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Slope instabilities monitoring in mountain periglacial environment using DInSAR - Application to the Valais Alps

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Permafrost is a widespread phenomenon in the Alps concerning about 5% of Switzerland and obviously much more of the Valais Alps. The lower limit of the discontinuous permafrost is estimated in the Valais Alps region at about 2400 m a.s.l. in north-facing slopes and 2700 m a.s.l. in southern expositions. Sporadic permafrost may occur at lower elevation in shaded locations and blocky terrain. Loose sediments (talus slopes, moraines, rock glaciers, etc.) as well as rock walls may be affected by permafrost. All unconsolidated terrains (with or without permafrost) are susceptible to move typically with an order of magnitude ranging from millimeter to several meters per year. According to recent studies, ground warming in the 20th century seems to have generated an acceleration of slope movements related to the creep of permafrost (for instance rock glaciers), particularly since the end of the 1980s. Consequently, an increase of potential natural hazard for people and infrastructures cannot be excluded and requires the knowledge of the regional overview of slope instabilities.

Differential SAR interferometry (DInSAR) has proven its capability for mapping different kinds of surface deformations such as tectonic and volcanic activities, land subsidence, ice sheet and glacier movement, and landslides. The potential of DInSAR for detecting slope motion in a periglacial mountain environment has already been tested in different parts of the Swiss Alps. Analysis of DInSAR data allows the systematic detection of mass wasting phenomena in mountain areas. Compared to classical geodetic techniques - such as GPS - InSAR provides advantages in terms of costs, coverage, data accessibility, as well as availability of data archives. InSAR data seems to be the solution for the systematic detection and monitoring of slope instabilities in the periglacial environment. However, referring to landslide phenomena, the application of DInSAR techniques is a relatively new and still challenging topic. Only isolated cases of successful applications of DInSAR for landslides studies have been achieved and the confident use of this technique requires validation.

This study provides an overview of the DInSAR technique to understand the potentialities and the limitations of its applicability to landslide monitoring in mountain periglacial environment. Our region of interest is located in the periglacial belt of the Valais Alps (extended to the area located above the tree line and below the snow line) and is constituted of 23 test sites surveyed by GPS measurements. Firstly the study presents the validation of DInSAR data to monitor landforms in terms of reliability and repeatability of the technique. DInSAR potential is here investigated by the mean of a new indicator defined as a reliability map allowing to properly characterize DInSAR data for further investigations at specific scale of analysis. Then, some validations for monitoring velocity are done by comparing GPS measurements and DInSAR data from 2008 to 2010. This second part gives first elements to conclude on the performance on DInSAR technique using Terrasar-X data* to monitor slope instabilities in the periglacial environment of the Valais Alps.

* TERRASAR-X data courtesy LAN0411 (c) DLR, DHM25 (c) 2003 swisstopo