
Guide lines for monitoring

Spring temperature and water chemistry

Definitions

Spring temperature is defined as the temperature of the water measured (°C) directly at the spring.

Water chemistry describes the chemical composition (amount of dissolved solids: anions, cations, elements, particularly heavy metals like Ni, As).

Relevant parameters

Spring temperature gives information about the thermal regime of the bedrock and/or debris. Water temperature (WT) depends on different parameters:

- Altitude
- Exposition
- Retention time
- Permafrost present or absent

In presence of permafrost, the negative heat flux coming up from the cold frozen subsurface/debris/rockglacier will cause extremely low WTs (typically less than 1 °C), whereas on non frozen soil, the WT will be much higher. Thus the WT may be a good indicator of permafrost occurrence and may help to discriminate permafrost from permafrost-free areas.

The following typical threshold values of WT were used as indicators :

- WT 0 - 1 °C : permafrost probable.
- WT 1 -2 °C : permafrost possible, uncertainty range.
- WT > 2 °C : permafrost unlikely.

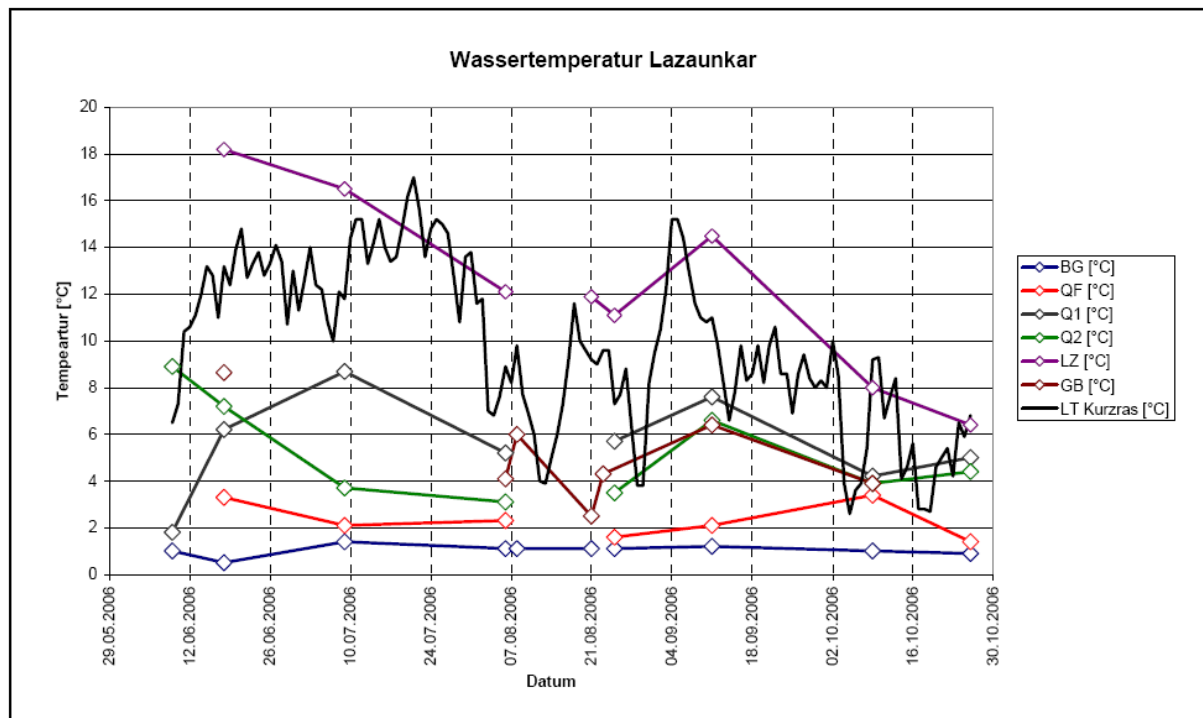


Fig. 1: Spring temperatures measured in the Lazaun Kar (Schnals Valley, South Tyrol). BG=Rockglacier runoff, QF=Spring Tapping, Q1, Q2=Springs, LZ=Lazaun Lake, GB=Glacier Runoff, LT=Air Temperature Kurzras (Bressan, 2007).

