



Alpine research in the region of Obergurgl



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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.

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 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 contacts please visit the homepage of the Alpine Research Centre Obergurgl:
<http://www.uibk.ac.at/afo/>

Volume 1: Glaziale und periglaziale Lebensräume im Raum Obergurgl
Eva-Maria Koch, Brigitta Erschbamer (eds.)
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Volume 2: An den Grenzen des Waldes und der menschlichen Siedlung
Eva-Maria Koch, Brigitta Erschbamer (eds.)
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Volume 3:
Klima, Wetter, Gletscher im Wandel
Eva-Maria Koch, Brigitta Erschbamer (eds.)
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Contents

History of Obergurgl	6
The beginning of mountaineering	7
Skiing tourism in Obergurgl	8
Geology und geomorphology of the area around Obergurgl	9
Long-term monitoring of the Tyrolean glaciers	10
Glaciers around Obergurgl	11
Reconstruction of the glacier retreat in the ‘Gurgler’ Valley	12
The history of the ‘Vernagtferner’ – Glacier advances and lake outbursts in the last millennium	13
Life on snow and ice	14
Faunal succession on glacier moraines	15
Plant succession in the glacier foreland	16
Lichens and mosses around Obergurgl	17
Stone pine forests and dwarf shrub heaths	18
Forest and treeline research	19
The actual vegetation of the agricultural landscape	20
The naming of landscapes and fields	21
Dendrochronological research around Obergurgl	22
Archaeological findings around Obergurgl	23
Temperature and precipitation at the weather station Obergurgl, 1953-2011	24
Microclimatic monitoring around Obergurgl	25
Microclimate and biotemperatures at the 1971 moraine of the ‘Rotmoosferner’ glacier foreland	26
High alpine river habitat ‘Rotmoos’	27
The hydrographic regime of the ‘Ötztaler Ache’	28
The fauna of the ‘Ötztaler Ache’	29
List of authors	30



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., which makes it 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 Gurgle", a vassal of the South Tyrolean lords of 'Montalban'.

Around 1760, Obergurgl was a community inhabited by about 200 people, most of which lived on livestock farming 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. The demand on these local products decreased in the 19th century, leading to a dramatic emigration and leaving the community of Obergurgl with no more than 39 people in 1910. The population in the region started to increase when the Alps were discovered as a recreational space and the Ötz Valley was put on the map for tourists and mountaineers.

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').



"Schönwieshütte 2340m mit Gaisberg- und Rotmoos-Gletscher bei Ober-Gurgl – Tirol"; Mountain lodge 'Schönwieshütte' near Obergurgl at 2340 m a.s.l., against the backdrop of the 'Gaisberg'- and 'Rotmoos' glaciers.

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

The beginning of mountaineering

Mountaineering in the Ötz Valley is inseparably linked to personalities like Adolf Trientl and Franz Senn. The two priests were not only pioneers in alpine path construction but also figure heads of alpine tourism since they frequently accommodated mountaineers in their rectories in Gurgl (from 1857 to 1864) and Vent (from 1860 to 1872). With the first mountaineers travelling to the valley, many locals found work as mountain guides and burden bearers and it did not take long until the first mountain lodges and guest houses were built: the 'Hochjochhospitz' and the 'Samoarhütte' were established by Josef Grüner from Sölden in the years 1871/72 and 1877/78, and the building of the 'Ramolhaus' was initiated by Martin Scheiber from Gurgl in 1881/83.

In the summer of 1875, up to 400 travellers and mountaineers visited Obergurgl and the first guest houses were 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

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 10th January, 1911. Its first chairman was 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 at the 'Gurgler Ferner' on 27th August, 1931. 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 10th January, 1932.

During World War II, tourism in Obergurgl almost completely stopped but tourism infrastructure was revived and expanded only a few months after the war and the first ski lift of the Ötz Valley opened in Obergurgl on 14th March, 1948. Six years later 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.

The boom of travelling that set in in the second half of the 20th century facilitated Obergurgl's development from a small mountain village to a centre of mountaineering and skiing. 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 visit the region per year.



"Auf dem Rotmoos-Gletscher bei Obergurgl, 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, Öztaler Alpenverlag, private property

Geology und geomorphology of the area around Obergurgl



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)



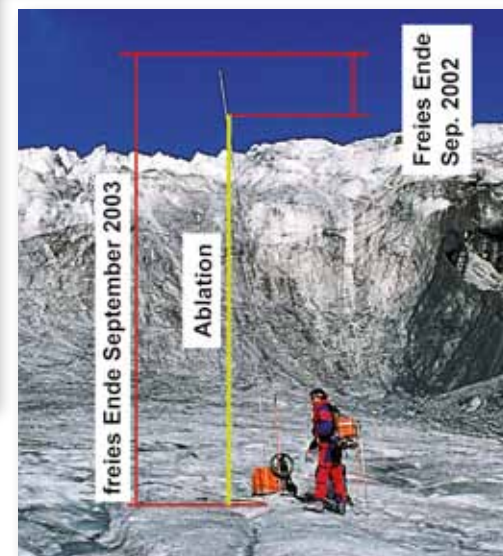
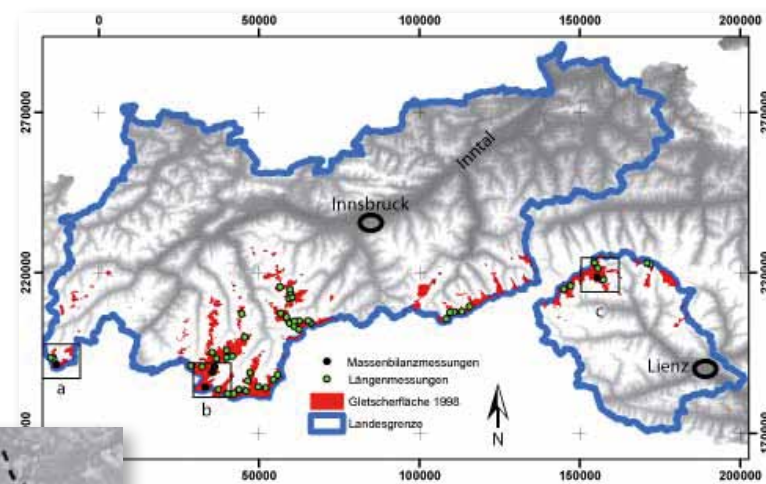
Long-term monitoring of the Tyrolean glaciers

