Snowpack Evolution On Permafrost, Non-Permafrost Soils And Glacier In The Monte Rosa Massif (NW Alps, Italy)

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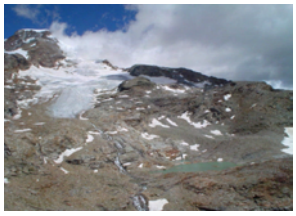
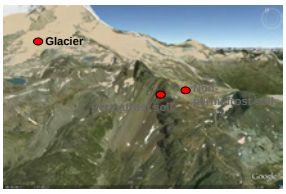
Snow cover evolution is governed by several variables, such as meteorological factors, local topography and snow characteristics. Different types of substrata might present different surface temperatures, influencing therefore the temperature gradient within the snowpack and its evolution.

In non-permafrost soils, a thick early winter snow cover maintains soil temperature close to 0 °C, independently from air temperature. In permafrost soils, beneath at least a 1m cover of snow, the ground temperature during February and March is below - 2 to - 3 °C. For glaciers, less literature exist, with some researches that reported an interface temperature between snow and ice of about - 5 °C.



The aim of this study is to follow the evolution of the snow cover on three different substrata (permafrost, non-permafrost soils and glacier) in the Monte Rosa Massif on the Italian NW Alps.



Study area

The three study sites are located in the area of the Monte Rosa Massif in the North-Western Italian Alps. The permafrost site is at an elevation of 2910 m asl on a North-West oriented slope of about 10° of inclination; the non-permafrost site is placed at an elevation of 2900 m asl, on horizontal terrain; the glacier site is located on the Indren glacier at an elevation of 3400 m asl, with a South-West aspect and about 10° of inclination.

Nivometeorological data

Snow pits were dug periodically, according to the accessibility of the sites, from December 2006 to July 2007: 9 surveys at the permafrost site, 8 surveys at the non-permafrost site, and 6 at the glacier one. Snow temperature was measured every 10 cm with 10-cm long dial stem thermometers. Snow density measurements were made using a 0.5-L stainless steel core in each layer of the snowpack, where also grain type and dimension were recorded. Continuous measurements of the temperature at the interface between snow and the three different substrata have been made through data-loggers (UTL-1).

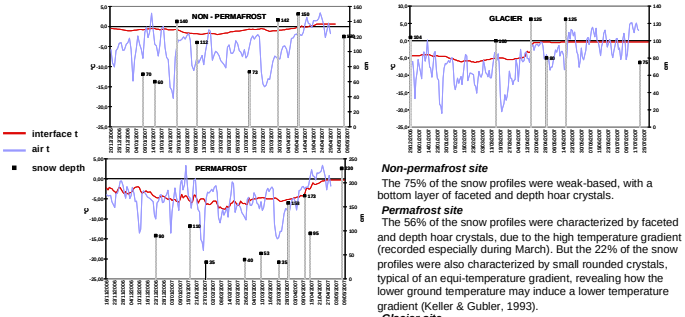
Meteorological data in the area, such as wind speed and direction, air temperature and humidity, were registered by an automatic station of the Italian Army (Comando Truppe Alpine-Servizio Meteomont) located at 2901 m asl near the three sites.

The characteristics of the snow cover above the three different substrata are summarized in the Table below.

Table Snow cover characteristics for the three sites. Except for snow depth and the snow/substratum interface temperature, the other parameters are average values computed on data from manual snow profiles (N = 8 at non-permafrost site, N = 9 at permafrost site, N = 6 at glacier site).

Parameter		Non-permafrost	Permafrost	Glacier
Max snow depth	cm	180	230	125
Grain type in bottom layer of snowpack		5a, 4a	5a, 4a, 3a	4c
Maximum grain size in bottom layer	mm	2.4	1.8	1.7
Hand hardness index in bottom layer		1.8	2.2	5.0
Snow/substratum interface temperature*	°C	- 0.9	- 5.1	- 4.8
Temperature gradient within the snowpack	°C/m	- 6.5	- 7.4	- 2.1
Density	Mg/m^3	0.305	0.273	0.389
Effective heat conductivity	W/mK	0.131	0.116	0.257

* average values computed on data recorded by data-loggers (12/29/2006 – 04/20/2007).



Non-permafrost site

The 75% of the snow profiles were weak-based, with a bottom layer of faceted and depth hoar crystals.

Permafrost site

The 56% of the snow profiles were characterized by faceted and depth hoar crystals, due to the high temperature gradient (recorded especially during March). But the 22% of the snow profiles were also characterized by small rounded crystals, typical of an equi-temperature gradient, revealing how the lower ground temperature may induce a lower temperature gradient (Keller & Gubler, 1993).

Glacier site

Except for the last snow profile, the snow cover was characterized by a bottom layer of faceted crystals, often well bonded together. The snow hardness was very high (level 5), higher than in the other sites.

Our results shows that the main differences in the evolution of the snow cover on permafrost, non-permafrost and glacier substrata are related to hand hardness in the bottom layer (higher on glacier), snow/substrata interface temperature (higher on non-permafrost soil) and temperature gradient (lower on glacier). Moreover, an important out-coming of this work is that the temperature at the snow/substrata interface remains constant around certain values, when enough snow covers the substrata, showing the important insulating effect of the snow.

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