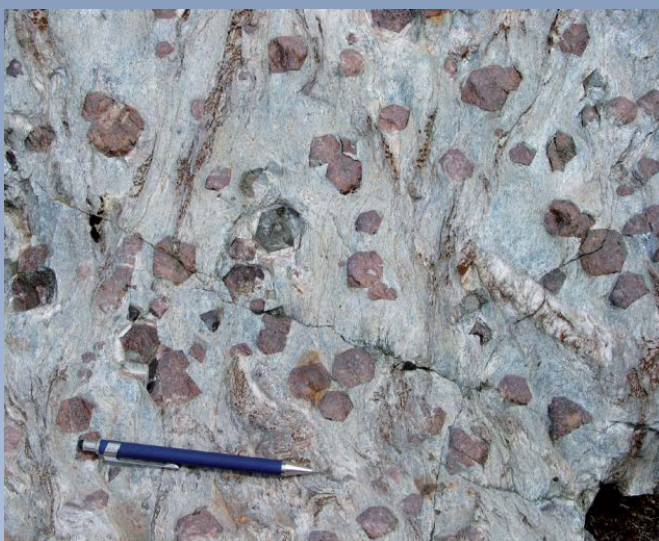
The area of Obergurgl is highly diverse from a geological point of view because basement rocks of the Ötztal-Stubai Complex and the Schneeberg Complex are exposed. The Ötztal-Stubai Complex is mainly composed of paragneiss and mica schists, the Schneeberg Complex consists of coarse mica schists with centimeter-large phenocrysts of garnet and hornblende, but also amphibolite and marble can be found. The landscape around Obergurgl was shaped morphologically by huge glaciers during the Ice Age. Traces of the glacial activity such as U-shaped valleys, cirque lakes, rock drumlins, glacial striations and moraines are common.



Schist with hornblende (Schneeberg Complex, Rotmoos Valley)



Schist with garnet and hornblende with layers of marble (Schneeberg Complex, Rotmoos Valley)



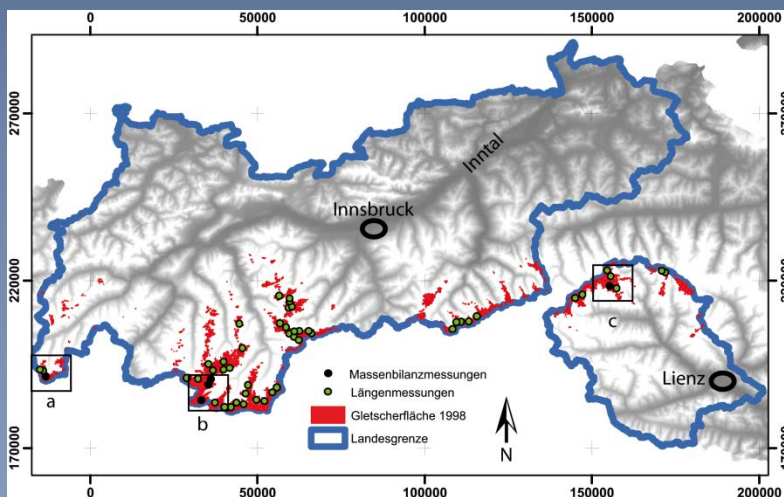
Garnet embedded in schist (Schneeberg Complex, Rotmoos Valley)



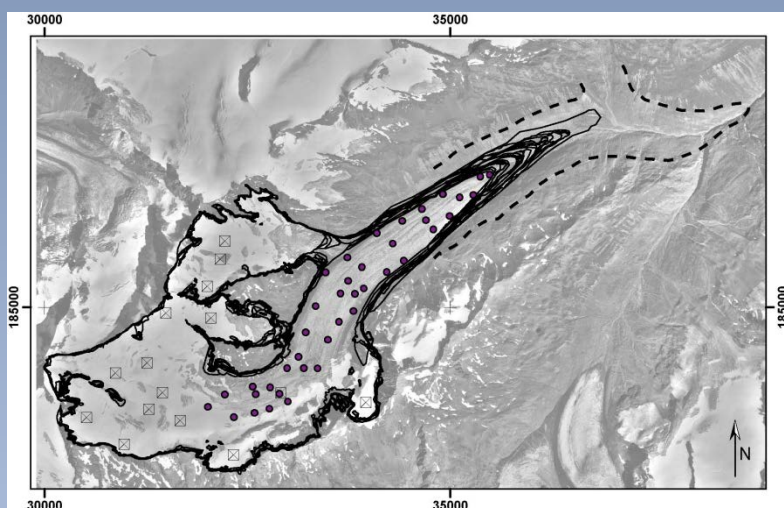
The Rotmoos Valley is a good example for a glacial U-shaped valley. (all photos: K. Krainer)

## Long-term monitoring of the Tyrolean glaciers

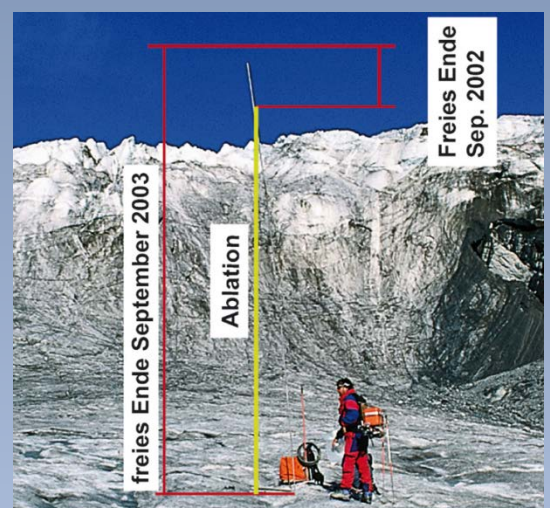
3 % of the Tyrolean territory is covered by glaciers. After the end of the Little Ice Age around 1850, the glaciers have lost more than 50 % of their area. The glacier changes are recorded by annual length monitoring on 54 glaciers and mass balance measurements on 5 glaciers. Between 1901 and 2008, the temperature during the ablation season (May to September) increased by 1.6 °C. In the same period, winter accumulation (October to April) showed no significant trends. The reaction of glaciers to the climate signal differs in timing and magnitude in relation to their topographic properties. The measurement of length changes shows a general glacier retreat, interrupted by advances in the 1920s and 1980s. The mass balance measurements show an increase in mass loss during the last decades.



Left: Glaciers (red) cover 3 % of the area of Tyrol (blue). Annual changes in length were measured on 54 glaciers (green), the mass balance is recorded on five glaciers (black). Glaciated areas are shown on a digital elevation model by Jarvis et al. (2006).