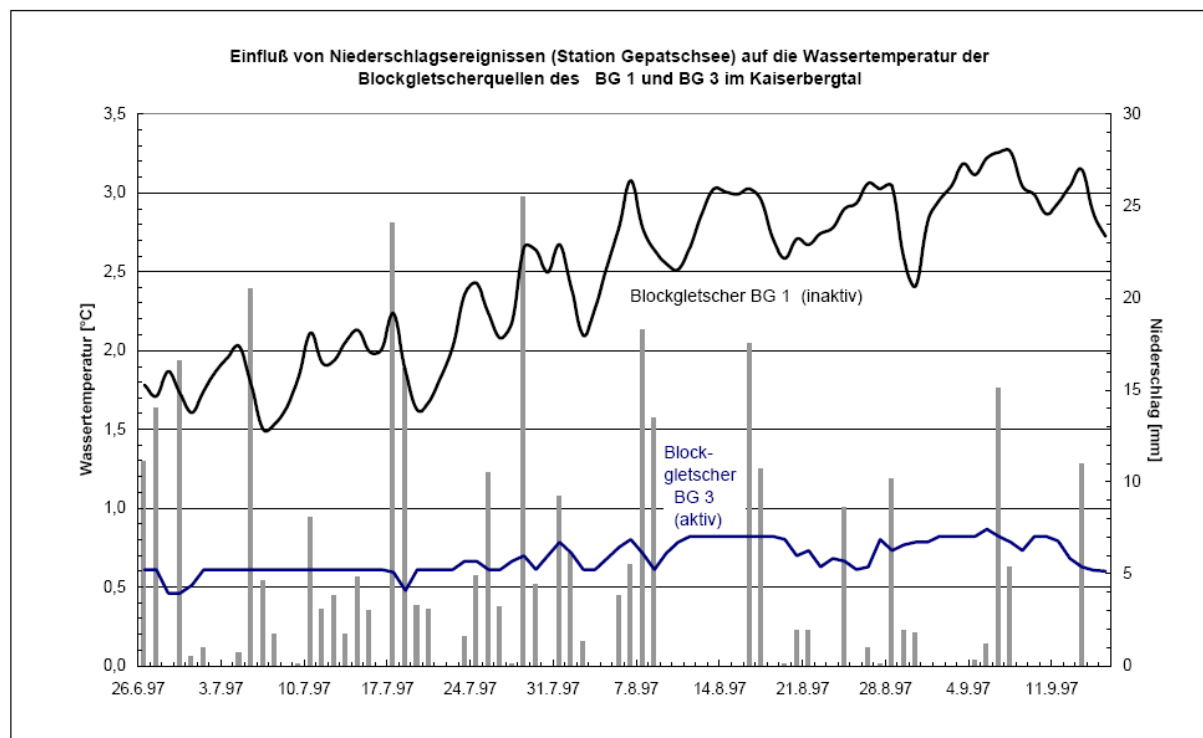


Fig. 2: Spring temperatures of an active and inactive rockglacier in the Kaiserbergvalley (Kaunertal, Tyrol) (BERGER 2002 und BERGER et al. 2004).

However, the WT is also influenced by local conditions (air temperature, precipitation, geology, etc.).

Water chemistry (WC) provides also information about the presence/absence of permafrost.

In alpine catchment areas physical and chemical weathering processes dominate. In the course of chemical weathering mainly soluble cations like Ca^{2+} , Mg^{2+} , K^+ , Na^+ , Al^{3+} and SiO_2 are released. Therefore the chemical composition and concentration depend on the geology of the bedrock, the underground constitution and retention time. Normally Ca^{2+} , Mg^{2+} , Na^+ and K^+ dominate, other elements are of minor importance (BRÖGLI 2001).

