



UNIVERSITY OF PERUGIA

Perugia, 13th February, 2015

DEPARTMENT OF PHYSICS AND GEOLOGY

PhD course in Science and Technology for Physics and Geology

PRELIMINARY PROJECT TITLE

ACQUISITION AND USE OF REMOTE INTERFEROMETRIC DATA (GBInSAR TECHNIQUE):
STUDY OF THE OPEN PROBLEMS ON LANDSLIDES IN MOUNTAIN AREAS



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XXX cycle - Academic Year 2014/2015

INTRODUCTION

Landslides represent a serious threat to human life and activities. Depending to the landslide, different monitoring instruments are available.

Traditional monitoring instruments:

- Inclinometers
- Piezometers
- Tiltmeters
- Extensometers
- Fissurometers
- Topographic survey
- GPS
- SAR (Syntetic Aperture Radar)
- **GBInSAR (Ground Based InSAR)**

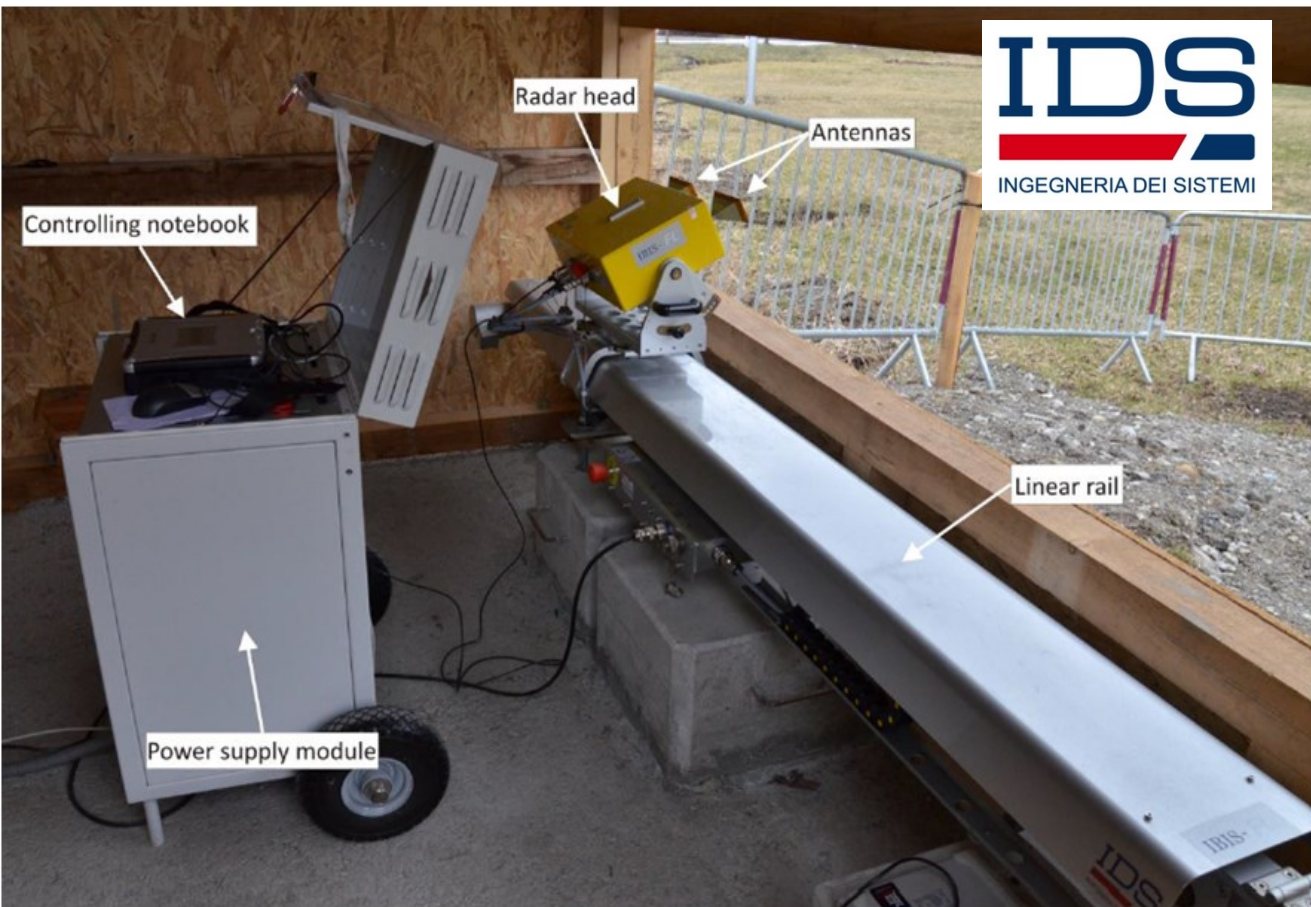


Landslide of Termeno (Bolzano, January 2014)

Forecasting the occurrence of landslide phenomena in space and time is a major scientific challenge (Manconi et al., 2014).



