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Thermal regime of an alpine talus slope

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In mountain areas, the permafrost is largely discontinuous. The modelling of its extension requires the identification and the comprehension of the different factors which control the ground thermal regime. Located in the west flank of the Mont Gelé (Valais Alps, Switzerland, 3023 m a.s.l.), between 2600 and 2800 m a.s.l. (MAAT about -1°C), Les Attelas talus slope has been investigated since 2001. According to direct observations (borehole drilling) and to a large set of geoelectrical and thermal data (ground surface and borehole measurements), permafrost is present in the lower half of the slope. This configuration is common in mountain talus slopes (Lambiel and Pieracci, 2008).

Mean annual ground surface temperature (MAGST) recorded downslope by two loggers between 2001 and 2007 is about +0.3°C. Temperatures increase upslope, where MAGST can reach +4°C in some places. Summer ground surface temperatures are rather homogeneous all over the landform. The lower part of the slope is not especially colder than the upper part. Places located downslope are even warmer than places located some tens of meters higher. The warmest temperatures are generally measured where fine-grained sediment is present, but there is no clear relationship between the coarseness of the blocs and the summer temperatures. In winter, the ground surface temperatures are clearly correlated with the altitude: a strong cooling occurs downslope (equilibrium temperatures are often around -5°C), whereas temperatures remain close to 0°C upslope. The data shows that the granulometry does not have a strong influence on the winter ground temperatures.

The good correspondence between the highest electrical resistivities and the coldest winter ground surface temperatures indicates that the cooling occurring in the lower part of the slope in winter is probably the cause of the presence of permafrost in this sector. The repeated passage of skiers in this area may increase the thermal conductivity of the snow, which may slightly cool down the ground. However, it is probably not sufficient to provoke such a thermal contrast between up- and downslope. The chimney effect is known to be a key controlling factor for the ground overcooling in low elevation talus slopes (Delaloye et al. 2003). In Les Attelas, data in the upper part of the slope shows that winter cold spells provoke regularly a warming of the ground, while the warm periods of the winter are often accompanied by a ground cooling. In the lower part of the slope however, there is no evidence of ground overcooling by aspiration of cold outside air through the snow cover. Thus, a slight chimney effect seems to work, even if its strength is limited. This is probably due to the presence of ice-saturated sediments below 3.5 – 5 m deep (borehole data), which confine the mechanism to the active layer. However, the mechanism is probably sufficiently effective to cause a lateral cooling (air advection) by the movement of warm air upslope. This would explain the cold temperatures measured downslope.

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