Project no.043386

TRIGS

TRIGGERING INSTABILITIES IN MATERIALS AND GEOSYSTEMS

Sixth Framework Programme (FP6) - STREP

New and Emerging Science and Technology Pathfinder Initiative (NEST)

Deliverable n. 5.1.1 - **Report on the processes that drive the dynamics of slow moving landslides. Implications for hazard assessment on ongoing slope movements**

Due date of deliverable: 31 December 2008
Actual submission date: 25 December 2008

Start date of project: January 2007 Duration:36 months

Revision [1]

Organisation name of lead contractor for this deliverable: UJF
Diffusion Level: PU

Deliverable 5.1.1 Report on the processes that drive the dynamics of slow moving landslides. Implications for hazard assessment on ongoing slope movements

Author: A. Helmstetter (UJF)

Introduction

The Séchilienne movement is located in the French Alps near Grenoble, in the Romanche Valley. The slope is made of micaschists with subvertical foliation at right angle with the valley and is affected by subvertical fractures. The part of the slope which exhibits signs of current instability is located in the middle of the hill, at an elevation between 700 m and 850 m, and the most active part of the rockslide represents a volume estimated to about $3x10^6$ m^3. This area has been extensively instrumented since 1988 by CETE Lyon, with extensometers, inclinometers, strainmeters, GPS and distancemeters (laser and radar) [Evrard et al 1990; Lemaître et al, 2004]. The displacement rate of the most active zone (called the « Ruins ») has increased up to 1.4m/yr in 2008. The other regions have displacements less than 10cm/yr. More recently, this rockslide has been instrumented with a network of spontaneous polarization, running since 2005, and by a seismic network. Two stations have been installed in may 2007 for passive monitoring of Séchilienne landslide. Each station is connected to 6 vertical 2 Hz sensors and one 3-components 2 Hz seismometer. The typical distance between sensors is about 50 m. A 24-channels station ('GAL') with 4.5 Hz geophones (21 vertical sensors, and one 3-components) has been installed in April 2008 in the 240 m long survey gallery close to the unstable area.
For more details about this work see :
http://www-lgit.obs.ujf-grenoble.fr/observations/omiv/SECHILIENNE/SISMO/sismo.html

Influence of the rain on the landslide dynamics

We have analyzed the influence of the rain on the rockslide movement and micro-seismicity. There is a clear correlation between seismicity, displacement rate, and precipitation. The seismic activity is very variable, from a few events per day to more than 100 events per day during seismic crisis. Most peaks are associated with precipitations, with a time delay smaller than 1 day between rain and triggered seismic events (see figure 1). Seismicity is also correlated with accelerations of the slope movement.
Looking at the displacement data (from CETE Lyon) in figure 2, we see strong annual fluctuation of the displacement rate. The peak occurs most of the time in winter, except for the year 2007 when the displacement rate was maximum in summer. The movement acceleration may be due to the rain, or to freeze-saw cycles. The displacement rate has been increasing on average since 1996. The amplitude of the perturbation induced by precipitations has also increased during this period. This suggests that the rockslide is more and more susceptible to the rain. Similar results has been obtained by Amitrano et al. (2007) for another Super-Sauze landslide in the southern French Alps.