GBInSAR EQUIPMENT



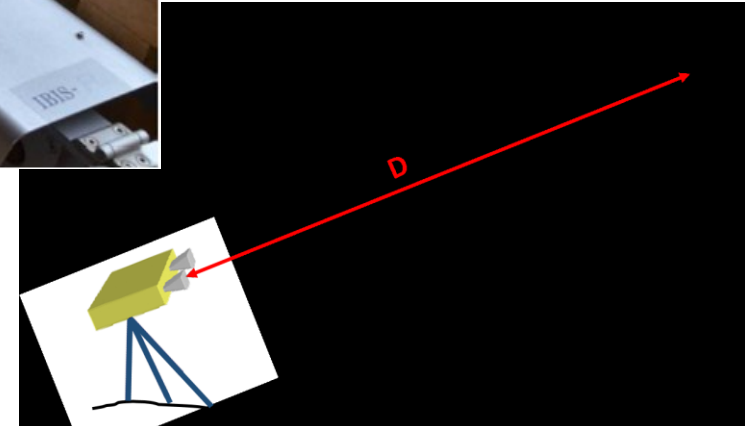
RADAR:
RAdio Detection And Ranging

IBIS-FL Frequency:
17,1 – 17,3GHz (Ku band)

Typical spatial resolutions:

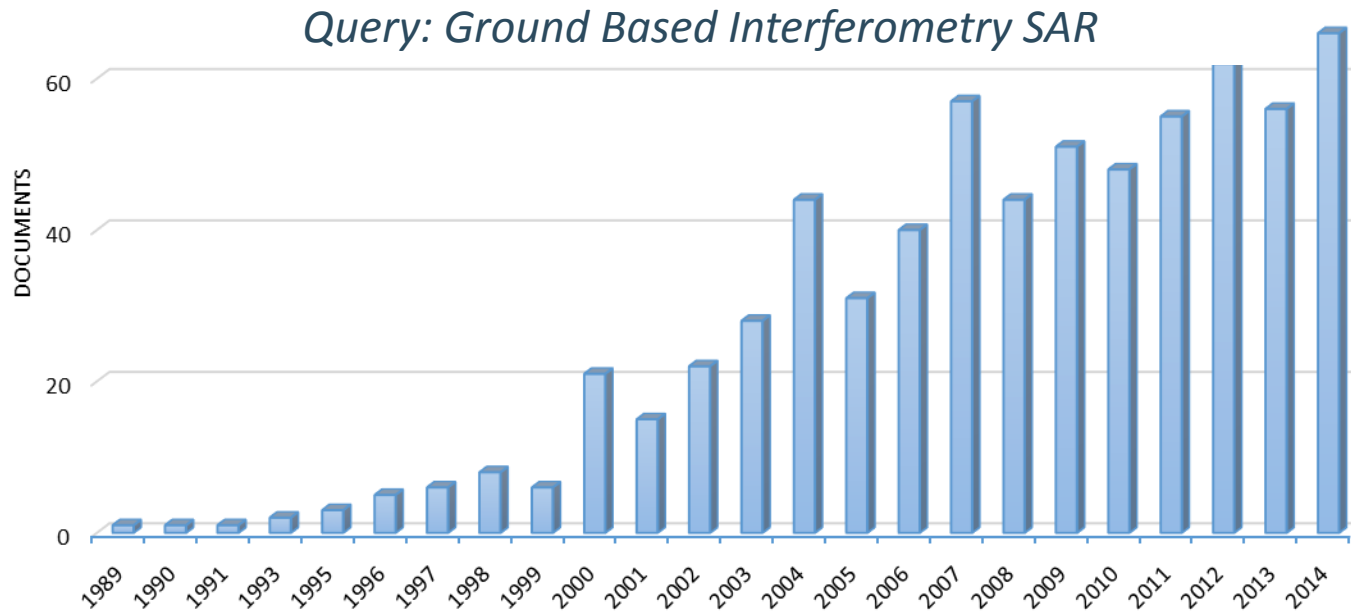
- $\Delta R = 0,5\text{m}$
- $\Delta CR = 4,3\text{m}$ at 1000m

Conventionally, in GBInSAR technique, displacement is positive if the pixel moves away from the sensor and it is negative if the pixel moves towards the sensor (Hanssen, 2001).