Over the past years, a substantial rise in solute concentration at some remote high mountain lakes in catchments of same metamorphic bedrock (gneiss, micaschists) in the European Alps has been observed (Thies et al. 2007). At Rasass See (2682 m, South Tyrol, Italy), electrical conductivity has increased by a factor of 18 (Fig. 1) and the concentrations of the most abundant ions magnesium, sulfate and calcium have reached the 68-fold, 26- and 18-fold values. At Schwarzsee above Sölden (2796 m, North Tyrol, Austria), electrical conductivity has increased by a factor of 3.

In addition to the increased values of major ions, very high nickel concentrations have been found recently at Rasass See (i.e. $243 \mu\text{g L}^{-1}$), which exceed the nickel limit for drinking water by more than one order of magnitude. The pronounced change in lake water chemistry is attributed to the solute release from rock glaciers in both lake catchments, which has intensified as a response to the recent increase in air temperature in the Alps. Glacial melt water draining into the lakes has caused solute concentrations to increase since the 1990s, while direct anthropogenic impacts, bedrock weathering and current atmospheric deposition as source for enhanced ion and metal values are considered to be negligible for both high alpine sites.

The observed larger solute increase at Rasass See is attributed to a greater impact of glacial melt water from a larger size rock glacier, situated at a lower elevation. In addition, lake volume and estimated annual water residence time of Rasass See are four to five times smaller compared to Schwarzsee ob Sölden.

High mountain freshwaters may become increasingly impacted by melt waters from active rock glaciers, which are widespread in cold-climate mountain regions around the globe and are located near the local boundary of permafrost, thus being sensitive to ongoing and anticipated future climate warming (cf. IPCC 2007).

Measurement techniques

Water temperature is measured during summer with special temperature logger or a simple thermometer.

At present we use the following measurement techniques:

- Installation of automatic storage temperature logger (optic stow away temperature logger from Onset Computer Corporations, USA). Accuracy of measurement is $\pm 0,2^\circ\text{C}$. Price: ca. 120 € ;
- Temperature logger in a water gauging station positioned in the rockglacier runoff



Fig. 3: Gauging station.



Fig. 4: Micro from Logotronic (measures pressure and water temperature in the gauging station).



Fig. 5 : Optic stow away temperature logger from Onset Computer Corporations, USA.

Water chemistry

Rockglacier runoff is mostly punctiform or in the form of a line on the rockglacier front. Rockglacier runoff and different springs were sampled.

The electrical conductivity ($\mu\text{S}/\text{cm}$), which is measured in the field with a handheld conductivity meter, allows to estimate the amount of dissolved solids.

Water samples were taken in 250 ml PET bottles and analysed via atom adsorption spectrometry by the Institute for Mineralogy and Petrography, University of Innsbruck (Bressan, 2007).

Measurement strategies

Temperature monitoring over at least one hydrological year (measuring interval 1 or 2 hours) of rockglacier springs or springs at the foot of frozen debris can be used for detecting the presence of permafrost.

Collection of data over longer periods provides more reliable data than punctual measurements.

This is also valid for the monitoring of water chemistry (sampling over at least one hydrological year with a sampling interval of one month or less).

References

- Bressan, D. (2007) – Aufbau und Dynamik aktiver Blockgletscher am Beispiel der Lazaunalm (Ötztaler Alpen / Südtirol), Unpubl. Diplomarbeit, Inst. für Geologie und Paläontologie, LFU Innsbruck, 198p.
- IPCC (2007) - Intergovernmental Panel on Climate Change. Climate change 2007: The physical science basis. Solomon S. et al. (eds.), Cambridge University Press.
- Thies, H., Nickus, U., Mair, V., Tessadri, R. Tait, D., Thaler, B. & Psenner, R. (2007) - Unexpected response of high alpine lake waters to climate warming. *Environmental Science and Technology* **41**: 7424-7429.