Currently approximately 3 % of the Tyrolean territory is covered by glaciers. Around 1850, after the end of the Little Ice Age, the glaciers lost more than 50 % of their area. The glacier changes are recorded by annual length monitoring on 54 glaciers and mass balance measurements on five 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 changing climate conditions 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.

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)



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).



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

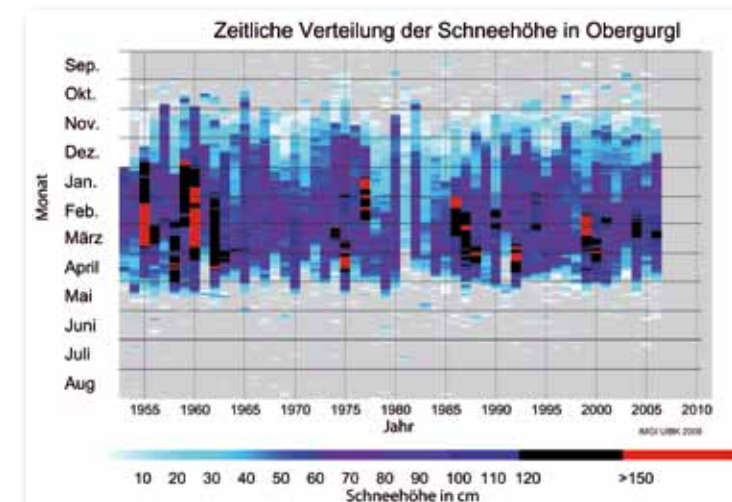
Excerpt from: "Klima, Wetter, Gletscher im Wandel";

Chapter 2: "Langzeitmonitoring von Gletschermassenbilanzen und -längenänderungen in Tirol" by Andrea Fischer and Lea Hartl

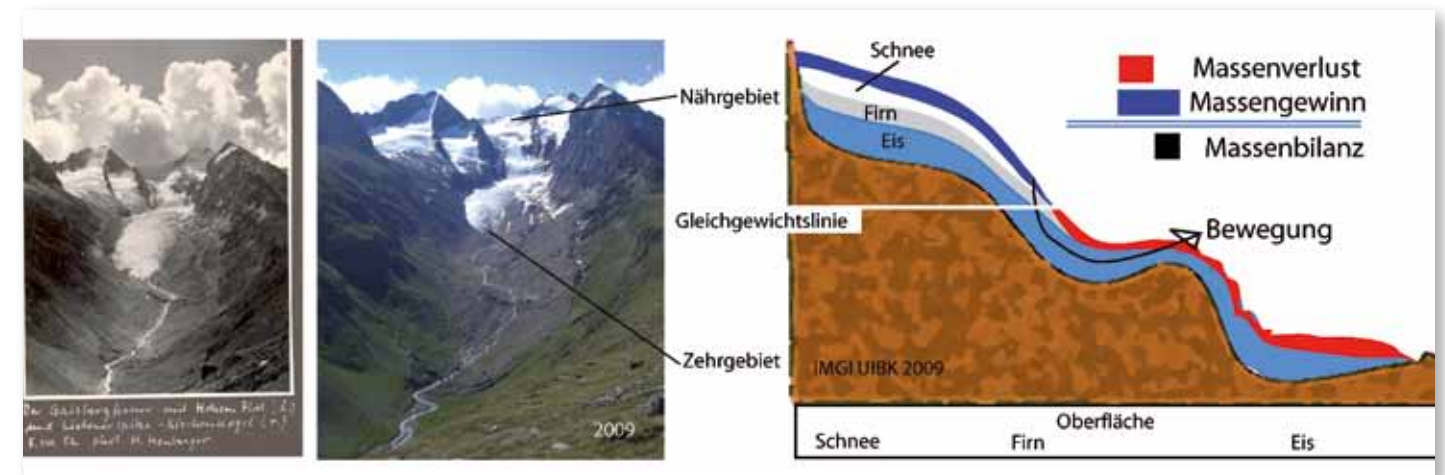
Glaciers around Obergurgl

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 surrounding Obergurgl reached their last maximum extension around 1850, at the end of the Little Ice Age. After 1850, 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, while precipitation and snow conditions do not display any significant trends in the same period.