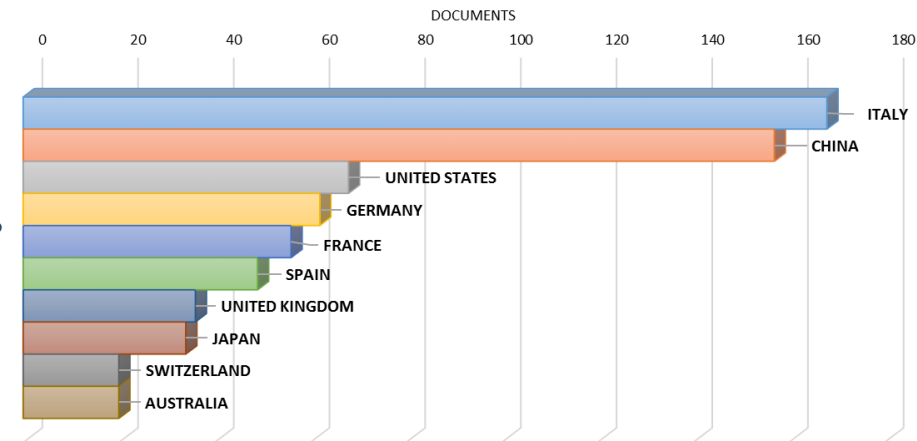


Scan length $L = 2\text{m}$	Maximum distance $R = 4000\text{m}$	Total weight $\approx 160\text{Kg}$
Scan time (IBIS-FL) $\Delta t = 5\text{min}$		Average power consumption $\approx 60\text{W}$

By checking for “Ground Based Interferometry SAR” on Scopus database, several papers were published by Italian researchers in the last decade.

