From mapping to monitoring: using ground based InSAR on slope instabilities

Lene Kristensen, PhD[1]; Lars Harald Blikra, PhD[1]; Carlo Rivolta[2]

INTRODUCTION

As a high relief country, Norway is affected by landslides of various types and scales. On a small scale, about 1000 rock falls or rockslides hit the road network every year; causing danger to people and blocking roads. On a large scale, the Åknes rockslide (up to 54 mil. m^3) located above a fjord, may fail and create a huge tsunami wave affecting seven municipalities and several thousand inhabitants and tourists along Storfjorden, Western Norway. The Norwegian Water Resources and Energy Directorate (NVE) has the national responsibility to prevent accidents related to landslides and avalanches (rock, debris, snow). The Section for Rockslide Management is responsible for monitoring and early warning for classified large high risk rockslides, but may also assist decision makers in evaluating other types of landslide hazards. The monitoring is focused on providing real time measurements of surface and subsurface deformation, as movement is the most critical parameter for evaluating stability and safety.

GROUND BASED INSAR FOR MONITORING SLOPE MOVEMENT

LiSALab ground based Interferometric Synthethic Aperture Radar (GB InSAR) systems from Ellegi has been used to map distributed displacement in both the large rock instabilities and on rockwalls prone to rock-falls. GB InSAR is an active remote sensing that allows detection of movement (changes in distance) on a sub millimetres level. It records reflection from natural surfaces, and is able to map movement in a large area mounted at safe distance to the slide area. The radar data is georeferenced from the rail position by transforming the radar data to map coordinates using a DEM. In some cases, our use of the system has evolved from primarily mapping areas of movement to a real time monitoring devise (Figure 1). Time series from selected point can be extracted and changes in movement can be analyzed, for example with respect to meteorology. A few examples are given to demonstrate this.

EXAMPLES: MAPPING AND MONITORING

The first example is at a road section in Sunndalsøra, where we identified and mapped a moving area (15 x 30 m) in the rock wall prior to a large rockfall using periodic InSAR scanning. Movement in the area was seen already a year before the event (about 5 mm) and increased to more than 9 mm the last 6 months before the rock-fall. After the rock-fall, measurements confirmed that the release area was stable. Similarly, after a rockfall at a camping site in Tafjord, we were able to confirm stable conditions in the release area. Such measurements are important for reopening the runout areas as they provide information to the geologist that cannnot be obtained by visual inspection. In these two instances, the data was processed offline, and stability assessments therefore delayed from the measurements.
In Romsdalen the high risk large rockslide Mannen has been monitored continuously with GB InSAR since 2010. The measurement has allowed us to outline the moving area and thus the slide scenario in detail. In 2014 during a periodic scan of a different part of the Mannen rockslide, a small area of

Figure 1: Photo of the GB InSAR system mounted on a mobile foundation.

fast movement was identified (Veslemannen, 150.000 m³) by offline processing. The velocity in Veslemannen was more than 100 times faster than the main part of the Mannen instability. The radar-system was then transformed from a mapping to a monitoring system with internet connection, online processing and time-series point analysis is the area of interest as well as alarms. During an acceleration following a heavy rainfall, movement of up to five cm/day were recorded. A similar transformation was done at another large instability in Flåm, where mapping campaigns and offline processing revealed a large block in movement (Figure 2). Now the movement is followed in detail online.

Websites have been set up for each system and allows for easy access and data analysis. The scan time and setting parmaters can be adjusted remotely to fit the rate of displacement - in this way we are able to follow movement up to 5-6 m/day. A custom made foundation and tent protects the system in most conditions, and we are able to install everything within an hour. With this design, it is possible to evaluate the stability conditions some few hours after establishing the system.

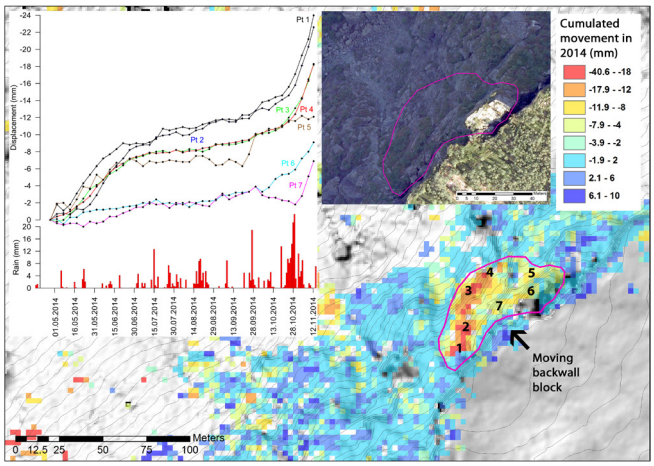

Figure 2. Map with InSAR measurements of movement in Flåm, 2014. Inserted graph shows displacement together with precipitation. An air photo of the moving block is also shown.

CONCLUSIONS

The experiences with use of GB InSAR in Norway demonstrate the capacity to document movements both from large rockslide areas to smaller areas prone to rock-fall processes. This concept is a powerful tool for evaluating the stability, and forms an important knowledge base for the handling the risk of natural hazards.

KEYWORDS

InSAR; Monitoring; rock slide; Rockfall;Norway.

1 The Norwegian Water Resources and Energy Directorate, Stranda, NORWAY, lkr@nve.no
2 Ellegi Srl, ITALY.