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Differential Synthetic Aperture Radar Interferometry in Monitoring La Frasse Landslide (Vaud, Switzerland)

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Introduction

Spaceborne Differential Interferometric Synthetic Aperture Radar (DInSAR) is a remote sensing technology based on the measure of the phase of a radio wave reflected by ground scatterers. **Exploiting the phase's difference of those ground scatterers detected by two radar satellite acquisitions at two distinct times allows to detect the small deformations of the topography which occurred between the temporal baseline** *[Massonnet & Feigl, 1998].*

Limited by atmospheric artifacts and decorrelation problems, DInSAR is more effective in urban, arid or rocky areas than in forest or cultivated areas. But it can **detect quasi vertical movements covering very large areas in a continuous way.** That is why DInSAR can be considered an efficient tool to detect and monitor slope instabilities *[Berardino & al., 2003].*

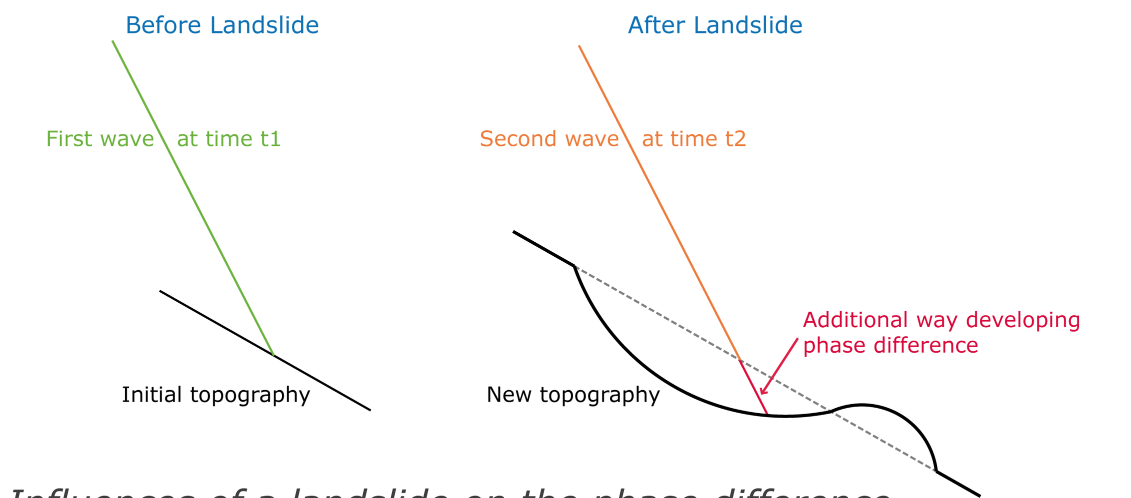
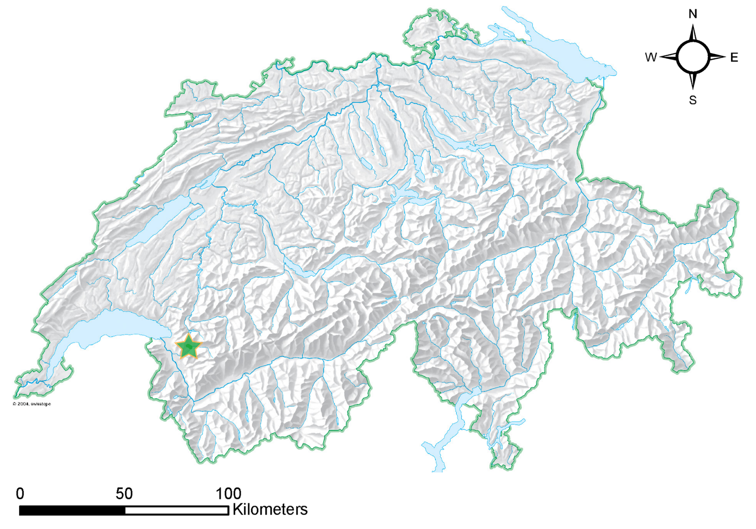


Fig.1: *Influences of a landslide on the phase difference*

Situation

La Frasse landslide is located in the Canton of Vaud, Switzerland. With high velocities (presently at 40cm/year in the active lower part), the **landslide is a highly hazardous area according to the Swiss legislation.**



It **affects some habitations and two main roads to touristic areas**. At present, a drainage gallery is being constructed under the active part of the landslide.

