Only superficial cooling for the permafrost in Switzerland

In the hydrological year 2021, the long-term permafrost measurements in the Swiss Alps show a different picture depending on the depth: The cooler weather conditions led to a decrease in temperatures near the surface as well as a deceleration of the rock glaciers. At depth, however, the warming trend observed over the past two decades continued. This is reported by the Swiss permafrost monitoring network PERMOS.

The hydrological year 2021 (October 2020-September 2021) was the coldest in Switzerland since 2013. It was characterized by a long-lasting snow cover, the coldest spring in the last 30 years, and the wettest summer since measurements began in 1864. At high elevations in the permafrost areas, snow already fell in October 2020 and heavy snowfall well into spring 2021 delayed snowmelt.

Slight cooling at the surface

As a result of these weather conditions, the mean annual ground surface temperature in the hydrological year 2021 decreased at most sites by about 1°C compared to the previous year, thus lying below the 20-year average. Rock glaciers (downhill moving ice-bearing debris masses whose velocity is an indirect measure of permafrost temperature) also decelerated by about 8.5% compared to the previous year.

The active layer thickness - the ground layer between the surface and the actual permafrost that thaws in summer - and the permafrost temperatures at 10 m depth showed a heterogeneous picture. At the borehole sites Gentianes (VS) and Schilthorn (BE), the active layer was thicker than ever before, while at many other sites it was shallower than in the previous year. Similarly, permafrost temperatures at 10 m depth were higher or lower than in hydrological year 2020, depending on the site.

Continued warming at depth

At greater depths, however, the general warming of the past 20 years continued. Permafrost temperatures at 20 m depth increased compared to the previous year at all sites and in some places reached the highest values since measurements began 15 to 20 years ago. At these depths, temperatures are subject to little annual variation and the changes reflect the long-term evolution of the climate. The surface cooling of the hydrological year 2021 did not (yet) reached these depths. At the Stockhorn near Zermatt (VS), the average permafrost temperature at 20 m depth in hydrological year 2021 was -2.1 °C, whereas 20 years ago it was -2.6 °C. A similar warming occurred at the Murtèl-Corvatsch rock glacier in the Upper Engadine. Here, -1.1 °C was measured at 20 m depth in 2021, compared to -1.6 °C in the hydrological year 2001 and -1.8 °C at the beginning of the measurements in 1988.

In summary, the results of the Swiss permafrost monitoring network for the hydrological year 2021 show that the warming trend of permafrost at depth continues despite a slight cooling near the surface. This is the result of persistently warm conditions in recent decades.

Electrical resistivity measurements at Stockhorn (VS, 3'400 m asl.). Picture: C. Mollaret

PERMOS

The Swiss Permafrost Monitoring Network PERMOS has been documenting the state and changes of permafrost in the Swiss Alps since 2000. It is currently financed by MeteoSwiss within the framework of GCOS Switzerland, by the Federal Office for the Environment (FOEN) and by the Swiss Academy of Sciences (SCNAT). It draws on the expertise of six Swiss research institutions: The Universities of Lausanne, Fribourg and Zurich, the ETH Zurich, the University of Applied Sciences of Italian-speaking Switzerland (SUPSI) and the WSL Institute for Snow and Avalanche Research SLF. Measurements within PERMOS focus on three main elements: 1. ground temperatures near the surface and at depth, 2. changes in ice content and 3. permafrost creep velocities.

Permafrost

Permafrost is a thermal phenomenon defined as earth material (i.e. rock, debris) that remains below 0°C for at least two consecutive years. In Switzerland, it covers around 5% of the territory and is typically found in cold talus slopes and rock faces above about 2'500 m asl. The occurrence and evolution of permafrost are primarily driven by the ground surface temperature which in turn is strongly influenced by the air temperature, the solar radiation and the onset and duration of the snow cover. Rock glaciers are landforms indicative of the presence of permafrost. They consist of a mixture of loose material (i.e. rock debris) and ice that moves downhill and are recognizable in the landscape by their tongue-like shape.

More information and illustrations: http://permos.ch/MM2022/permafrost2021.html

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