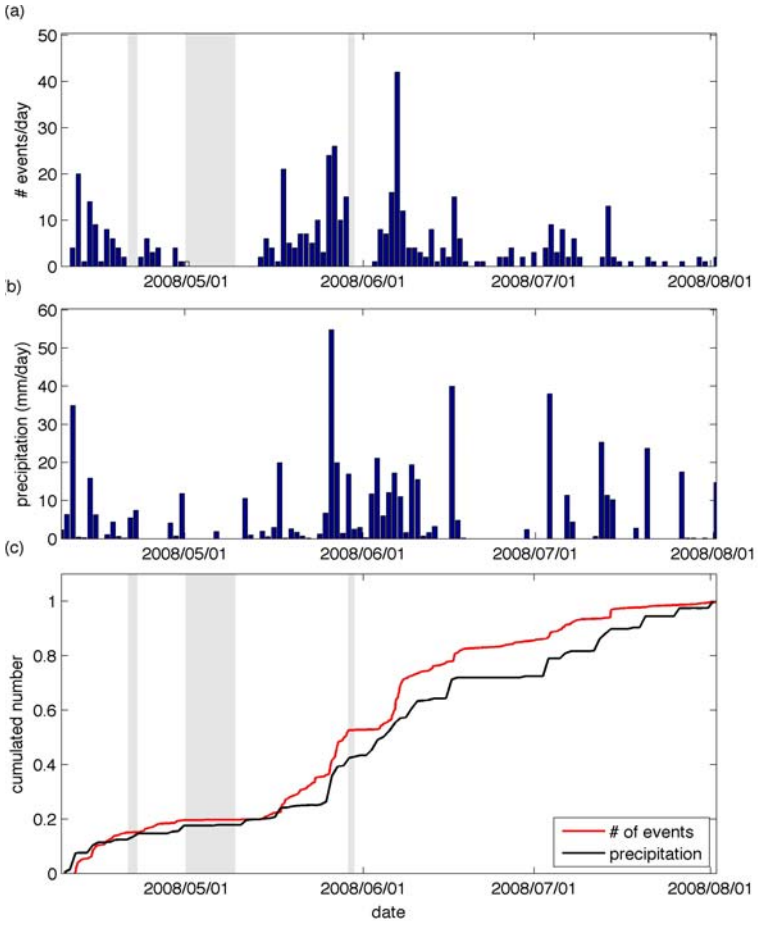

Figure 1 : Comparison of seismic activity, rain, and displacement (for target #625 located in the most active zone) for station RUI from April to August 2008.

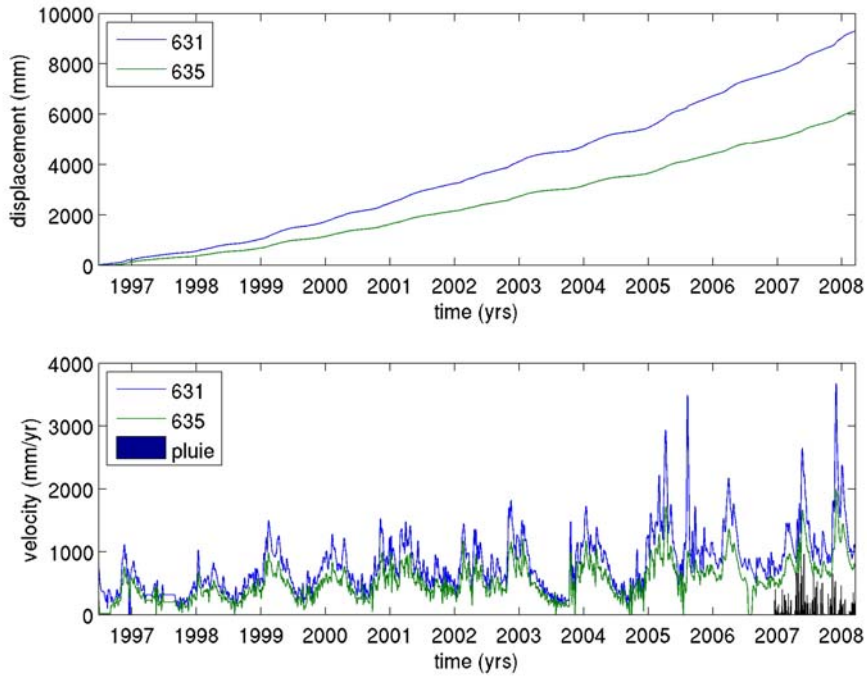

Figure 2: Temporal evolution of the displacement (top) and displacement rate (bottom) for 2 targets located in the most active zone, and correlation with the rain (rainfall data only available after 2007). Data from CETE Lyon.

Influence of distant earthquakes on the landslide dynamics

Séchilienne rockslide is located very close to the Belledonne fault, in one of the most active seismic zone of the northern french alps. The largest recent earthquake in this area is a m=3.5 event, which occurred only 5 km away from Séchilienne rockslide. This earthquakes also produced a m=2.8 aftershock in 2005. Figure 3 illustrates the effect of these 2 events on the landslide dynamics . For the first largest earthquake, there is only a very slight velocity increase during the 2 days following the earthquake, which can be observed on most targets. The amplitude of this acceleration is however very small compared with that induced by rain. The second earthquake, although smaller, seems to have produced a stronger effect. An acceleration of the displacement can be seen for all targets located in the active zone, which have an average velocity larger than 1mm/day, while the other targets do not show any change in displacement rate. The fact that the latter event had a stronger impact on the landslide may be due to to the fact that the rockslide was moving faster at that time, and may thus have been more sensitive to external perturbations.