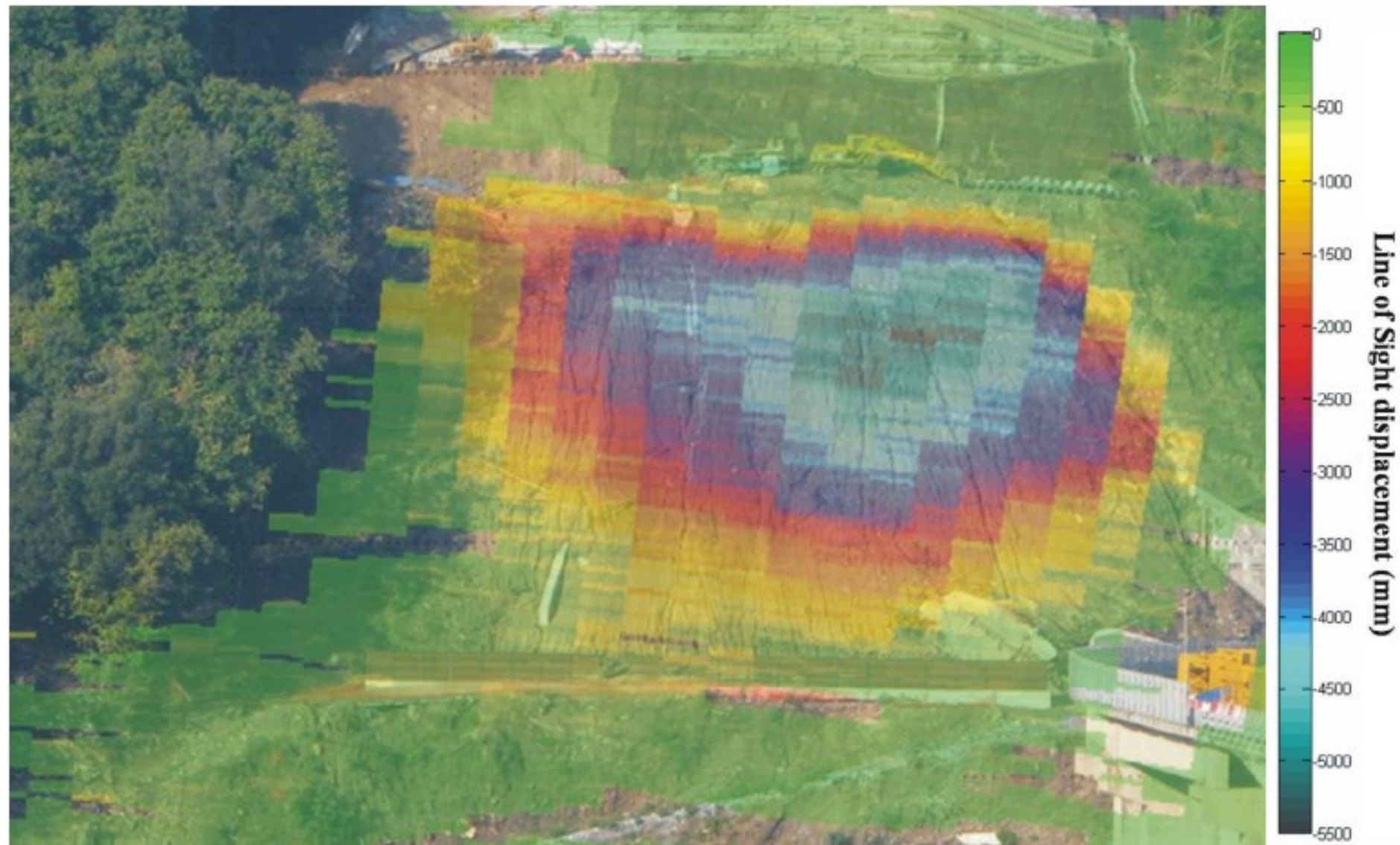


Source: Scopus



Ground-Based Interferometric Synthetic Aperture Radar is a displacement monitoring technique developed in the late '90 and now considered one of the most effective solutions for