Remote Sensing Modelling and Visualization of the Permafrost Distribution in the Hautes Alpes Calcaires (Western Switzerland)

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Small Scale permafrost repartition models are often constructed with empirical methods based on the observation of regional lower permafrost limits. In this contribution geomorphologic units are derived from analysis and interpretation high-resolution aerial photographs. A classification of satellite images considering these units is then performed to model permafrost distribution.

Based on properties of exposition, slope and topography, three permafrost-related geomorphological landforms were observed: an active rock glacier, a moraine with gelifluction lobes and the lowest part of a high altitude talus slope. The first two landforms are characterized by discontinuous permafrost occurrence; talus slopes close to the lower limit of alpine discontinuous permafrost are characterized by important ice amounts at the bottom (Lambiel 2006). These three geomorphologic landforms are easy to detect by high-resolution aerial photographs: validation of the areas has been made directly on field by geomorphologic cartography in the highest part of the Vallon de Nant (Phillips, 1993).

These units with potential presence of permafrost were identified on an ASTER high-resolution satellite image to analyse their spectral signature. Spectral signatures presented in figure 1 are similar, but still present some fluctuations. The fact that landform units could present a variety of reflectance profiles makes difficult to build a unique signature for permafrost distribution. Hence a combination of signatures is chosen for the classification.

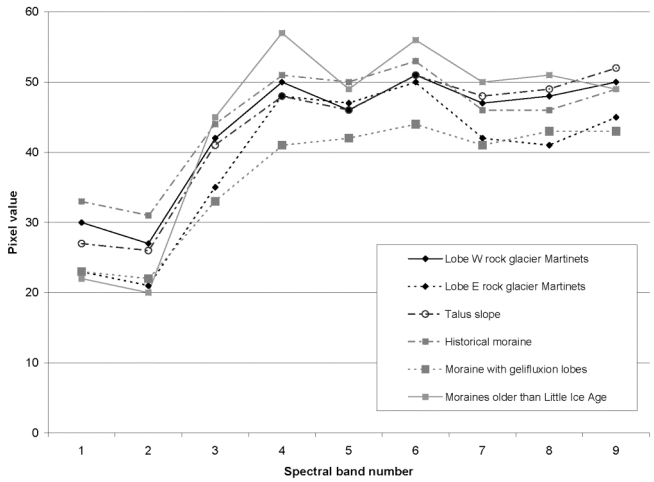

Figure 1. Spectral profiles for permafrost- and glacier-related landforms in the high region of the Vallon de Nant.

A supervised classification is applied to the ASTER image using the maximum likelihood criteria. The three potential units for permafrost-related geomorphologic landforms were grouped into a single signature of permafrost for the region of the Hautes Alpes Calcaires (VD). For the classification, eight classes have been defined: permafrost (based on the combination of the signatures described), glaciers, moraines (younger than the Little Ice Age), alpine grassland, clouds, forests, rocks and shades. Error matrix for the classification model showed consistency of the approach, with 95 % of the pixels being classified correctly. Figure 2 shows the results for the class permafrost. Comparison of results with an empirical topoclimatic model within the region showed the relevancy of the method developed (Scapozza et al. 2006).

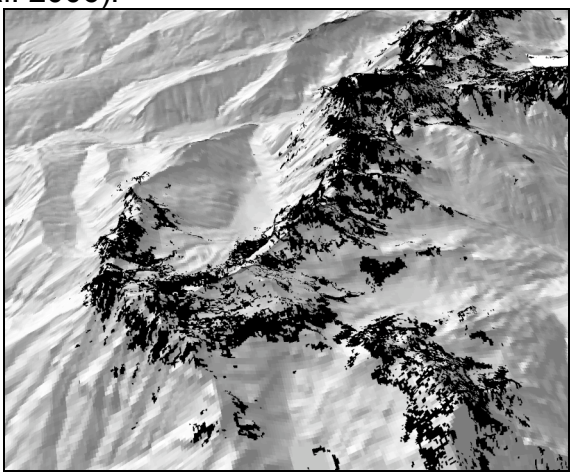

Figure 2. Remote sensing classification of discontinuous permafrost potential distribution in the Hautes Alpes Calcaires (VD – Switzerland).

In this paper, aerial photographs have been used to define permafrost-related geomorphologic areas, used afterwards to construct a mixed operative spectral signature of potential permafrost: the application showed that remote sensing classification reveals discontinuities in permafrost distribution that cannot be underlined with empiric models.
In future, it will be important to perform a quantitative comparison between remote sensing model and other classical models for permafrost distribution: for instance the GIS application PERMAMAP developed by Martin Hoelzle and based on a statistical relation between direct sun radiation and the mean annual air temperature. It will be also important to apply the method developed in a region characterised by different climatic and structural conditions. A test in the Mont Gélé area (VS) is ongoing.

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