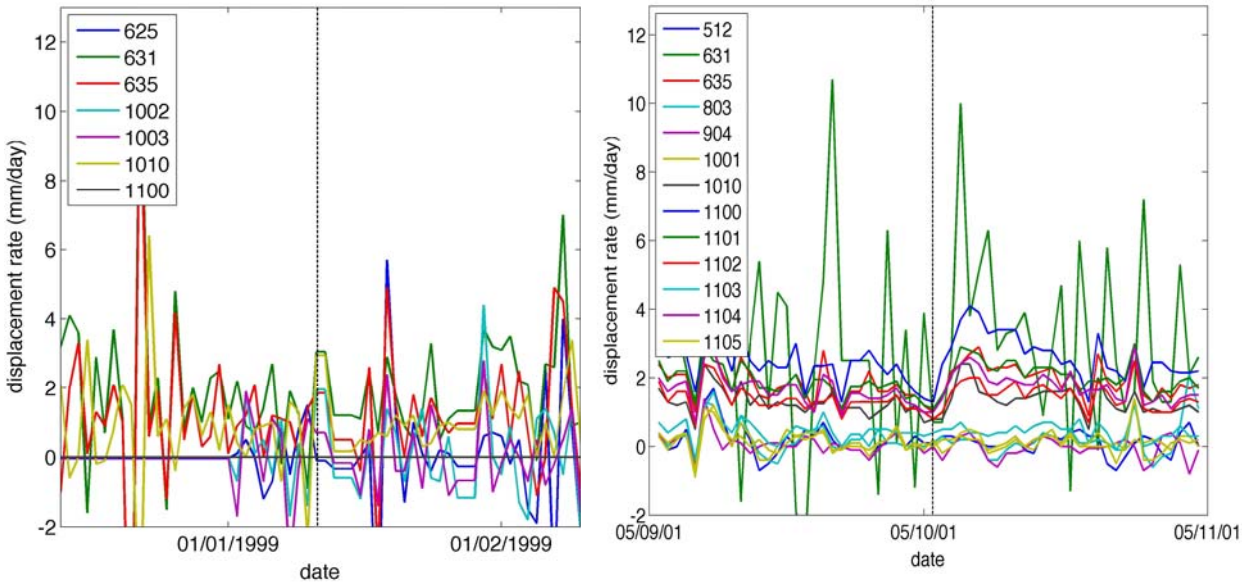

Figure 3 : Displacement rate of several targets located on Séchilienne rockslide, one month before and one month after 2 earthquakes, the 1999 m=3.5 Laffrey earthquake (left), and the m=2.8 aftershock in 2005 (right). The earthquake time is shown as a vertical black line in each plot.

Implications for hazard assessment

Slow moving landslides are sensitive to external perturbations such as precipitations and earthquakes. In the case of Séchilienne rockslide, the response of the movement to perturbations (rain and earthquakes) seems to be stronger for more recent events. The increased susceptibility of the rockslide may be associated with acceleration of the movement since 1996. It is thus more and more likely that the rockslide can be triggered by a rainfall or a large earthquake.

References

- Amitrano, D., S. Gaffer, J-P. Malet and O. Mauquaire, “Understanding mudslides through microseismic monotoring: the Super-Sauze (South-East French Alps) case study”, Bulletin de la Societé Géologique de France 178, 149-157 (2007).

- Evrard, H., Gouin, T., Benoit, A., and Duranthon, J.-P.: Séchilienne (1990), Risques majeurs d'éboulements en masse: Point sur la surveillance du site, Bull. Liaison Lab. Ponts Chauss., 165, 7-16
- Helmstetter A., L. Sanchez, S. Garambois, J.-R. Grasso, F. Doré, Y. Orengo, J.-P. Duranthon, P. Pothérat and J. Kasperski, Multidisciplinary Monitoring of a Huge Rocky Landslide (Séchilienne, The Alps, France) *Eos Trans. AGU, 89*(53), Fall Meet. Suppl., Abstract H51F-0899
- Lemaître, F., J.-C. Duranthon, L. Effendiantz (2004), L'utilisation du radar au sol pour la surveillance des mouvements de terrain, Bull. Liaison Lab. Ponts Chauss. 249, 19-34