Map of the 'Hintereisferner', the position of snow shafts (squares) and ablation gauges (dots) as well as the glacial extent in ~1850 (dashed line) and the extents from 1953 to 2003 (solid lines)



Glaciological mass balance programs comprise measurements of ablation at gauges and accumulation at snow shafts (photo: A. Fischer)

Excerpt from: "Klima, Wetter, Gletscher im Wandel"; chapter 2: "Langzeitmonitoring von Gletschermassenbilanzen und -längenänderungen in Tirol" by Andrea Fischer and Lea Hartl

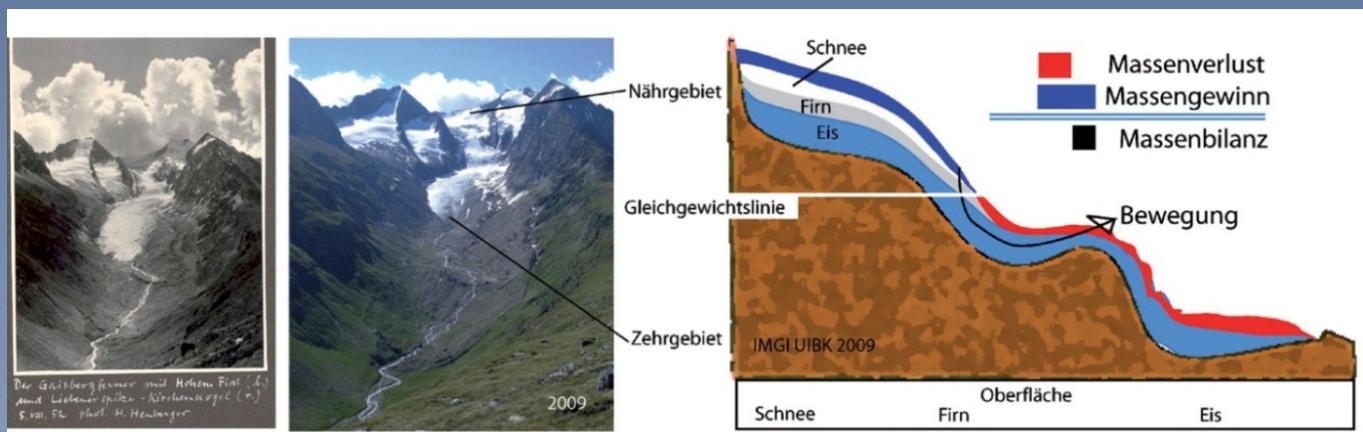


## Glaciers around Obergurgl

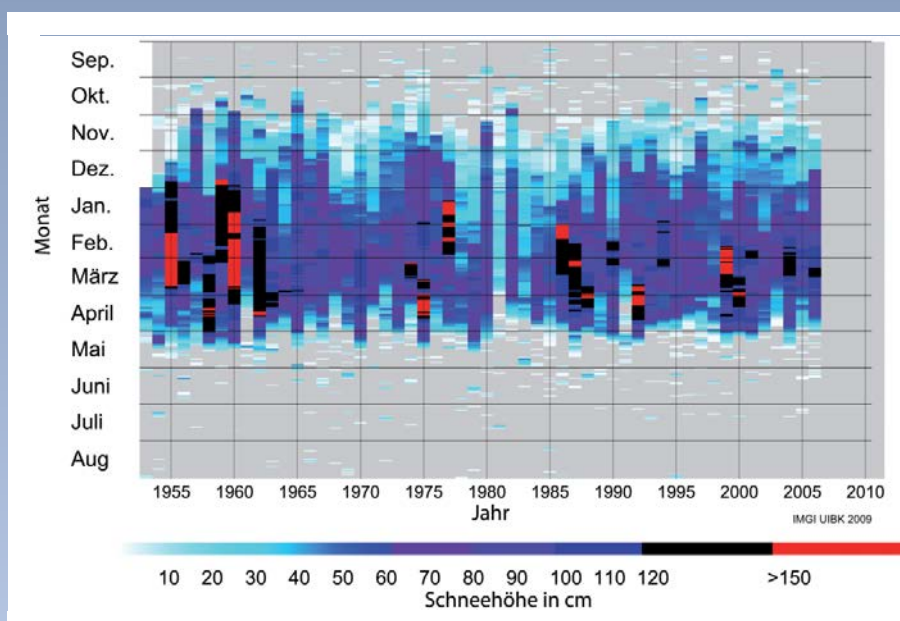
The Alpine Research Centre Obergurgl is located in the centre of one of the most glaciated areas in the Alps. The glaciers have been subject to scientific research for more than 100 years. The observed former and recent glacier changes visualize the corresponding changes of climate and allow an interpretation of the relationship between glacier and climate.

The glaciers around Obergurgl reached their last maximum extension about 1850, at the end of the Little Ice Age. After that, the glacier continuously retreated and their maximum area of extension has been reduced by almost 50 %.

Since the beginning of climate measurements in Obergurgl in 1953, the annual mean of the air temperature increased by 1.2 °C, whereas precipitation and snow conditions do not display any significant trends in the same period



Retreat of the 'Gaisbergferner' ('Ferner' is a local expression for glacier) from 1952 to 2009 and a diagram of a typical glacier, describing the mass balance and displaying accumulation- and ablation zone (*Nähr-* and *Zehrgebiet*) and the equilibrium line (*Gleichgewichtslinie*) (photo: A. Fischer)



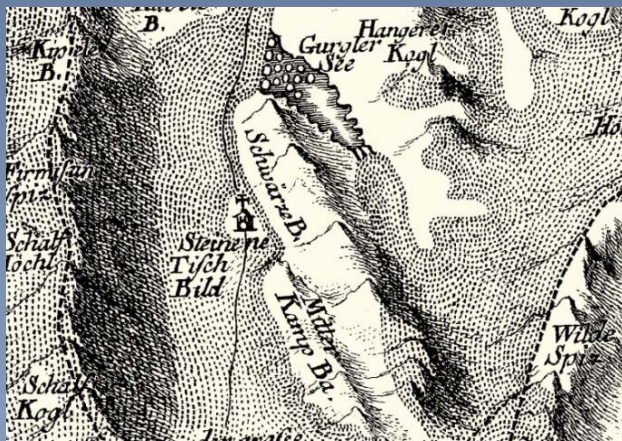
Depth of the snow in Obergurgl from 1953 to 2006

Excerpt from: "Glaziale und periglaziale Lebensräume im Raum Obergurgl"; chapter 3: "Klima und Gletscher in Obergurgl" by Andrea Fischer

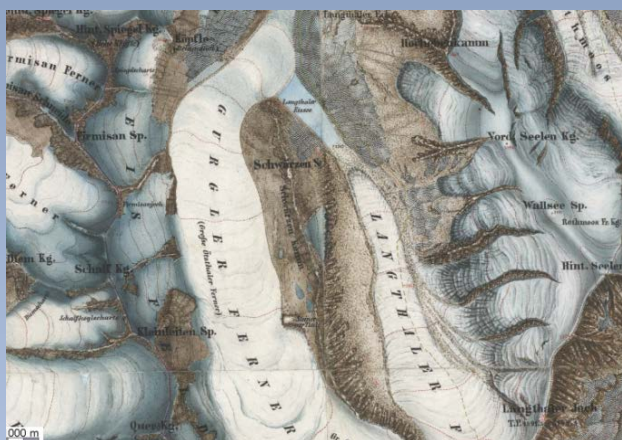
## Reconstruction of the glacier retreat in the ‘Gurgler’ Valley

Glacier boundaries and contour lines of several historical maps of the catchment ‘Pegel Obergurgl’ were digitalised and analysed to obtain information about changes in ice thickness and extension of the glaciers. By generating digital terrain models of the glacier surfaces using GIS, it was possible to determine the amount of ice lost during the observation period. Other historical sources of the ‘Gurgler Ferner’ could then be used to further increase the temporal and spatial precision of the data in the area of the glacial tongue.

