

## EARLY WARNING SYSTEM WITH INTERFEROMETRIC SYNTHETIC APERTURE RADAR

### NEW METHODS IN THE SWISS LANDSLIDE MANAGEMENT

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Natural hazards with high intensity processes are frequent in the Swiss Alps due to the relief energy. This concerns mainly rockfalls, landslides, debris flows, floods and snow avalanches. All of the alpine valleys are threatened by at least one of the mentioned processes. In the molasse region, the so called plateau, there are also natural hazards. The importance of mass movements is lower than in the alps, but the potential damage due to large floods is very high. For floods and other hydrologic themes Switzerland has started a century ago to monitor water parameters such as the level of lakes and rivers, the discharge, the sediment transport. For meteorological parameters the longest official series in Switzerland are starting in the middle of the 19<sup>th</sup> century. For landslides there was no national strategy in the past. Just some of the active or dangerous landslides or rockslides were monitored by local systems (e.g. crackmeters, geodetic measurements). It appears that a national strategy on the general monitoring of landslides is necessary nowadays, independently of the impacts of climate change. The Swiss Federal Office for the Environment, FOEN, is managing the prevention for natural hazards according to the national laws on forest and hydraulic engineering. They entered into force in 1991. Actually, the FOEN is preparing the guidelines for the management of mass movements (landslides, rockfalls, rock avalanches, debris flows) which define the principles of hazard mapping and the minimal requirements (Raetzo & Loup, in preparation (2011)). It is the main objective of the guidelines to prevent landslide damages and to warn the population as soon as possible. In the year of 1994 the landslide of Falli Hölli destroyed 41 houses and caused some 20 millions of Euros of damages. The village is dislocated now. Before the catastrophic acceleration of Falli Hölli no measurements were taken and nobody identified the acceleration in the upper part of the landslide. Some years later we recognised the precursory signs in remote sensing data, especially in satellite radar data of the year 1993. Due to the necessity to monitor landslides on a large scale for the prevention activities and to create inventories, the FOEN started a collaboration with the European Space Agency ESA (TerraFirma Project), the Swiss Geological Survey, the Cantons and private partners. Remote Sensing techniques are used to identify landslides and to assess them. Geological and topographic maps and digital elevation models are important basic information. The mapping of the extension and the assessment of the activity is mainly done by satellite data using the interferometric synthetic aperture radar technique (INSAR).

For the last years Interferometric Synthetic Aperture Radar INSAR data of the ERS-1/2, ENVISAT, JERS, ALOS, Cosmo-SkyMed and TerraSAR-X satellites has been used to systematically detect mass movements in the Swiss Alps. Large inventories containing a total amount of more 3000 moving objects (landslides, rock glaciers, solifluction, debris deformations) are actually in the Geodatabase. One of the attributes in the GIS database is the velocity field: the structure defines classes such as 0-2 cm/y, 2-10 cm/y, 10-50 cm/y and so on. INSAR and Persistent scatterer Interferometry (PSI) have evidenced that more than 20 rock glaciers or landslides were affected by rapid movement reaching

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several meters per year. Some hundred other masses are moving with several decimeters per year. But most of the landslides are slow masses with some millimetres or centimetres of displacement per year. Rockfalls and debris flows are starting in zones with steep slopes. Most of these instabilities are just on the slope, but bigger events are reaching the valleys where they may affect settlements and transportation infrastructure (deposit zones).

In response to the increase in air temperature that occurred since the 1980s, permafrost has warmed by about 0.5 to 1°C and some rockglaciers are moving faster. The rate of sediment supply is thus changing, potentially increasing the frequency and magnitude rate of debris flow activity in the downward connected torrents. It is hence important to detect the activity rate of rock glaciers located in inhabited mountain areas above torrential gullies that may directly or indirectly endanger human activities or infrastructures. In the framework of the European Alpine Space activities, large permafrost areas of the western part of the Swiss Alps were analyzed by satellite radar monitoring (Permanet project). The identification and assessment of landslides with the satellite based INSAR technique is ongoing and will take several years to cover the entire national territory. For some of the steep slopes terrestrial radar systems are used in addition for a higher spatial and temporal resolution. Such inventories contribute to the finer assessment of the ongoing changes in the Alps.

## **REFERENCES**

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