displacement monitoring in geology and structural fields.
(Mazzanti, 2011)

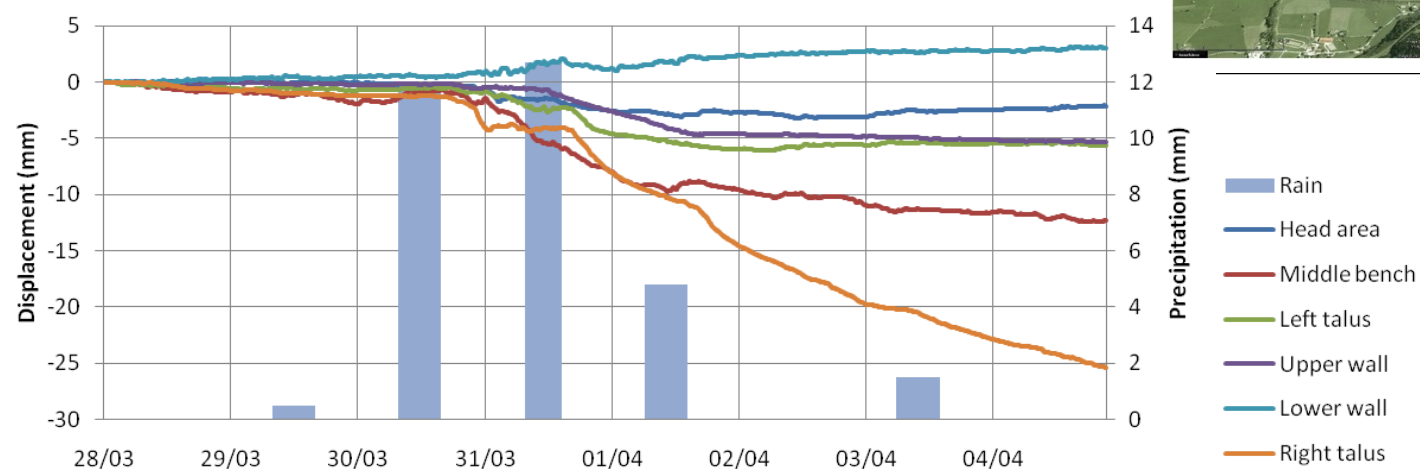
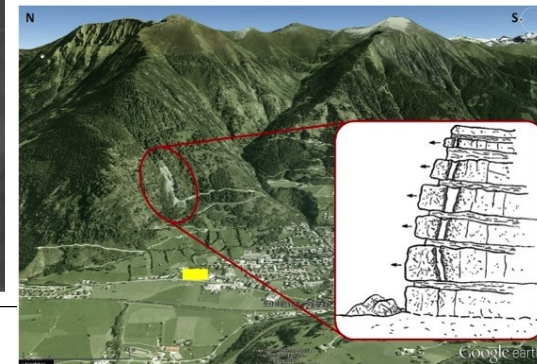
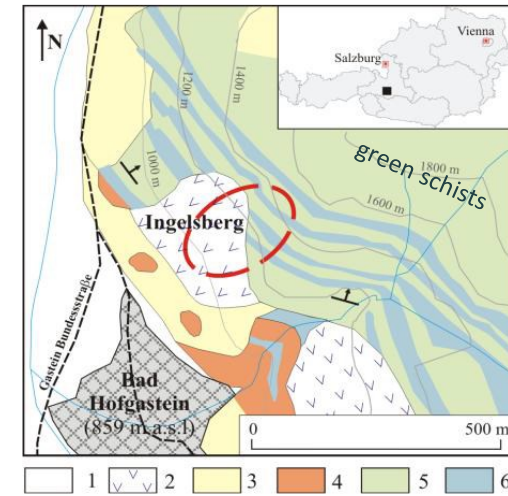
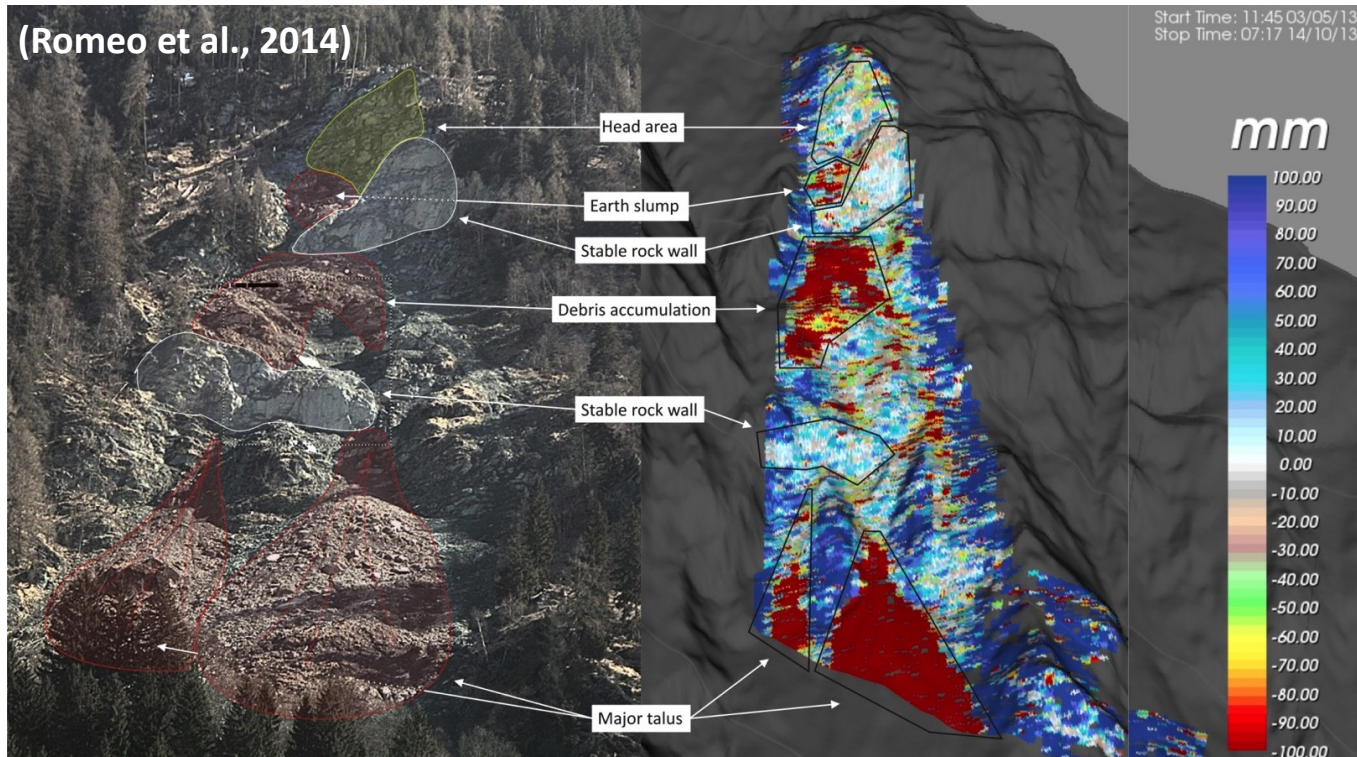
OUTPUTS