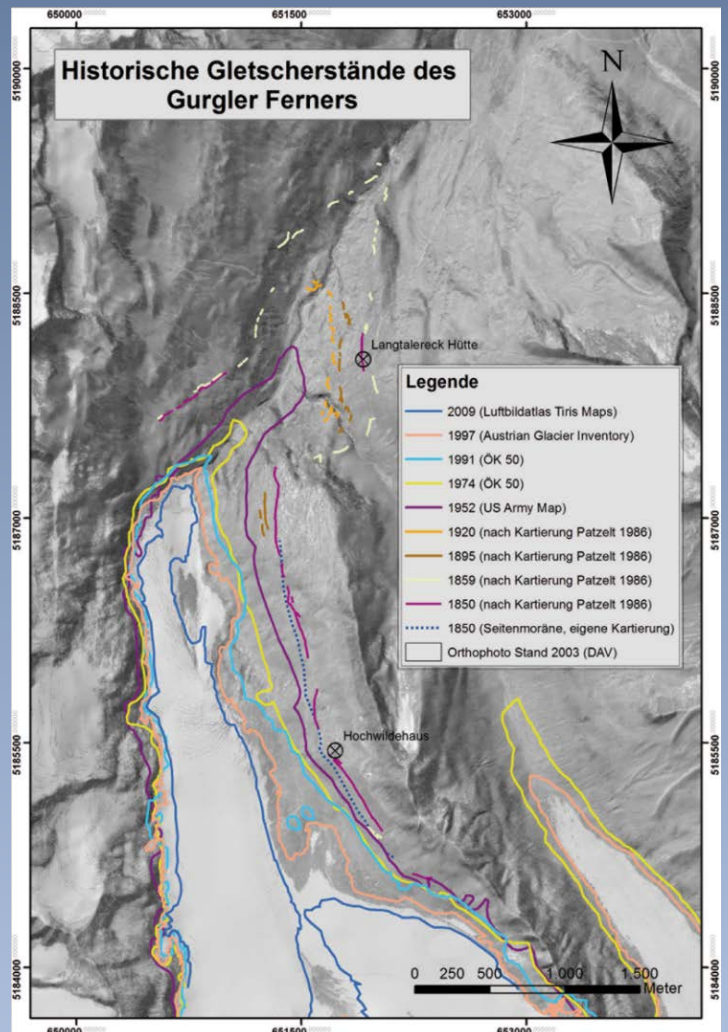
Except for short periods of glacial expansion, the results show a steady retreat of the glaciers in the area under study. These findings correspond to the worldwide trend (IPCC 2007), which is also approved by numerous studies from the Alpine region. This trend of glacier retreat has increased during the observation period from 1991 to 1997.



‘Atlas Tyrolensis’ from 1774 (source: Tyrolean Federal Archive)



Third Tyrolean geographical survey of 1870-73 (source: Tyrolean Federal Archive)



Spatial extent of the ‘Gurgler Ferner’ from 1850 to 2009

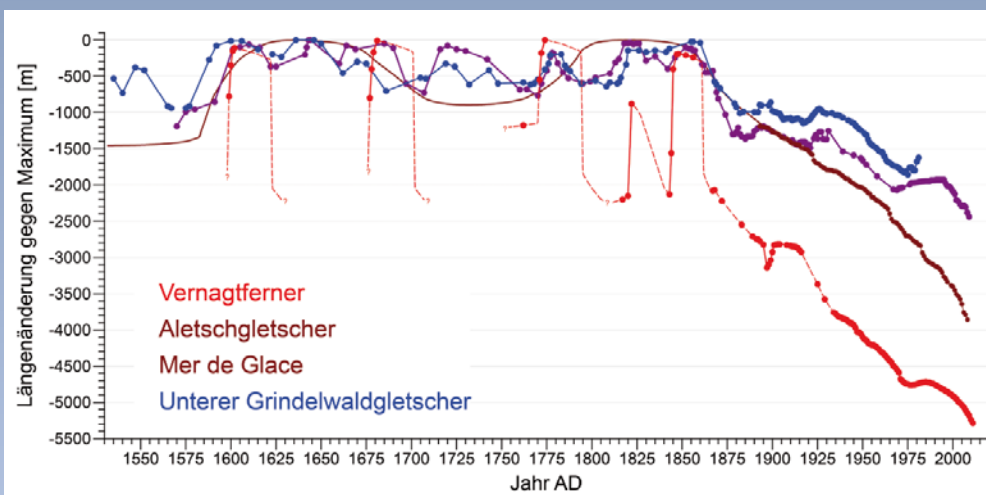


## The history of the 'Vernagtferner' – glacier advances and lake outbursts in the last millennium

The advances and maximum extents of the 'Vernagtferner' (southwest of Obergurgl near Vent) have been traced historically over the last millennium and the retrieved material and conducted measurements have been brought together to form a state of knowledge on the glacial development of the 'Vernagtferner'. Maximal extents of the glacier occurred in medieval times (around AD 1300) and in the historically well documented periods of AD 1600, 1680, 1772 and 1845. The dramatic advances of the 'Vernagtferner' happened synchronously with advances of other Alpine glaciers but were rather exceptional – not only regarding its advance speed and range but also in respect to repeated formation of an ice lake and its outbursts with severe consequences for local population.



The 'Vernagtferner' and the proglacial lake, 9<sup>th</sup> July 1601 (adapted from Abraham Jäger). Watercoloured pen and ink drawing, 220 x 525 mm (Tyrolean State Museum Ferdinandeum). This is the oldest known illustration of a glacier worldwide (Nicolussi 1993).



Length variations of the 'Vernagtferner', the 'Aletsch' Glacier, the 'Mer de Glace' and the Lower 'Grindelwald' Glacier during the last ~500 years.

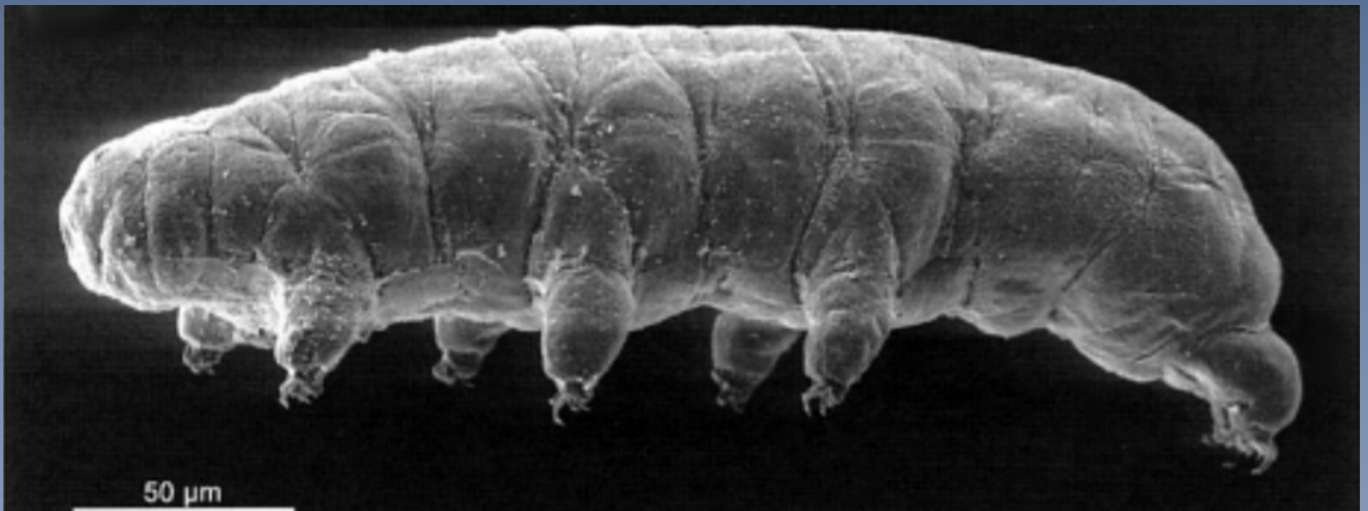
The measurements relate to the maximum extents of the glaciers during the Little Ice Age.

