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Snow control on active layer and permafrost in steep alpine rock walls (Aiguille du Midi, 3842 m a.s.l, Mont Blanc massif)

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Permafrost degradation through the thickening of the active layer and the rising temperature at depth is a crucial process of rock wall stability. The ongoing increase in rock falls observed during hot periods in mid-latitude mountain ranges is regarded as a result of permafrost degradation. However, the short-term thermal dynamics of alpine rock walls are misunderstood since they result of complex processes related to the interaction of local climate variables, heterogeneous snow cover and heat transfers. As a consequence steady-state and long-term changes that can be approached with simpler process mainly related to air temperature, solar radiations and heat conduction were the most common dynamics to be studied so far.

The effect of snow on the bedrock surface temperature is increasingly investigated and has already been demonstrated to be an essential factor of permafrost distribution. Nevertheless, its effect on the year-to-year changes of the active layer thickness and of the permafrost temperature in steep alpine bedrock has not been investigated yet, partly due to the lack of appropriate data.

We explore the role of snow accumulations on the active layer and permafrost thermal regime of steep rock walls of a high-elevated site, the Aiguille du Midi (AdM, 3842 m a.s.l, Mont Blanc massif, Western European Alps) by mean of a multi-methods approach. We first analyse six years of temperature records in three 10-m-deep boreholes. Then we describe the snow accumulation patterns on two rock faces by means of automatically processed camera records. Finally, sensitivity analyses of the active layer thickness and permafrost temperature towards timing and magnitude of snow accumulations are performed using the numerical permafrost model CryoGrid 3. The energy balance module is forced with local meteorological measurements on the AdM S face and validated with surface temperature measurements at the weather station location. The heat conduction scheme is calibrated with the temperature measurements in the S-exposed borehole. Results show that the snow may be responsible for permafrost presence while it is absent in the surrounding snow free bedrock. The long lasting of the snow at high elevation, where it can remain until the mid-summer has a delaying effect on the seasonal thaw, which contributes to the lowering of the active layer thickness.