Displacement map superimposed on a photo of a monitored slope and displacement time series of some pixels.
(Mazzanti, 2011)

OUTPUTS – The Ingelsberg Landslide (Austria)

(Romeo et al., 2014)



PROS AND CONS

Main advantages



- Widespread monitoring (images instead of single points);
- **High temporal resolution** (few minutes);
- **Up to 0,1 mm displacement accuracy;**
- **Effective under any weather and lighting conditions;**
- **Fully remote monitoring** (targets or sensors in the monitoring area are not required);
- Long range operability (up to several km);
- Fully automatic acquisition;
- Suitable for real time - early warning monitoring.

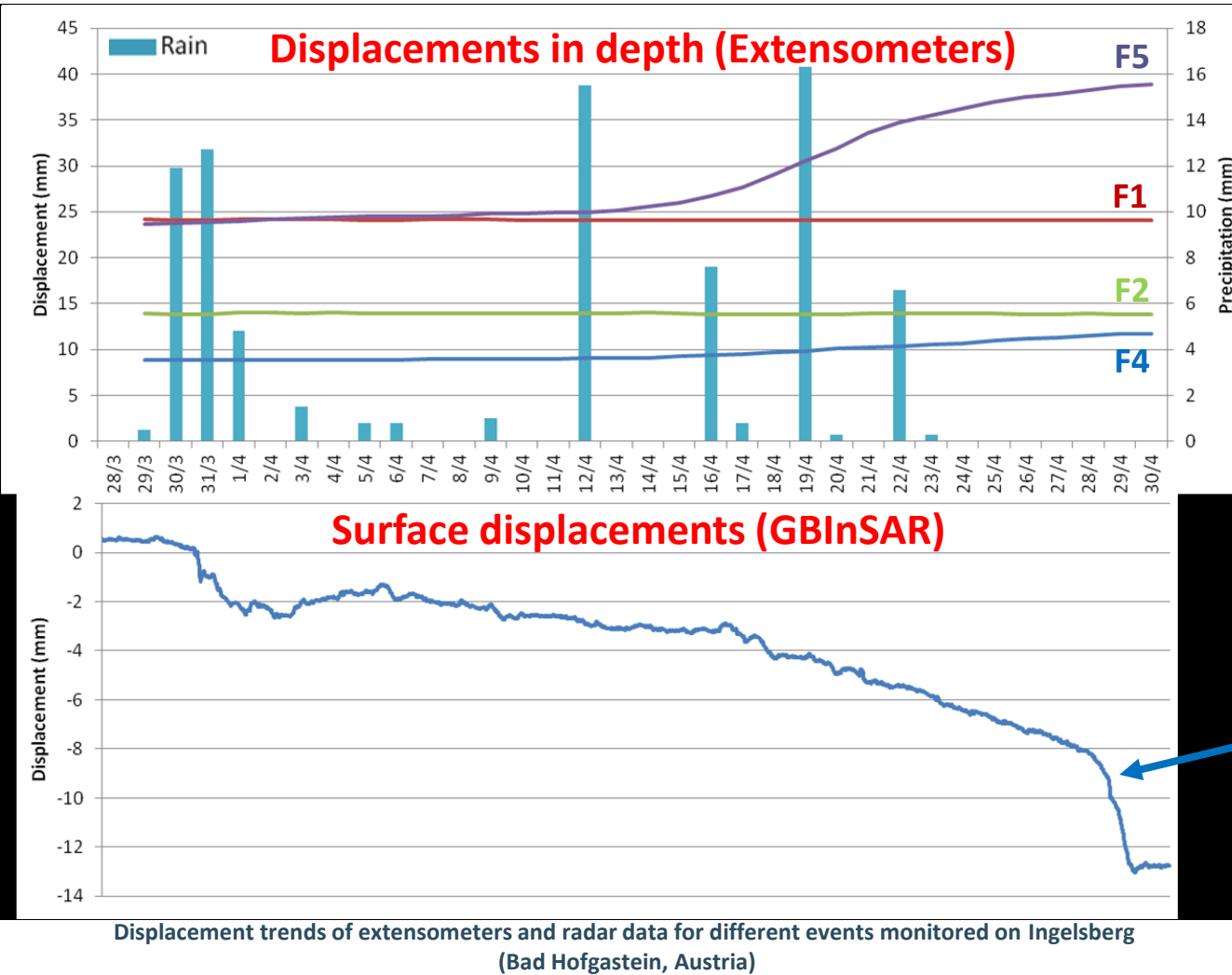


Main limitations

- **Surface monitoring;**
- Limited cone of view;
- Displacement monitoring along the Line of Sight;
- Phase ambiguity in case of discontinuous monitoring.
- **Non user-friendly software for analysis** (complicated interface)

OPEN PROBLEMS – RELIABILITY OF GBInSAR

Despite in the last decade the use of these technologies are increased, depth analyses on the reliability of the GBInSAR measurements are lacking.



