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Analysis and mapping of mountain permafrost data: a comparison between two machine learning algorithms

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Within the Alps, knowledge on mountain permafrost characteristics (thermal state and related processes) and distribution has significantly increased within the last 15 years thanks to many field studies and monitoring projects. They reveal the complexity of mountain permafrost, both in term of spatial repartition and sensitivity to current warming. This can be illustrated by the situation in talus slopes, where permafrost is only present in the lower part of the landform in reason of a reversible mechanism of air advection that leads to negative thermal anomalies downslope and to positive ones upslope.

Moreover, performances of existing equilibrium models are optimal basically only at a local or regional scale. At the micro scale, the nonlinear interrelationship that exists between the climatic components and the terrain surface/subsurface properties controlling the occurrence of permafrost is not well considered by this type of models. We often need to appeal to physical models, which are sometimes difficult to calibrate, often require heavy computational power to run and become increasingly complex as the amounts of empirical data grow.

By disposing of a large amount of spatial data, the application of robust and nonlinear algorithms is possible. In the present study, we investigate the potential of two classification algorithms that belong to machine learning (ML) domain: Random Forest (RF) and Support Vector Machines (SVM). With ML algorithms, functional dependencies are derived directly from data (a dataset of thousands of field observations and topo-climatic data). With this approach data speak for themselves and there is any need to appeal to physical models. The RF algorithm has recently gained a great popularity and also provides a weight of the contribution of each variable. This measure can be used to detect and display the main factors affecting the studied phenomenon. The SVM has proven to be efficient in past permafrost distribution modelling attempts, producing results less optimistic than other simple topo-climatic model simulations (and more consistent with the field reality).

The present research deals with the analysis and mapping of alpine permafrost patterns at the micro-scale for data gathered in the Western part of the Alps (Valais, Switzerland). An input dataset was constructed using local topographic variables derived from a digital elevation model, geology, climate data, etc. The permafrost data were taken from rock glacier inventories and completed by the geophysical and thermal data collected during the field campaigns. As poor permafrost evidences are available for rockwalls, we mainly focused the prediction in loose sediments. A comparison between RF and SVM algorithms will be presented as well as the classification results (distribution maps) along with corresponding model uncertainties.