Depth of the snow in Obergurgl from 1953 to 2006



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)

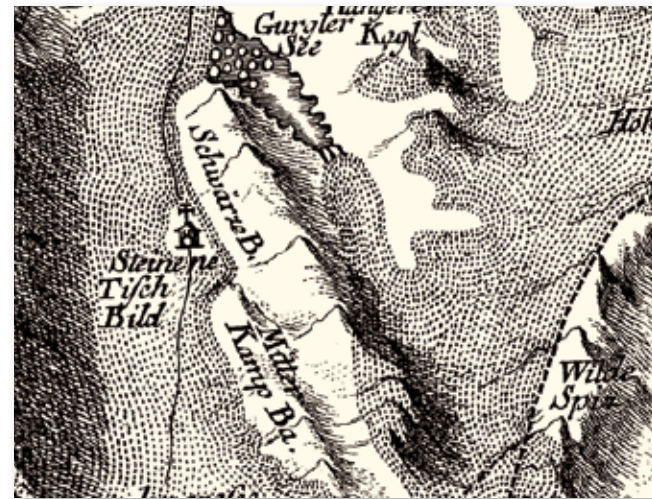
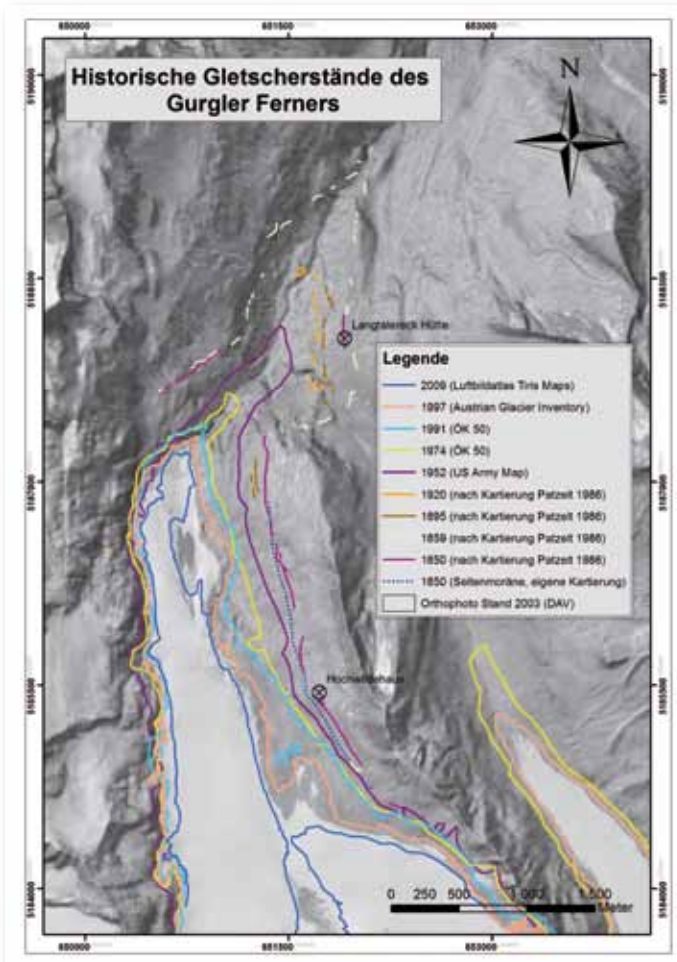
Excerpt from: "Glaziale und periglaziale Lebensräume im Raum Obergurgl";

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 glacial extension. 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 from 1991 to 1997. Other historical sources about the 'Gurgler Ferner' can 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 with the worldwide trend (IPCC 2007) and are supported by numerous studies from the Alpine region.



'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' (south-west 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'.

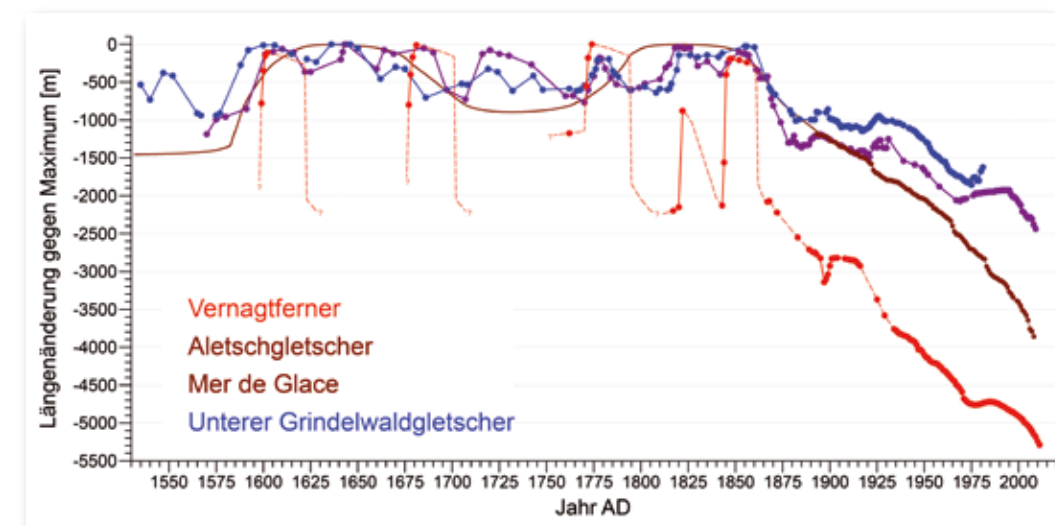
Maximal extents of the glacier occurred in medieval times (around AD 1300) and in the historically well documented periods of AD 1600, 1680, 1772 and 1845. The dramatic advances of the 'Vernagtferner' happened synchronously with advances of other Alpine glaciers but were rather exceptional – not only regarding its advance speed and range but also in respect to repeated formation of an ice lake and its outbursts, which had severe consequences for the local community.