Reference series: Aletsch Glacier: Holzhauser et al. 2005, 'Gletscherberichte' 1881-2002; Mer de Glace: Nussbaumer et al. 2007; Lower Grindelwald Glacier: Zumbühl et al. 1983

Excerpt from: "Klima, Wetter, Gletscher im Wandel"; chapter 4: "Zur Geschichte des Vernagtferners – Gletschervorstöße and Seeausbrüche" by Kurt Nicolussi

## Life on snow and ice

Glaciers are not mere chunks of ice but ecosystems providing habitats below, in and on the ice mass. Living conditions are harsh and characterised by repeated freeze- and thaw cycles, high UV-radiation and often low nutrient levels. During early summer snow algae containing UV-protective pigments – known as ‘red snow’ – are flourishing on the surface of the snow. Once the snow pack melts, so called cryoconite holes (water filled cylindrical depressions which are formed by melting processes of dark matter) occur at the surface. These cryoconite holes harbour communities consisting mainly of viruses, bacteria, algae, and fungi and – depending on the geographical position – also metazoa.



Water bear *Hypsibius klebelsbergi* Mihelčič, (Dastych et al. 2003)



*Chlamydomonas* cf. *nivalis* (Chlamydomonadales) from the Rotmoos Valley; this species causes the ‘red snow’ (Foto: D. Remias)



Cryoconite hole with exceptional shape (Foto: B. Sattler)



## Faunal succession on glacier moraines

To find out how an ecosystem can develop on barren ground and how long this process takes, the glacier foreland of the Rotmoos valley has been investigated over years. The first colonisers are almost exclusively predators. Herbivores and decomposers appear later. On 30 years old moraines Collembola, Acari, Enchytraeidae and larvae of Lepidoptera as well as Coleoptera are present. Nematocera and Myriapoda follow later on. Other groups appear after 90 years of soil formation once an organic layer develops. The major factors affecting faunal succession are soil formation and vegetation development along the chronosequence, temperature and moisture exert additional small-scale influences. Models show that the pioneer communities in the glacier foreland react strongly to climate change.



Predatory colonisers in recently deglaciated areas: a ground beetle (*Nebria jockischii*, a) and a harvestman (*Mitopus glacialis*, b)



The chronosequence of the Rotmoos Valley with the terminal moraine (*Endmoräne*, dated 1858) in the foreground and the glacier extent in 2004 in the background

A Barber pitfall trap poured-in-place – a good example for the labour-intensive sampling in the Rotmoos Valley (all photos: R. Kaufmann)

## Plant succession in the glacier foreland

Glacial retreat induces the exposure of uncolonised bare ground, which allows for a study of the development of plant populations and communities from the very beginning. Colonisation processes are affected by abiotic factors – such as altitude, microtopography, grain size of substrate and humidity – and biotic factors – such as seed availability, germination ability, growth potential and interactions. With increasing distance from the glacier, diversity and vegetation cover accumulate: Pioneer stages close to the glacier evolve into early successional stages at 40-50 years old moraines and to initial grasslands at 150 years old moraines.



Pioneer plants on recently deglaciated areas: a) *Saxifraga aizoides* and b) *Saxifraga oppositifolia* (photos: F. Nagl)



Pioneer moss on dry, sandy and coarse substrate: *Racomitrium canescens* subsp. *canescens* (photo: G. Gärtner)



*Solorina spongiosa* is a lichen with green algae and cyanobacteria as symbionts, enabling fixation of atmospheric nitrogen (photo: R. Türk)



## Lichens and mosses around Obergurgl

Lichens and mosses are prominent parts of the coniferous belt and the subalpine dwarf shrub zone around Obergurgl. More common and widely distributed species of terrestrial mosses and lichens can be found in the famous 'Zirbenwald' (stone pine forest, *Pinus cembra*), while specialists are covering tree barks (e.g. the macrolichen *Letharia vulpina* on stone pine) or rock surfaces (e.g. *Ophioparma ventosa*). In acidic fens like the 'Zirbenwaldmoor' *Sphagnum* mosses and brown mosses (e.g. *Warnstorfia*, *Straminergon*) are dominating. The locality 'Gurgler Heide' is characterized by terrestrial fruticose lichens (e.g. *Flavocetraria*, *Alectoria*) and reindeer lichens (*Cladonia* species).

Specific habitats for mosses are lumps of herbivore dung covered by Splachnaceae or snow beds where the arctic-alpine *Polytrichastrum sexangulare* can be found together with the foliose lichen *Solorina crocea*.



Epilithic crustose and fruticose lichens: *Ophioparma ventosa* (centre), *Dimelaena oreina* (at the lower left) and *Melanelia hepatizon* (dark, at the right side of the picture)



'Heideflechte' *Icmadophila ericetorum* and 'Schönes Haarmützenmoos' *Polytrichum* = *Polytrichastrum formosum*



*Vulpicida pinastri* (yellow) and *Parmeliopsis ambigua* (grey green) on larch bark



*Letharia vulpina* on stone pine (all photos: G. Gärtner)

## Stone pine forests and dwarf shrub heaths

Stone pine forests (*Pinus cembra*) and dwarf shrub heaths are characteristic plant communities in the subalpine zone of the inner Ötz valley.

According to tree crown cover and altitude, two variants of the stone pine forest can be distinguished: a variant with *Oxalis acetosella* (higher tree crown cover,  $\leq 2060$  m a.s.l.) and a variant with *Loiseleuria procumbens* (lower tree crown cover,  $\geq 2100$  m a.s.l.).

The dwarf shrub heaths can be differentiated by canopy height and microrelief: *Loiseleuria procumbens* - lichens communities being the most wind-exposed ones and *Rhododendron - Vaccinium* communities being on sites with snow protection in winter. With the exception of the wind-exposed Loiseleurio-Cetrarietum, significant changes were detected in the dwarf shrub communities from 2000 to 2008, probably caused by global climate warming, atmospheric nitrogen deposition and skiing.



Stone pine forest (photo: R. Mayer)



Stone pine forest with high tree cover southwest of Obergurgl (photo: B. Erschbamer)



Creeping dwarf shrub communities grow together with lichens (photo: R. Mayer)



Tall-growing dwarf shrub communities are dominated by rusty leaved alprose *Rhododendron ferrugineum* (photo: R. Mayer)



## Forest and treeline research

Research started when the protection function of forests was diminished in the first half of the 20<sup>th</sup> century due to earlier anthropogenic reductions of the forested area in the timberline ecotone. For afforestation projects in high elevation no suitable reference cases from comparable regions were available. Consequently the appropriate measurements had to be developed.

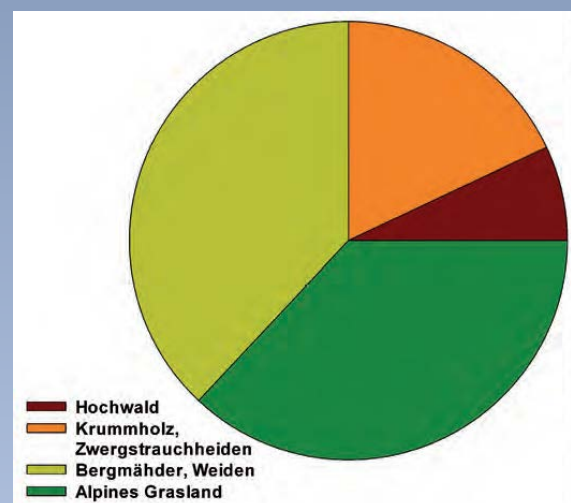
One of the results of this work was the development of a Wind-Snow-Ecogram which supports practical forestry in the spatial and temporal organization of afforestation projects in the timberline ecotone. Later research addressed other topics: especially the sequestration of carbon in soils as well as in biomass of forests and forest-replacing plant communities are nowadays of relevance due to its bearing on the national budget of greenhouse gas emissions.



