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# Permafrost station at Sommeiller Pass (NW Italy): from the monitoring to reference site and methods

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## Abstract

The Sommeiller Pass permafrost monitoring station, at about 3000 m of altitude, is the key site of the regional network installed in 2009 during the European Project *PermaNET* in the Piedmont Alps (NW Italy). The station consists of 3 vertical boreholes 5, 10 and 100 m deep with different characteristics, equipped with thermometric chains for a total of 34 Pt100 sensors. Due to infiltration and freezing of water inside the instrumentation and boreholes, the station became operational in 2011 after recovering. The collected data shows a constant active layer 8-9 m of thickness, while the permafrost temperature curves show a degradation of the base at approximately 65 m of depth since 2014. In order to verify this variation (about 0.4 °C), considering the station history, a sensor calibration was carried out in laboratory and on site aimed to understand the reliability of the measurements in progress.

**Keywords:** permafrost monitoring, sensor calibration, reference methods, reference site

## Introduction

Up to about 10 years ago, knowledge on permafrost in the Piedmont Alps was rather poor, limited to a few localized rock glacier studies in the Maritime Alps. Since 2006, ARPA Piemonte, in collaboration with the Insubria University, started a regional study aimed to improve knowledge on relations among alpine permafrost and climate change, natural hazards and water resources. These activities increased during the European project *PermaNET - Long-term monitoring network* (2008-2011) [1], thanks to which 5 permafrost monitoring stations were established in the Piedmont Alps, from 2,500 m to more than 3,000 m of altitude, including the Sommeiller Pass station. Since 2009, the activity on "Permafrost Monitoring" has became an institutional service of ARPA Piemonte, allowing the maintenance and implementation of the study and monitoring of the permafrost and periglacial environment in Piedmont Alps [2].

## Permafrost monitoring station of the Sommeiller Pass

*Site characterization*

The Sommeiller permafrost monitoring station is the key site of the regional network, located at about 3,000 m a.s.l. in high Susa Valley (NW Italy), near the France border. The station consists of 3 boreholes 5, 10 and 100 m deep vertically drilled in the bedrock, a few meters from each other, equipped with Pt100 thermometric chains (Pt107 Campbell Sci.). The 5 m borehole is equipped with two sensors placed directly in the uncovered hole filled with cuttings. The 10 m and 100 m boreholes are equipped with 12 and 20 sensors respectively, placed in both cases in a ∅50 mm HDPE tube. The 100 m borehole is equipped with a metal covering for the first 10 m due to drilling problems, with head buried under about 70 cm of debris. Data are collected in the datalogger (CR1000 Campbell Sci.) and manually downloaded once a year.

In addition, a weather station equipped with thermo-hygrometer and nivometer has been installed in the same site. Since 2009, the site was also subjected to other surveys such as geoelectric and Bottom Temperature of the Snow (BTS) measures.

*The history of the station*

The station was initially planned completely underground to reduce environmental impact, vandalism and lightning events. In 2009, data loggers and batteries were placed in metal and concrete manholes and the head of boreholes in plastic manholes, all below ground surface. Unfortunately, water infiltrations flooded the manholes and boreholes, damaging dataloggers irreparably and blocking the thermistor chains in the ice.

Therefore, in 2011 a recovering station has been completed with datalogger, solar system and head of boreholes raised above ground surface. The ice-locked thermometers in the boreholes have been released through a hot water recirculation system and boreholes emptied from the water with high-pressure air.

*Preliminary data*

The available dataset covers the period summer 2011-summer 2017, with valid elaboration for the years 2012 to 2016, for only 32 sensors in boreholes 10 and 100 m deep (the 2 sensors in the 5 m deep borehole were activated in summer 2017).

From the elaborations it is noted that the active layer and the Zero Annual Amplitude (ZAA) are approximately constant respectively 8-9 m thick and about 13-14 m deep. The thermal state of permafrost indicates temperature close to 0 °C with a few tenths of degrees in the negative temperature range. Permafrost conditions were present at least for 100 m of depth until 2013. Since 2014, a positive temperature transition (+ 0.2 °C) has occurred at about 65 m of depth indicating a degradation of the permafrost base.

*Sensor calibration activity*

In the framework of EURAMET project MeteoMet [3,4], an in-situ calibration campaign was planned in 2016, in cooperation with Istituto Nazionale di Ricerca Metrologica (INRiM), for the permafrost temperature sensors hosted at the Sommeiller station. The campaign was carried out in a week in August 2017, when reference temperature sensors, along with a thermostatic bath, a high-accuracy readout bridge, two power generators and a light shelter were brought to the site (Fig. 1).

Figure 1 - The mobile calibration facility at Sommeiller Pass during the 2017 campaign.

Thirteen out of the 34 total sensors were calibrated in the alcohol-powered thermostatic baths at 5 temperature points close to the freezing point of water (-7 °C, -3 °C, 0 °C, +3 °C, +7 °C and repeated 0 °C calibration to check for stability-hysteresis), in order to maximize the calibration accuracy in the temperature range most important for permafrost studies and minimize the interpolation uncertainties.

## Towards reference methods and reference site

In February 2017, a workshop was held within the activities of the MeteoMet project. Among the topics, permafrost temperature measurements methods and accuracy, high mountains climate research sites, metrology for the cryosphere, reference grade measurements for glaciology were discussed.

The workshop underlined the need to discuss and agree on common approach, best practice and uncertainty evaluation on the numerous measurements made in glacial and periglacial areas, including methods to measure permafrost temperature profiles. Together with the experience achieved during the calibration campaign at the Sommeiller pass, and the issues encountered during laboratory calibration of different typologies of thermometers, the need is now fully defined and studies can be started towards definition of reference methods and reference observation sites. This initiative is expected to also benefit the GCW[1] station network, due to the primary interest of WMO[2] initiatives and GCOS[3] networks [5], towards measurement traceability and comparability and for identifying reference sites from baseline networks.

## References

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