The 'Vernagtferner' and the proglacial lake, 9th 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

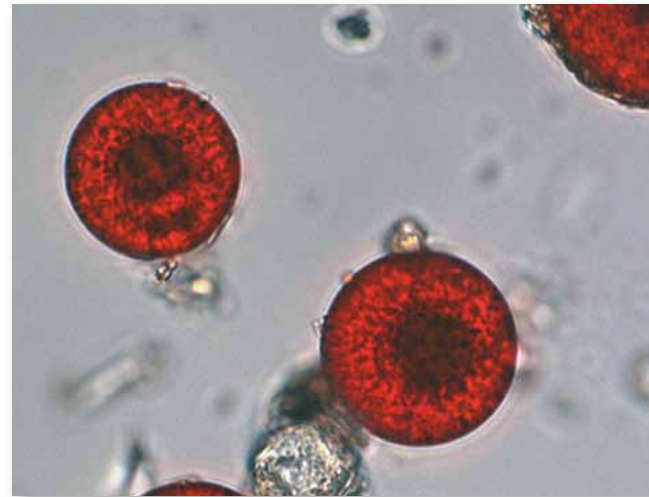


Life on snow and ice

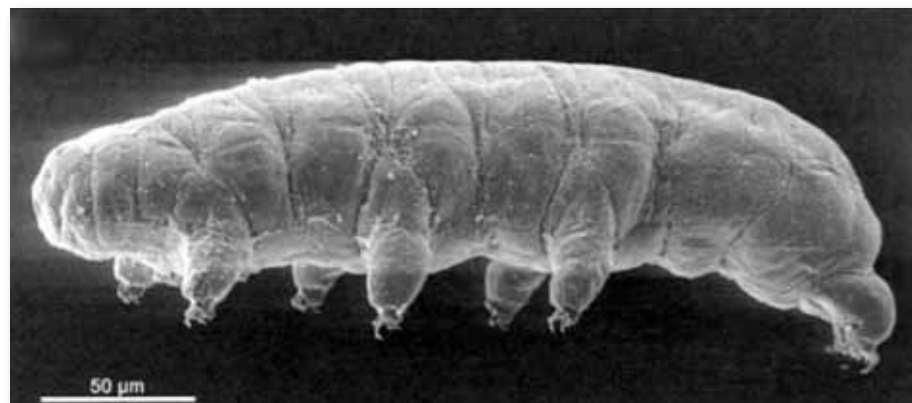
Glaciers are not mere chunks of ice but ecosystems providing habitats below, in and on the ice. Living conditions are harsh and characterised by repeated freeze-thaw cycles, high UV-radiation and low nutrient levels. During early summer, snow algae containing UV-protective pigments – known as ‘red snow’ – 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, fungi and – depending on the geographical position – also metazoa.



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



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



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

Faunal succession on glacier moraines



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



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 predatory beetles, spiders and harvestmen. Herbivores and decomposers appear later. On 30 years old moraines springtails, mites, pot worms and larvae of butterflies and beetles are present. Midges and millipedes follow later on. Other groups appear after 90 years of soil formation once an organic layer has developed. 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.



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, vegetation diversity and vegetation cover increase: Pioneer stages close to the glacier can develop into early successional stages at 40 to 50 year old moraines and into 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)



Excerpt from: "Glaziale und periglaziale Lebensräume im Raum Obergurgl";
Chapter 6: "Pflanzliche Sukzession im Gletschervorfeld" by Brigitta Erschbamer, Georg Gärtner, Roman Türk and Fabian Nagl

Lichens and mosses around Obergurgl



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



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

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 cover 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 dominant. The '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*.



Letharia vulpina on stone pine



Vulpicidapinastrum (yellow) and *Parmeliopsis ambigua* (grey green) on larch bark (all photos: G. Gärtner)

Excerpt from: "An den Grenzen des Waldes und der menschlichen Siedlung";
Chapter 7: "Zur Diversität der Flechten und Moose der subalpinen Stufe im Raum Obergurgl" by Georg Gärtner and Wolfgang Hofbauer

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: one with *Oxalis acetosella* (higher tree crown cover, ≤ 2060 m a.s.l.) and the other one with *Loiseleuria procumbens* (lower tree crown cover, ≥ 2100 m a.s.l.).

The dwarf shrub heaths can be differentiated by canopy height and microrelief: *Loiseleuria procumbens*-lichens communities are the most wind-exposed ones and *Rhododendron-Vaccinium* communities are frequently found 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 change, atmospheric nitrogen deposition and skiing.