Obergurgl in 1920 (left) and 2007 (right); a greater extent of pine stone forests in 2007 can be observed (photo 1920: Alpine Research Centre Obergurgl, photo 2007: R. Jandl)



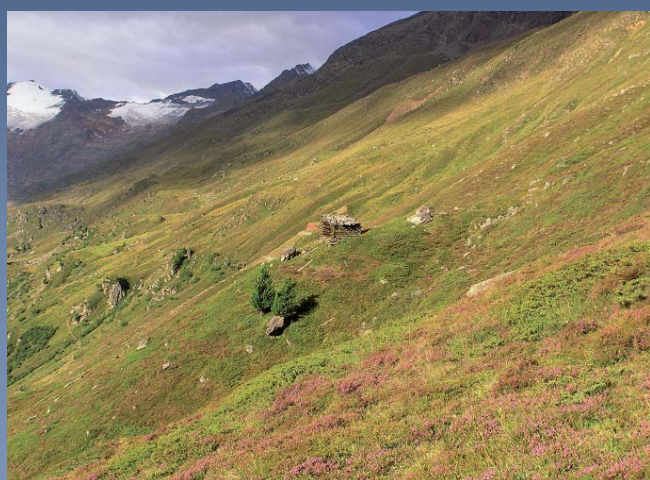
Afforestation at high altitudes is very important to maintain barrier forests (photo: L. Weißenbacher)



Proportions of different land use types in the Gurgler Valley around 1950 (source: Friedel 1961)

## The actual vegetation of the agricultural landscape

The pastures and meadows in Ober- and Untergurgl were investigated by 91 relevés. A *Sieversio-Nardetum strictae* and a *Trisetetum flavescens* were distinguished. These associations were differentiated into several subassociations. The *Sieversio-Nardetum strictae* is grazed by cattle and horses, however, many of these grasslands were abandoned. The *Trisetetum flavescens* is fertilized and mown once or twice a year. Due to the different management intensities, the diversity of the *Sieversio-Nardetum strictae* is significantly higher compared to the *Trisetetum flavescens*.



The *Sieversio-Nardetum strictae vaccinietosum* has a high proportion of dwarf shrubs such as ling (*Calluna vulgaris*, in the foreground) (photo: F.Nagl)



The *Trisetetum flavescens typicum* is growing at the valley floor. It is an intensively farmed species-poor community (photo: F. Nagl)



The *Sieversio-Nardetum strictae trifolietosum pratensis* grows in nutrient-rich habitats (photo: F. Nagl)



Some of the remote montane meadows are still manured and mowed by hand (photo: B. Erschbamer)



## The naming of landscapes and fields

At all times field names have been used by shepherds and farmers as an aid to orientation and as a code for communication. The richly structured alpine landscape as well as the century-old tradition of property partitioning have promoted a high diversity of toponyms in Obergurgl and Vent. Some field names have their origin in a pre-Romanic language or have Romanic roots. The majority, however, is German-based. Since the High Middle Ages names have been given to conspicuous places or places important for mountain agriculture. Toponyms refer to terrain shape such as *Rinne* (trough), to the location of a given area (e.g. *Äußere Wiese – Innere Wiese*: outer meadow – inner meadow) and their size (e.g. *Winkele*: little corner). The inclusion of the landowner in the name was also important: *Jakoben Wald* (Jacob's wood).



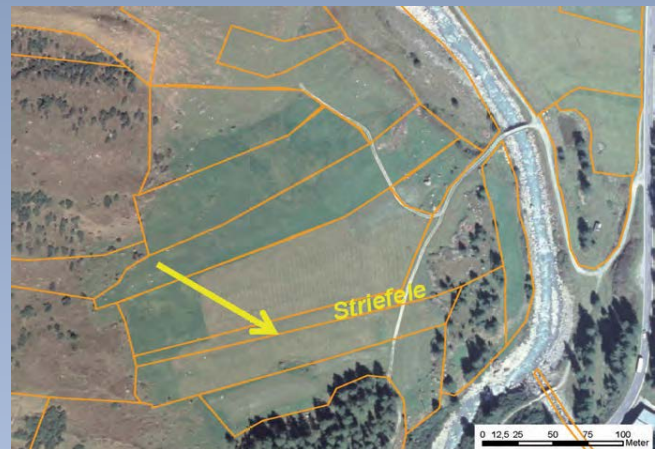
**Metonyms:** The area is named via its position: *Zwischen den Bächen* (between the brooks) (photo: R. Kaufmann)



*Pille* (hay barn) at the *Spitzigen Stein* (peaked rock); this rock (at the upper right part in the picture) is a distinct feature in this area (photo: R. Kaufmann)



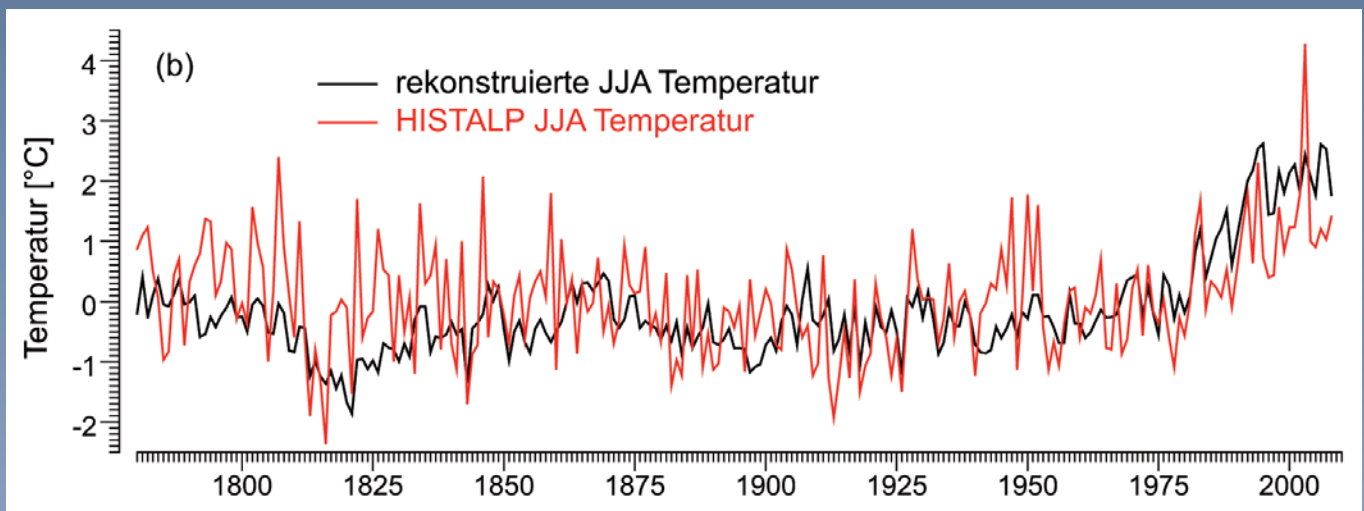
Hollow-way used to drive cattle: vernacular *Traje*, a word with Celtic origin; today this path is called *die Gasse*, after the German word (photo: R. Kaufmann)



Field names with reference to the extent of the area: *Striefele* (small strip) is the name of a very narrow area (aerial photo: BEV, flight 2003)

## Dendrochronological research around Obergurgl

The stone pine forest near Obergurgl was one of the first areas of dendrochronological research in Austria. Cores from living stone pine trees (*Pinus cembra*) from the so called 'Obergurgler Zirbenwald' as well as subfossil logs found in the peat of the 'Zirbenwaldmoor' and the small peat bogs below the 'Gurgler Alm' were investigated applying dendrochronological methods. The analysis of cores from living trees of the 'Obergurgler Zirbenwald' verifies the expected accordance of tree ring growth and summer temperature evolution (June-July-August average). Tree ring series established for 36 subfossil samples from the 'Zirbenwaldmoor' cover the time period between ca. 100 and ca. 1300 AD. In contrast to the subfossil samples of the 'Zirbenwaldmoor' the temporal distribution of 23 wood samples from the peat bogs below the 'Gurgler Alm' is to some extent related to the Holocene treeline evolution.