Fig.2: *Green star locates the La Frasse landslide (Swisstopo)*

Landuse

At an altitude of 1000m at least, **landscape is used by forests, pastures**, some habitations and two main roads.

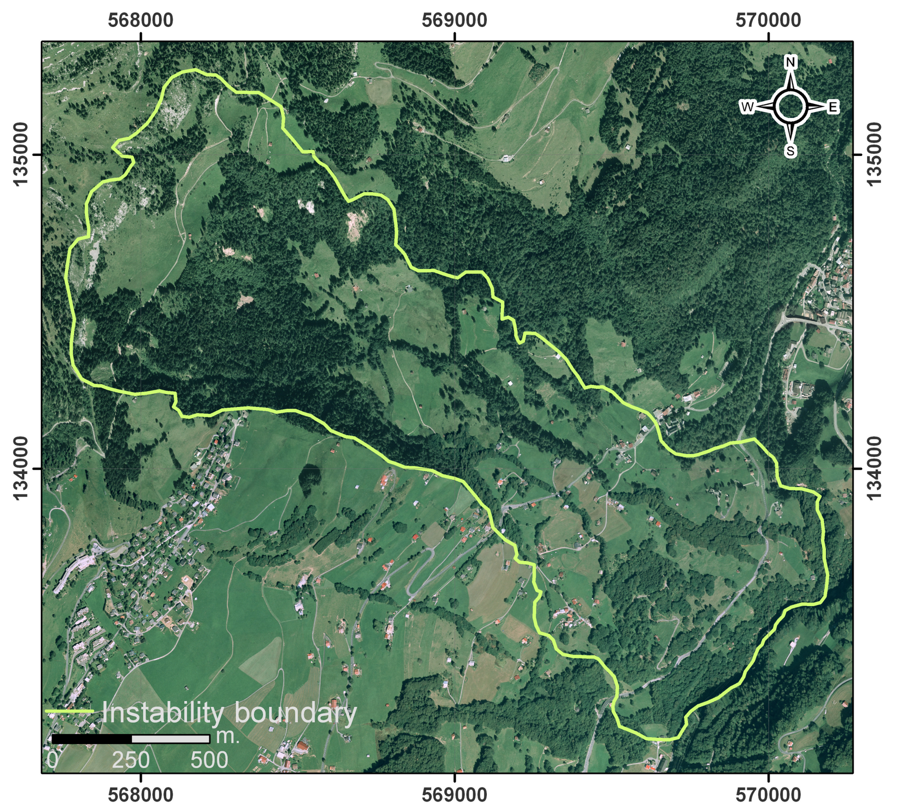


Fig.3: *Orthophoto of the La Frasse landslide area*

Geomorphology

According to Varnes classification, **La Frasse landslide is a complex slide** composed of tertiary flysch material and flowing on flysch and limestone bedrock *[Bonnard & Noverraz, 1986].*