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)

Excerpt from: "An den Grenzen des Waldes und der menschlichen Siedlung"; Chapter 4: "Lärchen-Zirbenwälder und Zwergstrauchheiden" by Roland Mayer and Brigitta Erschbamer



Stone pine forest

(photo: R. Mayer)



Stone pine forest with high tree cover southwest of Obergurgl

(photo: B. Erschbamer)

Forest and treeline research

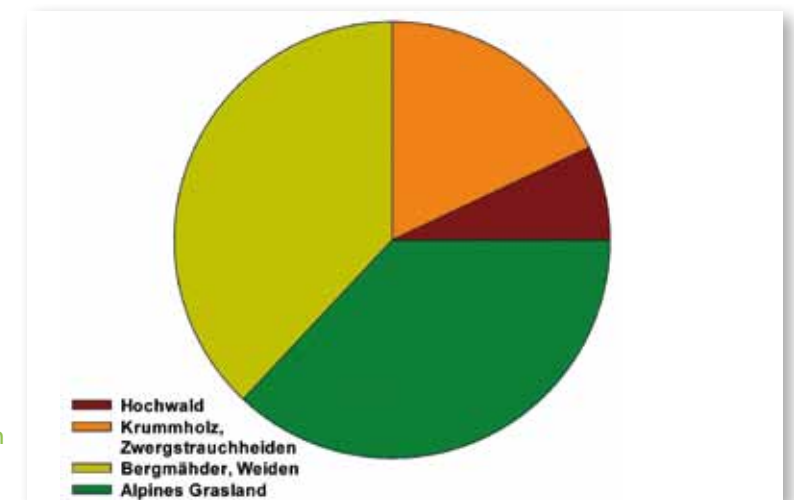


Afforestation at high altitudes is very important to maintain barrier forests

(photo: L. Weißenbacher)

Research started when the protection function of forests was diminished in the first half of the 20th 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 interests shifted and mainly addressed the sequestration of carbon in the soil and biomass of forests at the timber line. This is particularly relevant nowadays since carbon sequestration is directly related to greenhouse gas emissions.



Proportions of different land use types in the Gurgler Valley around 1950

(source: Friedel 1961)

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)



Excerpt from: "An den Grenzen des Waldes und der menschlichen Siedlung"; Chapter 5: "Wald- und Waldgrenzforschung in Obergurgl – Vergangenheit und Zukunft" by Robert Jandl, Andreas Schindlbacher, Silvio Schüler and Dieter Stöhr

The actual vegetation of the agricultural landscape

The pastures and meadows in Ober- and Untergurgl were investigated by means of 91 relevés, and a *Sieversio-Nardetum strictae* and a *Trisetetum flavescens* could be distinguished. These associations were differentiated into several subassociations.

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* would classically be grazed by cattle and horses but nowadays many of these grasslands are abandoned. The *Trisetetum flavescens* is fertilized and mown once or twice per year.



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 *Sieversio-Nardetum strictae vaccinetosum* 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 naming of landscapes and fields

For centuries shepherds and farmers have used field names 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 led to a high diversity of toponyms in Obergurgl and Vent. Some field names in the Ötz Valley have their origin in (pre-)Romanic languages, the majority, however, is German-based.

Since the High Middle Ages people named conspicuous and agriculturally important places. Toponyms can refer to terrain shapes (e.g. 'Rinne' trough), locations (e.g. 'Äußere Wiese – Innere Wiese': outer meadow – inner meadow), sizes (e.g. 'Winkele': little corner) and can also shed light on ownership (e.g. 'Jakoben Wald' – Jacob's forest).



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)



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)

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. Dendrochronological methods were used to analyse cores from living stone pine trees (*Pinus cembra*) from the 'Obergurgler Zirbenwald' and subfossil logs found in the peat of the 'Zirbenwaldmoor' and the small peat bogs below the 'Gurgler Alm'.

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.

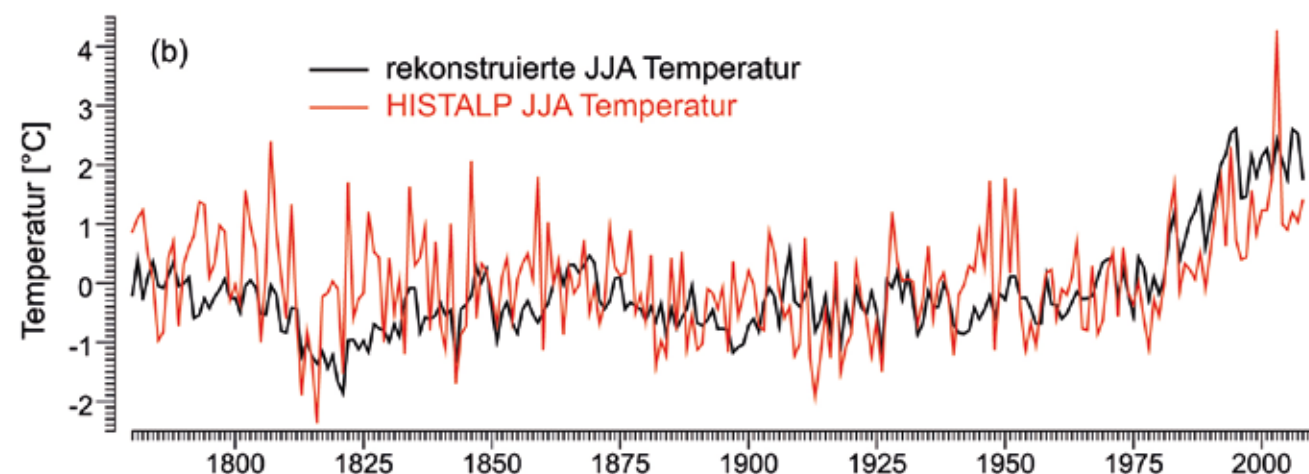


The 'Obergurgler Zirbenwaldmoor'