Results of the examination of recent pine samples from the stone pine forest in Obergurgl: Comparison of temperature data (mean of temperature of June, July and August, JJA) calculated via annual rings (black) and measured data (red; HISTALP Data)



The 'Obergurgler Zirbenwaldmoor'



The 'Gurgler Alm' (all photos: K. Nicolussi)

Excerpt from: "An den Grenzen des Waldes und der menschlichen Siedlung"; Chapter 6: "Jahresringuntersuchungen an rezentem und subfossilem Holzmaterial aus dem Raum Obergurgl" by Kurt Nicolussi and Andrea Thurner



## Archaeological findings around Obergurgl

There is proof for human presence in the area of Obergurgl and the surrounding valleys for the early Mesolithic from the first half of the 10<sup>th</sup> millennium BPcal onward. Then, the main focus of human activity was hunting. This kind of land use seems to continue throughout the Neolithic and until the Bronze Age, while agriculture was more and more established in the lowlands and greater alpine valleys. With the beginning of the Copper Age, around 6300 BPcal, alpine grasslands have started to be used as pastures. By means of pollen diagrams, a further intensification of this land use can be confirmed for the Bronze Age. This is also proved by a number of sheepcotes and shepherd huts, which are partly connected with radiocarbon dates starting in the middle Bronze Age. A continuous agricultural use until nowadays seems to be approved by findings from the Iron Ages and Roman times up to the first written records in the middle of the 13<sup>th</sup> century AD.



Findings from the 'Beilstein': Neolithic and Bronze Aged arrowheads



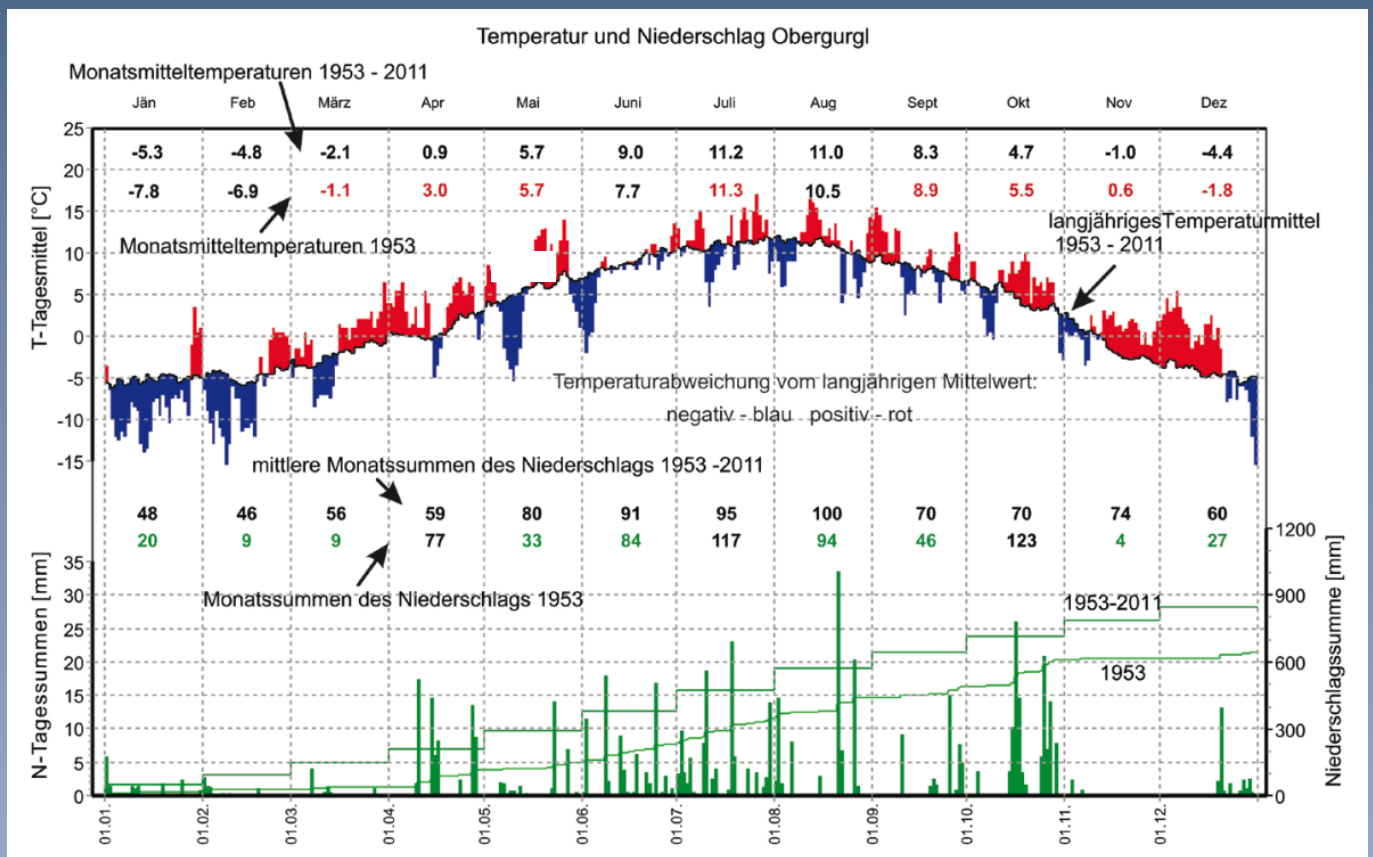
View to the 'Beilstein' (centre) and Obergurgl (behind); viewing direction: northeast



Excavations at the 'Beilstein'; viewing direction: south (all photos: A. Zanesco)

## Temperature and precipitation at the weather station Obergurgl, 1953-2011

The weather station in Obergurgl has been operated since 1953. It is located at an altitude of 1938 m a.s.l. next to the Alpine Research Centre / University Centre (11° 01.5' E, 46° 52' N). The weather station is equipped with various devices of the Austrian meteorological service ZAMG (Zentralanstalt für Meteorologie und Geodynamik) and is permanently measuring data such as air and soil temperature, air pressure and humidity, precipitation, wind speed and direction and radiation.