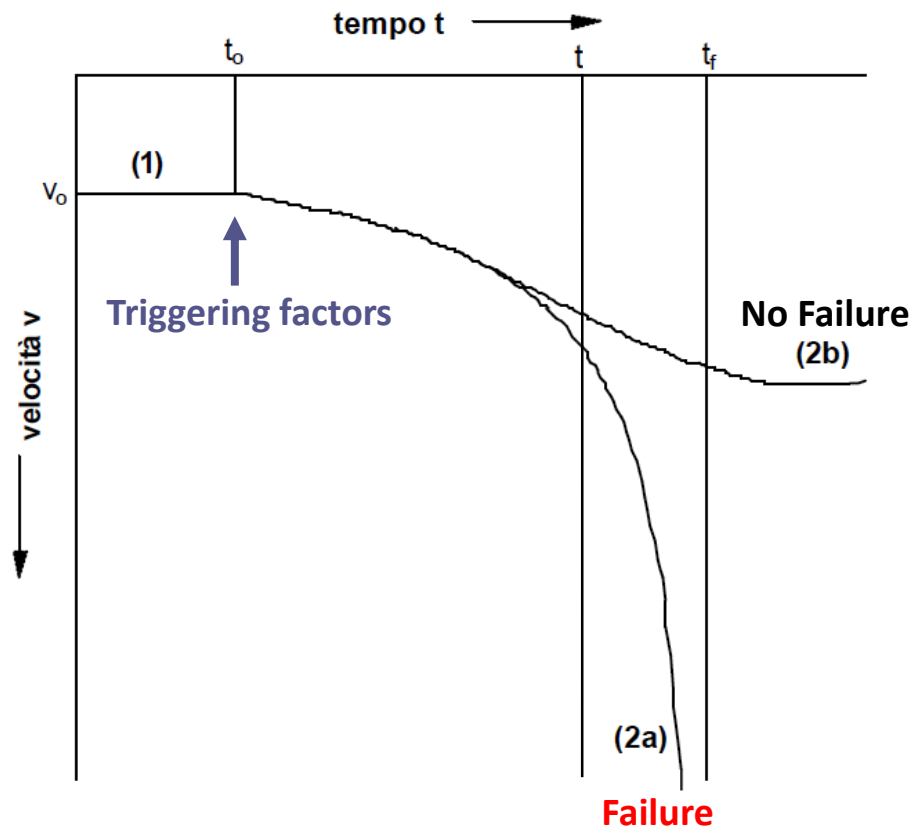
Extensometer in Ingelsberg



Map of extensometers in Ingelsberg

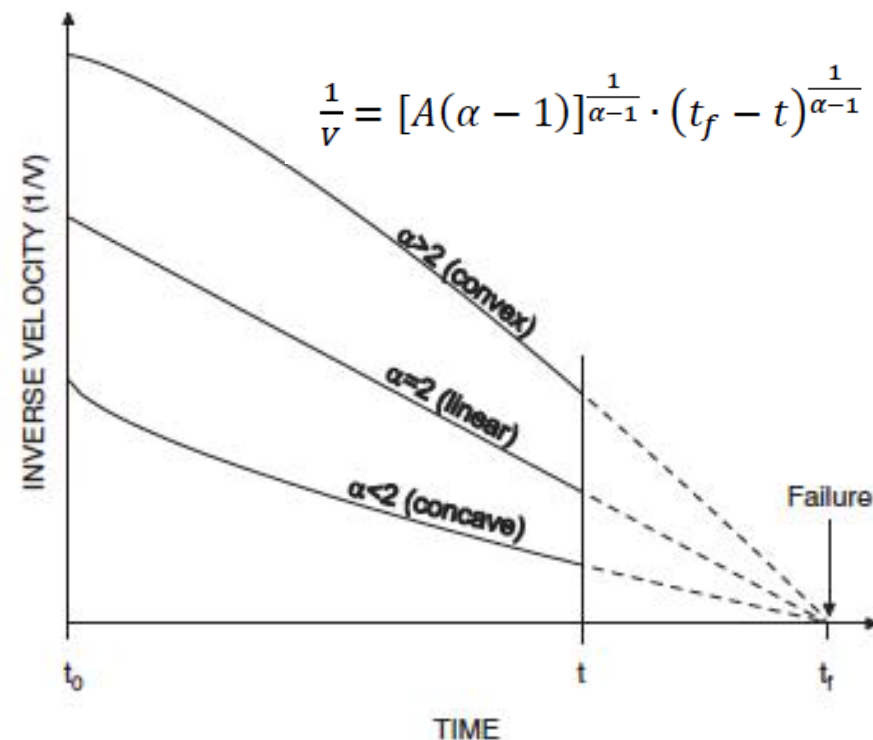
OPEN PROBLEMS – LANDSLIDE FAILURE FORECAST

Landslides forecasting based on displacement measurement data was introduced by Saito (1980), and developed by Voight (1989, 1990) and Fukuzono (1990).



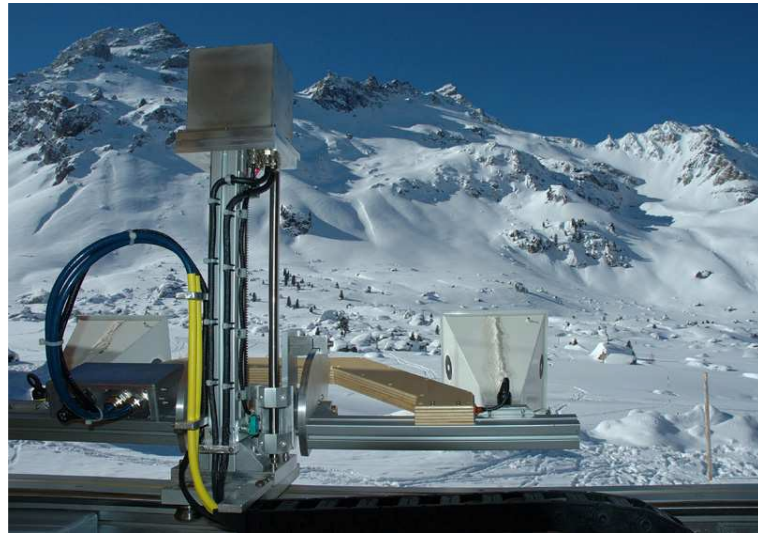
Cinematic landslide evolution
(modified by Pellegrino et al., 1992)