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

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)



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



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



Excavations at the 'Beilstein';
viewing direction: south

Findings from the 'Beilstein':
Neolithic and Bronze Aged
arrowheads (all photos: A. Zanesco)



Excerpt from: "An den Grenzen des Waldes und der menschlichen Siedlung";
Chapter 3: "Zum archäologischen Fundbild in Obergurgl" von Alexander Zanesco

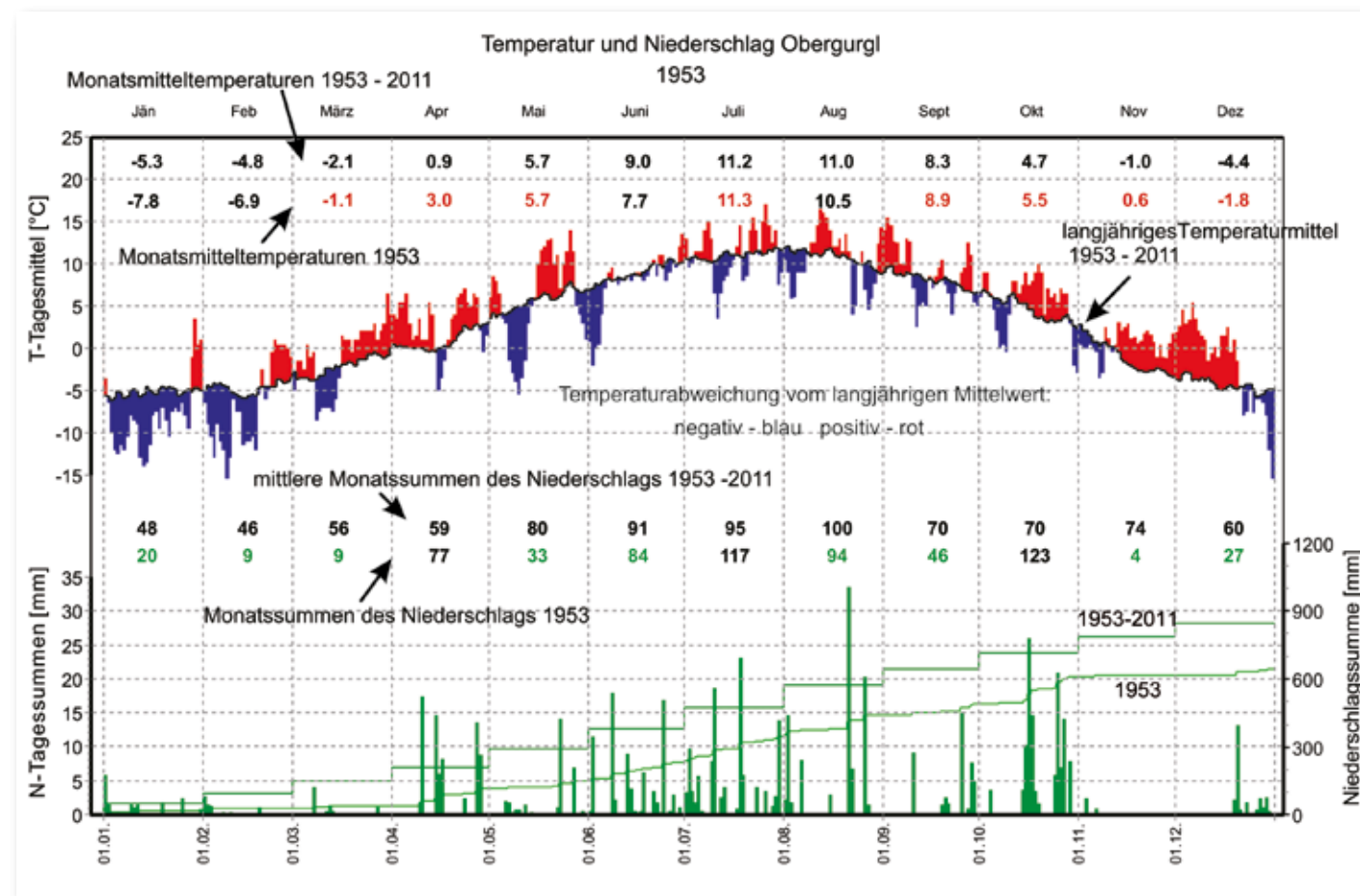
Temperature and precipitation at the weather station Obergurgl, 1953-2011

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 measures air and soil temperature, air pressure and humidity, precipitation, wind speed and direction and radiation.

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).