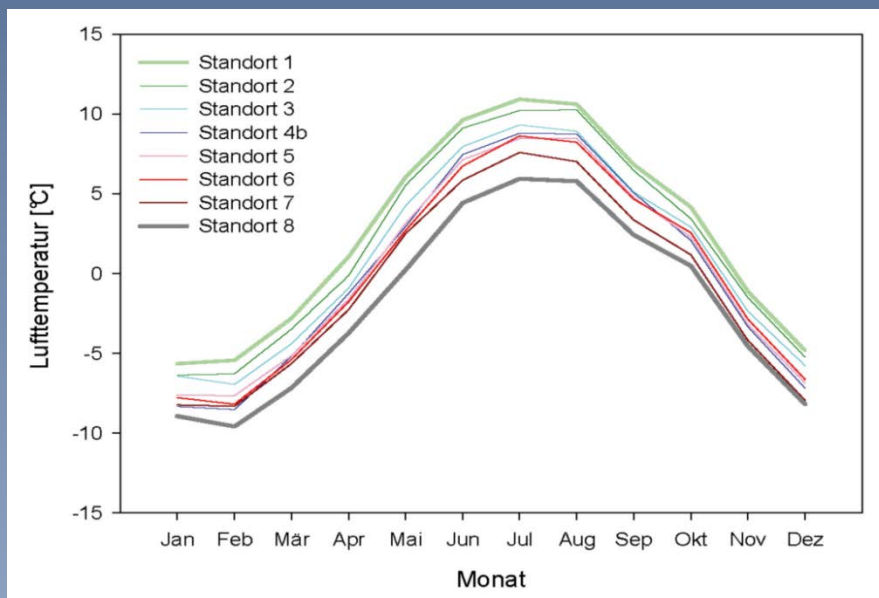
Above: Monthly means of temperature (above) and mean monthly sums of precipitation (below) in the period 1953-2011 and of 1953 in detail; The daily sums of precipitation are represented by green columns (left scale), the monthly sums and their addition over a year are represented by increments (right scale).

Left: The weather station of the ZAMG next to the Alpine Research Centre Obergurgl (photo: E.-M. Koch)

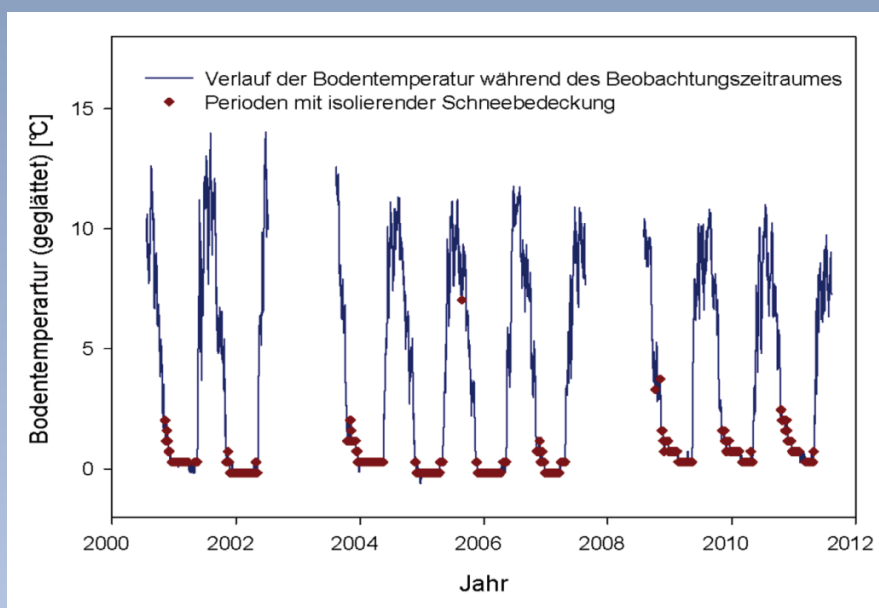


## Microclimatic monitoring around Obergurgl

In July 2000, nine treeless monitoring sites were established and equipped with data loggers in the vicinity of Obergurgl from the subalpine zone (1964 m a.s.l.) to the alpine and the subnival zone (2793 m a.s.l.) as part of the ecological long-term monitoring project. Measured parameters have been air temperature and relative air humidity 2 m above the ground as well as soil temperature and – moisture in 10 cm depth. The absolute minimum of the air temperature amounted to  $-30.0\text{ }^{\circ}\text{C}$  at the highest altitude. The absolute minimum of the soil temperature was monitored at the Gurgler Heide at 2255 m a.s.l. ( $-11.2\text{ }^{\circ}\text{C}$ ). The lowest number of days with snow cover was also found at this site. During the timeframe of 11 years the snow melt date in spring has significantly shifted forwards by approximately 1.2 days per year.



Monthly mean air temperatures at the different sites, averaged over the period 2000-2011; Monitoring site 1 is the lowest situated site (1964 m a.s.l.), site 8 is the highest situated site (2793 m a.s.l.)



Smoothed data of soil temperature (blue graph) at site 1 of the whole measuring period; the red dots display periods with constant soil temperature, revealing isolating snow covers

## Microclimate and biotemperatures at the 1971 moraine of the 'Rotmoosferner' glacier foreland

Glacier forelands are often seen as inhospitable areas, since abiotic conditions are expected to hamper colonisation. One of these factors are the low temperatures. However, biotemperatures in plant cushions can differ strongly from the ambient air temperatures.

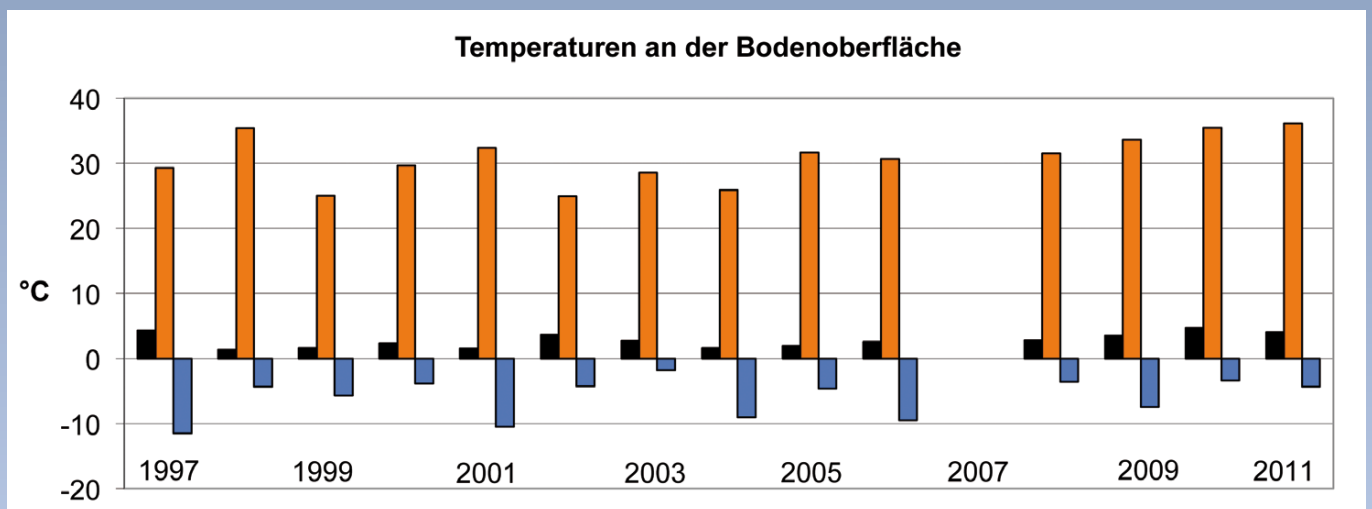
The glacier foreland of the 'Rotmoosferner' is one of the long-term ecological research sites in Obergurgl. Since 1996 soil surface temperatures have been measured on bare ground moraines of the glacier stage 1971 all year round. Air and soil temperatures, air humidity and temperatures of plant cushions are recorded during the growing season. Furthermore, the duration of the growing season, temperature extremes and means are shown and possible effects on plants are discussed. Data from 1996 until 2011 are presented.