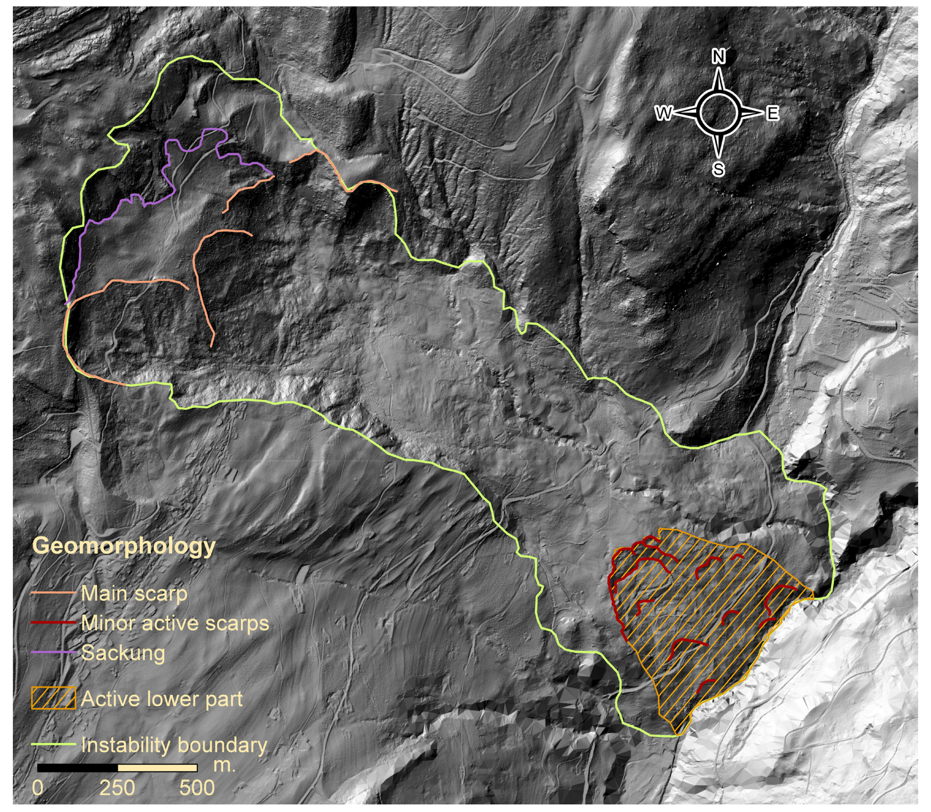
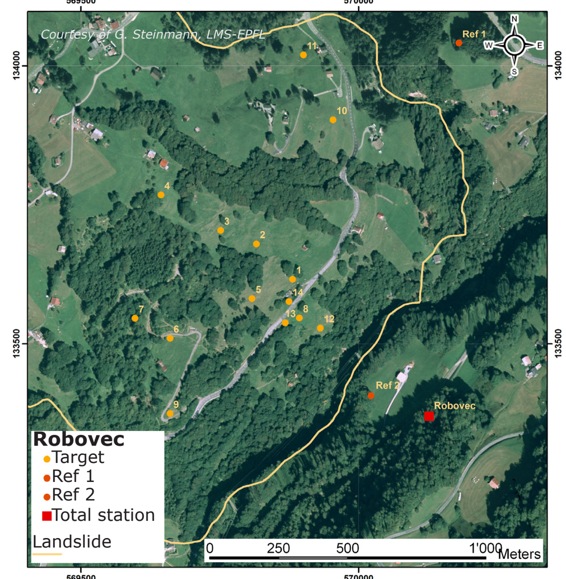


Fig.4: *Geomorphology of the landslide detectable with an aerial laser scanning DEM.*

Robovec™

The **Robovec™ system**, exploited by the Soil Mechanics Laboratory of the Swiss Federal Institute of Technology of Lausanne, **monitors ground displacements** every 2h by a laser total station since summer 2006.



During the summer 2007, a crisis period has been observed, triggered by very important rainfalls.

Fig.5: *Localization of the Robovec™ sytem. The total station (red square) is on the opposite stable slope and monitors 14 prisms on the landslide every 2h.*

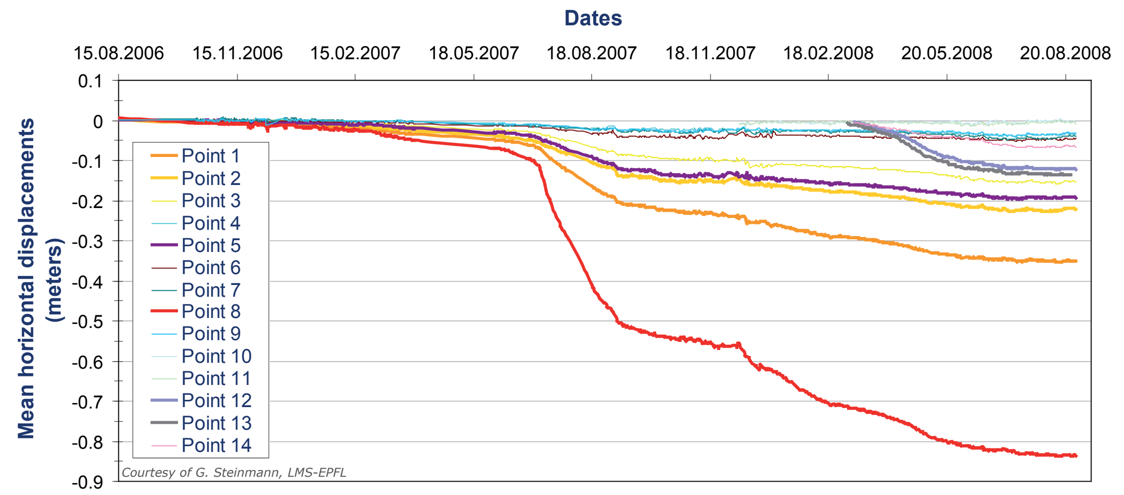


Fig.6: *Mean horizontal displacements monitored by Robovec™ sytem. With more than 80cm for the prism 8, annual displacements are decimetric.*