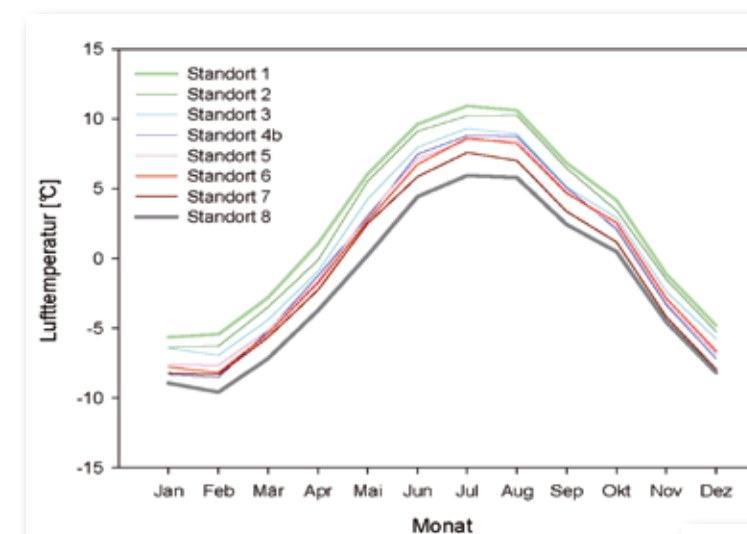
The weather station of the ZAMG next to the Alpine Research Centre Obergurgl (photo: E.-M. Koch)



Excerpt from: "Klima, Wetter, Gletscher im Wandel";
Chapter 1: "Temperatur und Niederschlag an der Wetterstation Obergurgl, 1953-2011" by Michael Kuhn, Ekkehard Dreiseitl and Markus Emprechtinger

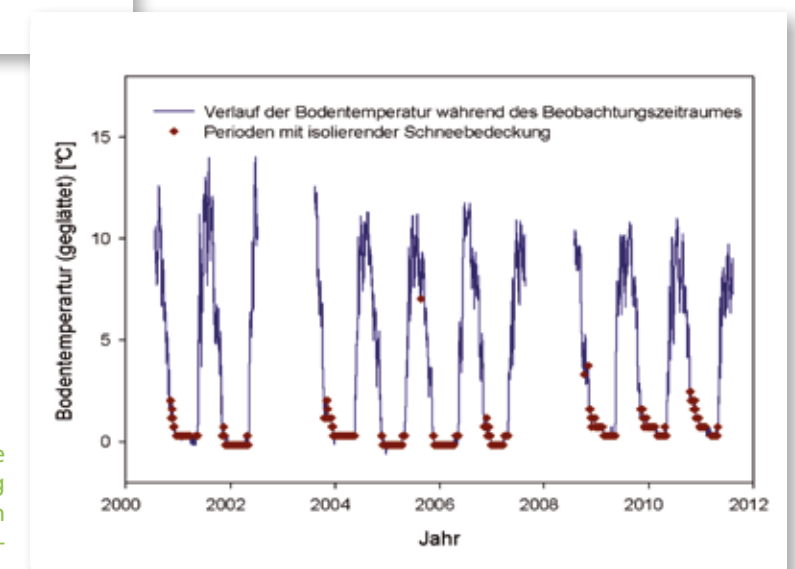
Microclimatic monitoring around Obergurgl

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.)



In July 2000, nine treeless monitoring sites were established and equipped with data loggers in the vicinity of Obergurgl from the sub-alpine 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. Air temperature and relative air humidity 2 m above the ground as well as soil temperature and soil moisture in 10 cm depth are measured. At the highest altitude the absolute minimum of air temperature was at -30.0 °C. The absolute minimum of the soil temperature was monitored at the 'Gurgler Heide' at 2255 m a.s.l. (-11.2 °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.

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



Excerpt from: "Klima, Wetter, Gletscher im Wandel";
Chapter 7: "Das Mikroklima waldfreier Standorte in der subalpinen, alpinen und subnivalen Stufe in Obergurgl" by Lea Hartl, Rüdiger Kaufmann, Nikolaus Schallhart and Brigitta Erschbamer

Microclimate and biotemperatures

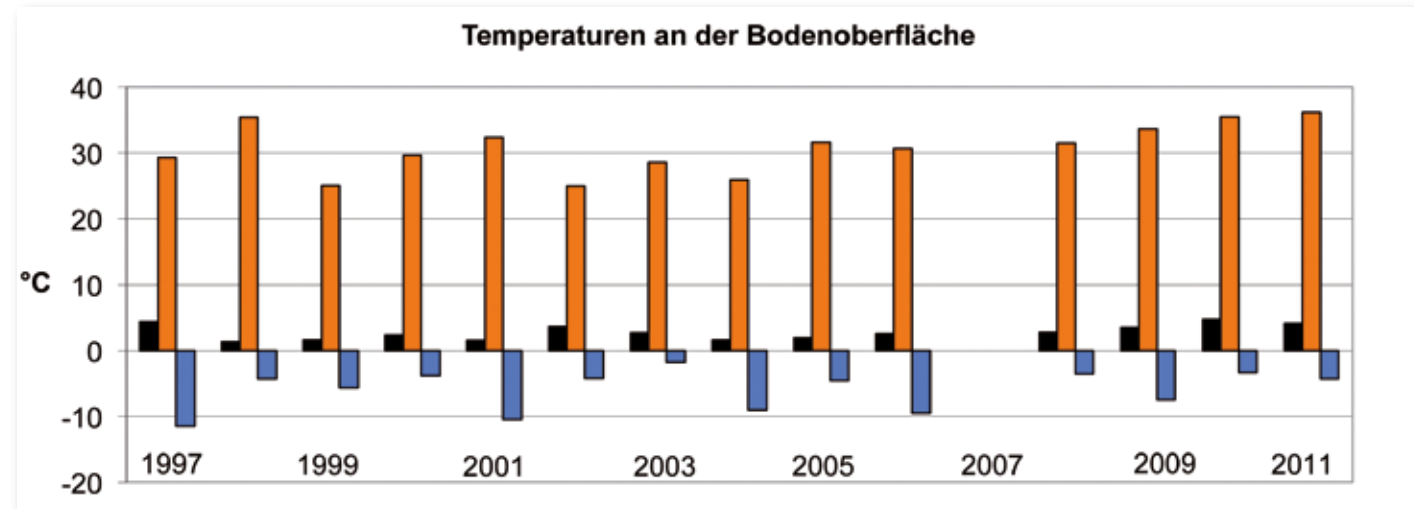
at the 1971 moraine of the 'Rotmoosferner' glacier foreland