Left: study site in the glacier foreland of the 'Rotmoosferner' on the moraine of the glacier stage of 1971 (photo: B. Erschbamer 2012)

Below: temperatures on the surface of the 1971 moraine: annual mean (black), absolute maxima (orange) and minima (blue) in the period 1997-2011.

Data are missing for 2007 since data loggers failed.





## High Alpine river habitat 'Rotmoos'

Alpine river systems are fed by glacial ice melt, snow melt and groundwater. They share common features (e.g., steep gradients, high flow velocities and dynamics) but each source and unique local conditions produce a characteristic discharge regime and distinctive physical and chemical characteristics. The distribution of snow, ice and groundwater springs varies spatially from stream to catchment scale, resulting in stream segments with characteristics, reflecting the different runoff sources. The alpine freshwater ecosystems – although species poorer compared to freshwaters at lower elevations – are rich in specialists which are strongly adapted to the extreme environmental parameters.



The 'Rotmoosache' – a typical high alpine river (photo: L. Füreder)



Larvae of the genus *Diamesa* are well known inhabitants of alpine rivers



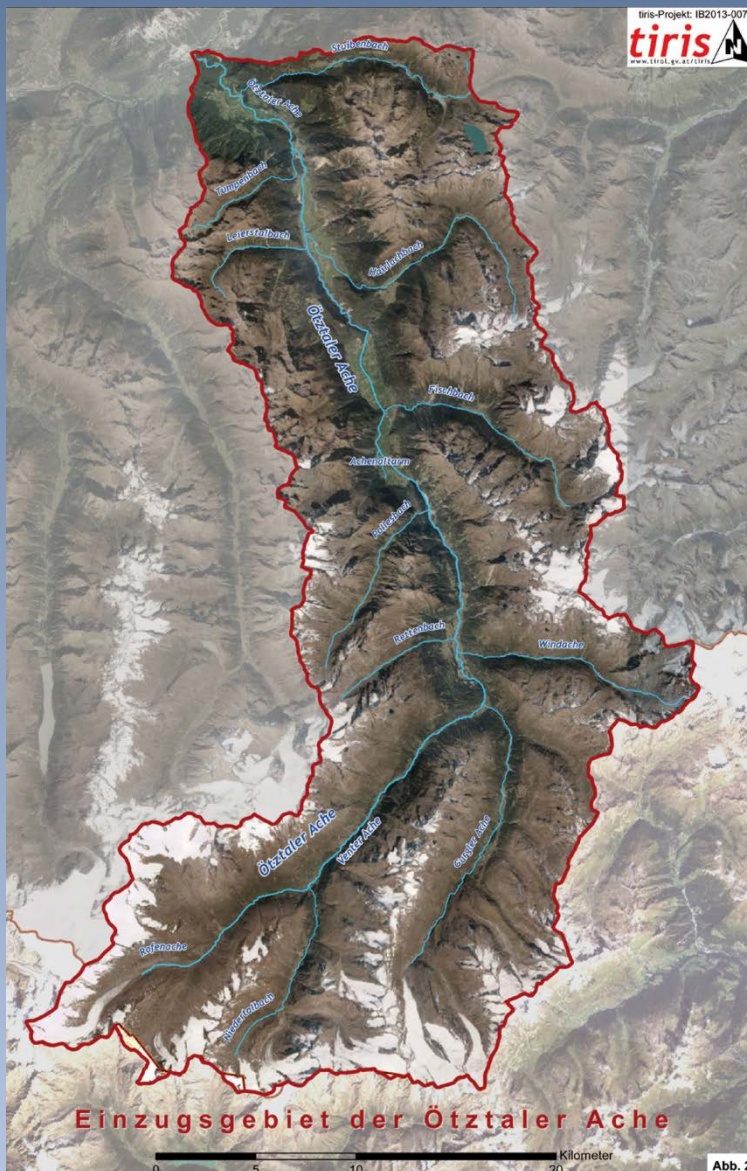
Mayflies of the genus *Rhithrogena* have a flattened body and lateral gills forming some kind of sucker cup



The mayfly *Baetis alpinus* is laterally flattened for a streamlined shape

## The hydrographic regime of the ‘Öztaler Ache’

The ‘Öztaler Ache’ (catchment area 894 km<sup>2</sup>) is one of the largest tributaries of the Inn River in Tyrol. The hydrological regime has been under observation since the foundation of the Hydrographical Service in Austria in 1893/94. In 1897 the first water gauge has been installed. Only few of the historical gauges are still being operated today. The monitoring includes parameters such as water level, discharge, water temperature, suspended load and bed load transport. The aim of the measurements is the generation of long-term series to identify trends or variation in the different parameters of alpine catchment areas, for instance caused by climate change. Measurement data are also needed for statistical analysis, for planning of watershed management and especially for flood forecasting by applying rainfall-runoff-models.



On top: The water gauge ‘Vent/Rofenache’; Measurements comprise water level (with RADAR and a pressure probe), surface flow velocity (with RADAR), water temperature, suspended sediments (with a turbidity probe), and bedload (with a geophone). All data are measured continuously, recorded on site and transmitted via GPRS (photo: Hydrographical Service Tyrol)

Left: The catchment area of the ‘Öztaler Ache’ with the main river and the bigger tributary rivers (tiris 2013)



## The fauna of the 'Öztaler Ache'

The 'Öztaler Ache' is one of the last hydrologically intact glacial and mountain streams in Tyrol. The water quality is nearly untainted. The existing hydrological regime and the glacial influence lead to a specific biotic environment. The Öztaler Ache is mainly colonised by organisms which are adapted to the special conditions of mountain streams. Examples are several species of algae as well as faunistic elements such as different species of fish and macrozoobenthos.

During winter the 'Öztaler Ache' is characterized by low flow velocities and reduced turbidity and bedload mobility. These conditions facilitate the growth of diatoms and other algae. The bottom of the water body is colonized by Turbellaria, insects and their larvae. The fish of the 'Öztaler Ache' have to deal with an enormous selective pressure due to the extreme conditions. Therefore, the number of species is quite low. Mostly, there are river trouts (*Salmo trutta fario*), at the mouth of the river even graylings (*Thymallus thymallus*) and bullheads (*Cottus gobio*). Additionally, alien species such as rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) were released into some parts of the river.



Larvae of stoneflies of the genus *Perla* can be found in the 'Öztaler Ache' (photo: Arge Limnologie)

An other typical coloniser is the river trout (photo: W. Mark)



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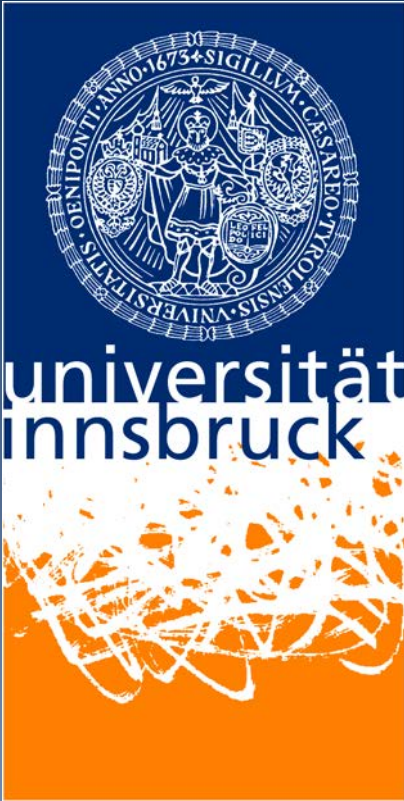


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