



## State of permafrost in the Swiss Alps in 2023

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Permafrost is classified as an essential climatic variable (ECV) by the Global Climate Observing System (GCOS) because of its sensitivity to changes in climatic conditions. The Swiss Permafrost Monitoring Network PERMOS documents the state and changes of permafrost conditions in the Swiss Alps since 2000 based on long-term field measurements. To account for the heterogeneous distribution and characteristics of mountain permafrost, PERMOS developed and implemented a comprehensive monitoring strategy, which relies on three complementary observation elements: (1) ground temperatures near the surface and at depth, (2) permafrost electrical resistivity to determine changes in ground ice content, and (3) rock glacier velocities, which can be used as a proxy to assess the permafrost thermal regime.

In this contribution, we discuss permafrost conditions in the Swiss Alps during the hydrological year 2023 with respect to the observations of the past two decades. Combining results from the three observation elements, we analyse the short and long-term responses of permafrost to climate evolution. The hydrological years 2022 and 2023 were characterized by two consecutive winters with below average snow heights and two summers ranked second and fifth warmest on record since 1864. These weather and climate conditions lead to different permafrost evolutions at different depth levels and at different sites. While ground surface temperatures and active layer thicknesses at or close to record values were registered, a slight decrease of the permafrost temperatures was observed at 10 and 20 m depth, which is consistent with the decreasing rock glacier velocity and increasing permafrost resistivity observations. The permafrost conditions observed in 2023 constitute short term variations likely not affecting the long-term trend of warming and degrading permafrost consistently observed in the Swiss Alps for the past two decades.

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