Input and Processing

To acquire the Radar dataset, the **project** « Differential Synthetic Aperture Radar Interferometry in monitoring large landslide in La Frasse » **was concluded with the European Space Agency**.

> 24 Envisat ASAR scenes
- Track 294 & Frame 2673 ; Descending orbits
- From October 2002 to November 2008 (snow free period)

The **Small BAseline Subset** (SBAS) can process **mean annual velocities** of **distributted scattering** pixels and **filter out artifacts** due to atmospheric disturbances *[Lauknes, 2004]*. The **software GSAR** developed by Norut Tromsø was used.

> 53 pairs processed
- Maximum temporal baseline: **400 days**
- Maximum normal baseline: **300 m**
- DEM used: **SRTM 90m**

Results

In the landslide, only areas covered by pastures have high coherences and consequently results. Furthermore, in the bottom of the instability, movements are important and create strong geometrical decorrelations.

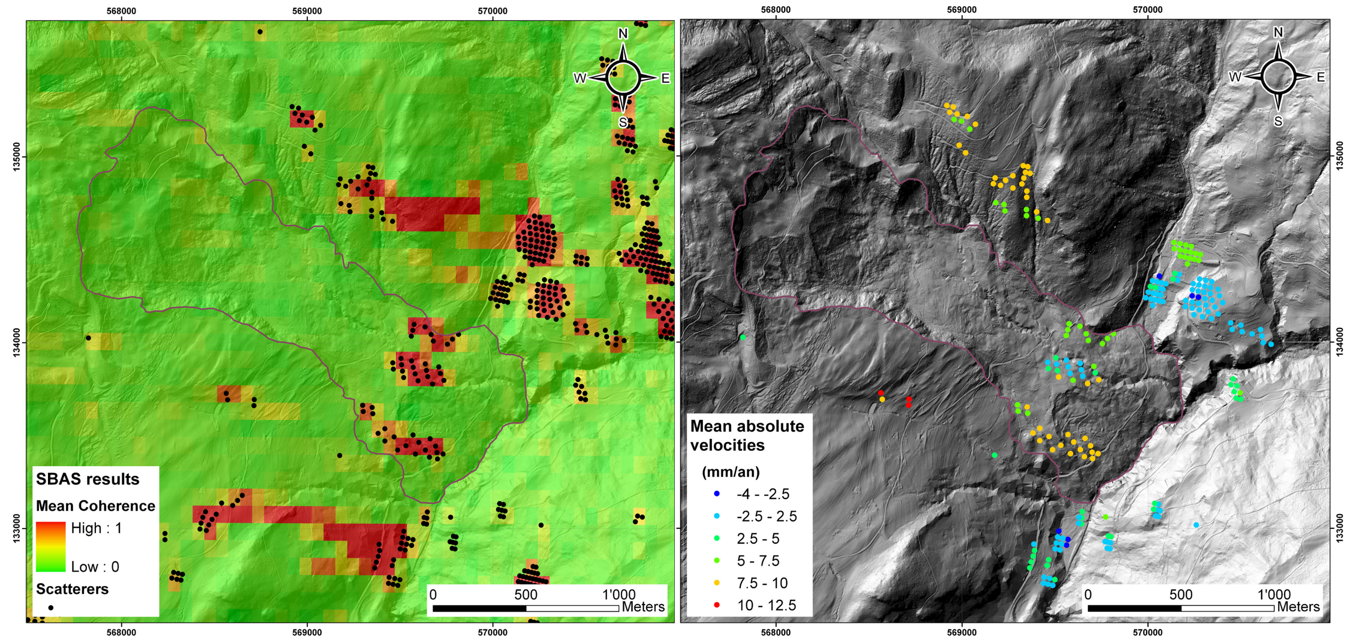


Fig.7: *Left: Coherences map. Right: Mean relative velocities map Resolution: 60x90m. Projection: CH1903_LV03. Software: GSAR™ (Norut) & ArcGIS™ (ESRI). Radar raw data ©ESA2008.*