Glacier forelands are often seen as inhospitable areas, since abiotic conditions are expected to hamper colonisation. One of these factors are 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 where temperatures are recorded throughout the year. Since 1996 soil surface temperatures have been measured on bare ground moraines of the glacier stage 1971. 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.



Study site in the glacier foreland of the 'Rotmoosferners' on the moraine of the glacier stage of 1971
(photo: B. Erschbamer 2012)

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'



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



Chironomid larvae of the genus *Diamesa* are well known inhabitants of alpine rivers

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 physical and chemical environment. 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 mayfly *Baetis alpinus* is laterally flattened for a streamlined shape



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

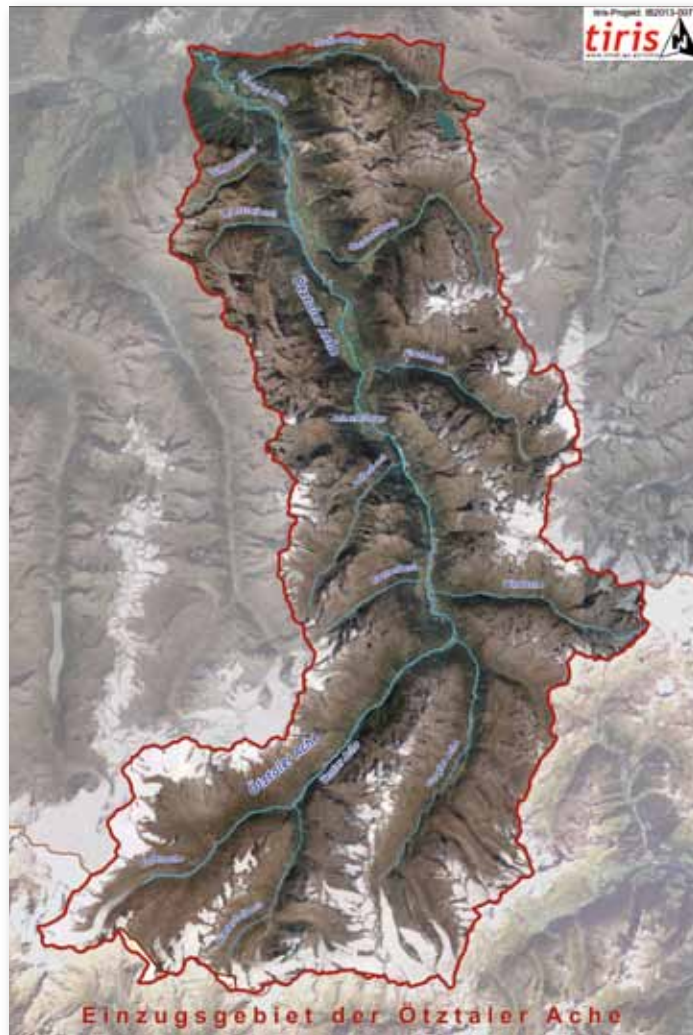
The hydrographic regime of the 'Ötztaler Ache'

The 'Ötztaler Ache' (catchment area 894 km²) 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. The first water gauge was installed in 1897. Only few of the historical gauges are still being operated today. The monitoring includes parameters such as water level, discharge, and temperature, as well as the suspended load and bed load transport. The aim of this long-term study is to identify trends and variations that might be caused by climate change and other parameters.

The data is also used for statistical analysis, planning of watershed management and flood forecasting. The latter is strongly based on the application of rainfall-runoff-models.



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)



The catchment area of the 'Ötztaler Ache' with the main river and the bigger tributary rivers (tiris 2013)

Excerpt from: "Klima, Wetter, Gletscher im Wandel";
Chapter 6: "Die Ötztaler Ache – Das hydrographische Regime der Ötztaler Ache" by Wolfgang Gattermayr

The fauna of the 'Ötztaler Ache'



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



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

The 'Ötztaler 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 Ötztaler Ache is mainly colonised by organisms which are adapted to the special conditions of mountain streams such as different species of algae, fish and macrozoobenthos.

Low flow velocities and reduced turbidity and bedload mobility characterize the 'Ötztaler Ache' during winter. 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 'Ötztaler Ache' have to deal with an enormous selection pressure due to the extreme conditions. Therefore the number of species is quite low. Mostly there are river trouts (*Salmo trutta fario*) in the water body, at the mouth of the river even graylings (*Thymallus thymallus*) and some bullheads (*Cottus gobbio*). Additionally, alien species such as rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) were released into some parts of the river.

Excerpt from: "Klima, Wetter, Gletscher im Wandel";
Chapter 6: "Die Ötztaler Ache – Die Lebewelt der Ötztaler Ache" by Daniel Erhart

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