INVERSE VELOCITY $\frac{1}{v} = \left[\frac{h}{mm} \right]$



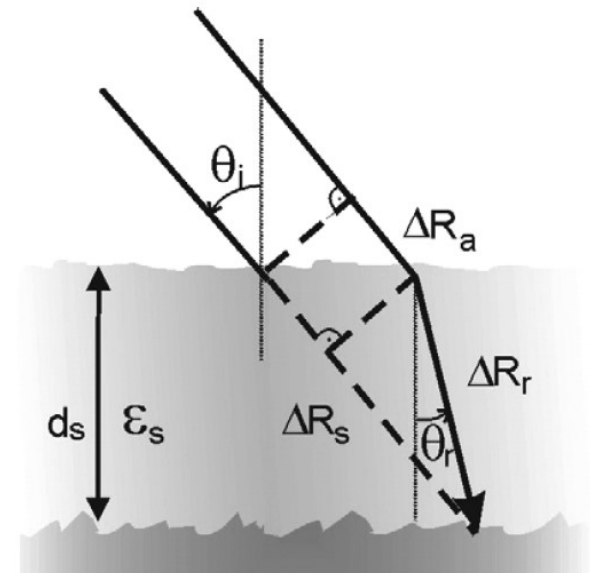
Typical figures of the changes of the inverse number of velocity of surface displacement just before the failure (Fukuzono, 1990)

OPEN PROBLEMS – THE INFLUENCE OF SNOW COVER



GB-SAR observing the snow-covered Wattener Lizum

In general, the dry snow is transparent to electromagnetic waves, then the waves emitted by the radar are able to penetrate through the snowpack until the underlying soil (Pieraccini et al., 2007).



Path of electromagnetic waves within the snowpack
(Pieraccini et al., 2007)

During the snowfalls, areas tend to assume **positive values** representing an increase of distance by the radar. These anomalies may be given by the interference phenomenon of snow cover.



European Project:

Advanced Remote Monitoring Techniques for Glaciers, Avalanches and Landslides Hazard Mitigation

POTENTIAL EXTERNAL PARTNERS OF THE PROJECT



- Instruments
- DataBase



**GEOHAZARD
MONITORING
GROUP**



- DataBase
- Experiences
- Hardware and software tools useful for *Time of Failure*

TRAINING IN PROGRESS

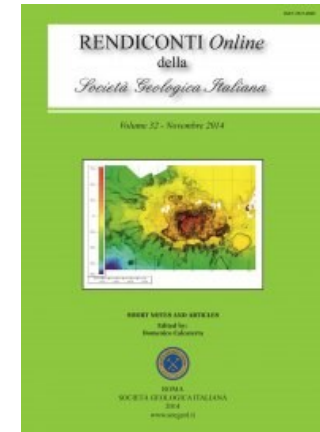
During the first year of PhD, many training activities are planned:

- Lectures at the Doctoral School (Department of Physics and Geology)
- Short courses:
 - i. Introduction to R software (Department of Economics)
 - ii. Atmospheric Physics and Climate (Department of Physics and Geology)
 - iii. Magmas, Eruptions and Hazard (Department of Physics and Geology)
- Course in English language (Centro Linguistico d'Ateneo)
- International School:
 - i. LARAM – Landslide Risk Assessment and Mitigation (University of Salerno)



MANUSCRIPTS

- Romeo S., Kieffer D.S., Di Matteo L. (2014) - The Ingelsberg landslide (Bad Hofgastein, Austria): description and first results of monitoring system (GBInSAR technique), *Rendiconti Online della Società Geologica Italiana*. 10/2014, 32:24-27.



INTERNATIONAL CONGRESS

- Attendance at *5th International Symposium for Geotechnical Safety and Risk* (Rotterdam 13th – 15th October, 2015). 2 Papers submitted:
 - Romeo S., Kieffer D.S., Di Matteo L. - Reliability of GBInSAR monitoring in Ingelsberg landslide area (Bad Hofgastein, Austria).
 - Di Matteo L., Valigi D., Ricco R., Romeo S. - Effect of laboratory repeatability of direct shear test on slope stability.



OTHER ACTIVITIES

- *Studio e monitoraggio dei fenomeni franosi*, lectures at the course in Rilevamento geologico-tecnico e monitoraggio (9th December, 2014).
- Several field trips in the context of the courses in Rilevamento geologico-tecnico e monitoraggio and Geologia ambientale (Nov - Dec, 2014)



THANKS FOR YOUR ATTENTION!



“An instrument too often overlooked in our technical world is a human eye connected to the brain of an intelligent human being”.

Ralph Peck