Reversed projections

According to *Bonnard & Noverraz (1986)*, the following properties are assumed to reverse projections and obtain velocities in the slope :

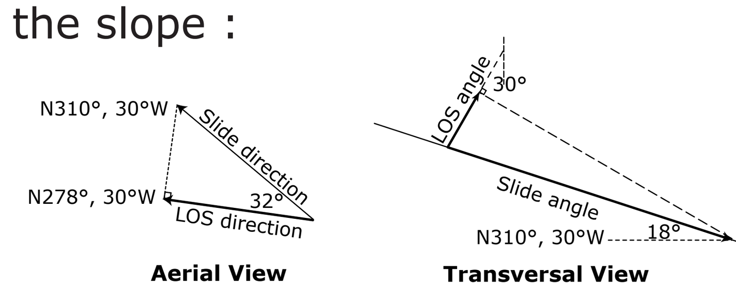


Fig.8: Real and monitored vectors
- *Mean slide direction: N130°*
- *Mean dip: 18°E*

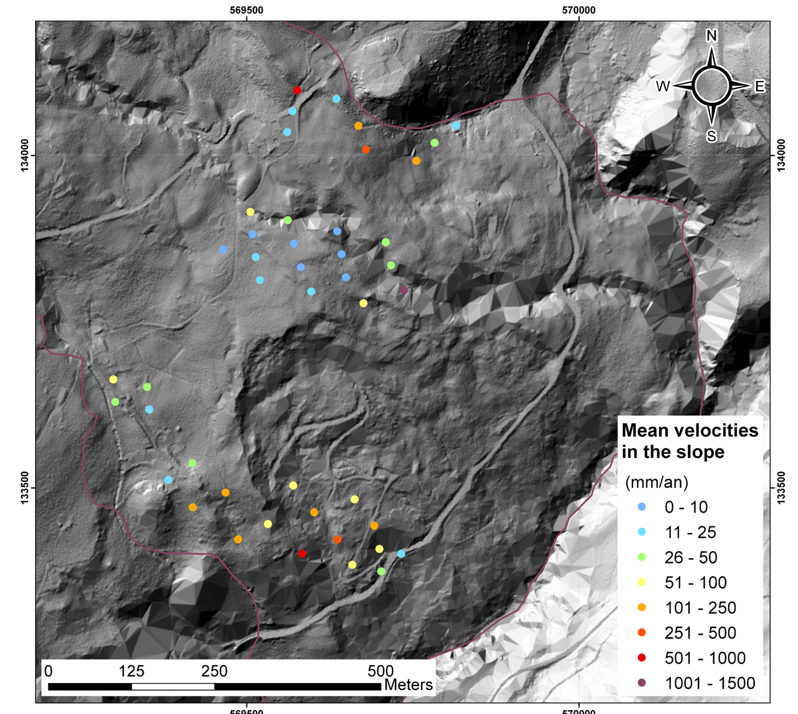


Fig.9: *Mean velocities in the slope. Resolution: 60x90m. Projection: CH1903_LV03. Software: GSAR™ (Norut) & ArcGIS™ (ESRI). Radar raw data ©ESA2008.*

Conclusions

The **results** of this study are **coherent with the amplitude** of the deformations monitored by **Robovec™**. Moreover, the computation of the mean velocities shows that today, total displacements are measured in the active lower part of the landslide; the **data complete Robovec™ results**.

The **accuracy** of the measured displacements and **the number of scatterers** could **be improved** by **synthetizing the topographic phase from an aerial laser scanning DEM** instead of the STRM DEM. The **number of scatterers** can also **be increased by installing corner reflectors** in the fastest-moving area of the landslide.

When archives of **Alos PALSAR scenes will be more complete** in the Alps, it will be interesting to use those L-band images to process SBAS, reducing artifacts and decorrelations.

As soon as the construction of the **drainage gallery is finished**, it would be **interesting to measure displacements** by SBAS to control the efficiency of the gallery.

References

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