Retrieving 3D deformation pattern of a landslide with high-resolution InSAR and in-situ measurements: “Just landslide” case-study

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Outline of the talk

• Problem statement
• Study area
• Concept of experiment
• Data processing
• Future plans
• Conclusions
Problem statement

- Hazardous landslides are monitored by in-situ systems – point wise (DISCRETE!)
- Subsurface, surface/RS methods can measure deformations highly accurate – point wise!
- Discrete data give only general info about hazards.
- Does not allow to estimate a 3D displacement field of deformation, and give a prediction of the future activity on surface.
Where: Just Landslide

Why:
• Active, creeping landslide (~1 dm/yr)
• Serious hazards
• Installed monitoring system (PGI + Road Directorate)
• Vegetation + man-made structures
• Ideal location for testing the limits of InSAR

Geology:
flysh-type rocks (sandstone, sandstone-shale and shale from the Upper Cretaceous to Oligocene),

Location: Saint Justus Hill
Dimensions:
- Length: 830 m
- Width: 740 m
Area: 40.5 Hectares
Top elevation: 430 m a.s.l.
Height difference: 164 m
Slope: 11°
How we are measuring

Landslide monitoring by PGI – current status

Subsurface monitoring

Inclinometers + piezometers

Surface monitoring

Rain gauges

FRINGE 2015 WORKSHOP
23–27 March 2015 | ESA–ESRIN | Frascati (Rome), Italy
Landslide hazards & damages

Just landslide – mapped Nov. 2010

- Active areas
- Scarps
- Toe & ridges
- Damaged buildings
- Buildings at risk
- Road damages
Monitoring system

- **Inclinometers**
  - 2 PGI
  - 8 General Road Directorate

- **Geodesy:**
  - 12 points (PGI)
  - 4 scan positions (PGI)
Just Landslide hazards & damages monitored

Inclinometer data
31-MAR-2010 – 26-AUG-2010

Cumulative Displacement

GNSS displacements
2011 - 2014

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Can we do it better with InSAR?

- Geological data
- Surface and subsurface monitoring
- Hi-res surface deformation data
- Deformation modeling
- General hazard assessment
- Detailed hazard evaluation & zonation
Insar: exploring SAR archive

• Method: Multi temporal InSAR
  – Processing strategy – PSI with 'StaMPS'

• Processed datasets:
  – ERS-1/2 descending (tracks 408, 179)
  – Envisat ASAR – ascending and descending
  – ALOS descending (under processing)
Can we do it better with InSAR?

Envisat ASAR data
T: 408, 24 scenes
03-DEC-2002 – 20-APR-2010

Method:
PSI with StaMPS

Only few (7) PS detected on landslide
Density: ~17 ps/km²
Can we do it better with InSAR?

- 20 TSX StripMap scenes
- PSI processing with StaMPS

Density: ~250 ps/km²

Deformation record of point no: 8912 (StaMPS processing)
X: 618176.4375(E) Y: 207342.71875(N)
Mean LoS Velocity (MLV): -16.0387 [mm/yr].

Can we do it better w.r.t PS density?
Challenges for InSAR in mountain areas

- Lack of defomation signal
- Strong deformation signal

LoS (Line of Sight)

- very rough topography (steep slopes causing geometry distortion, and resulting bad coregistration),
- lack of rock outcrops and very sparse urbanization concentrated in the valleys and along the roads (low number of stable phase PS),
- dense vegetation cover (forests in the higher parts of the slopes and meadows and fields in the lower parts),
- bad weather conditions with high precipitation, long season with thick snow cover (resulting overall coherence reduction)
- complex and nonlinear deformation pattern
Can we do it better with higher resolution?

- Whether ultra-high resolution InSAR can improve landslide hazard assessment?
- Can we use ultra-high res. InSAR with 3D geology to improve landslide deformation modeling?
- Can we do better hazard assessment with these data?
- What are the benefits from SpotLight and Staring SpotLight data?
- Higher resolution = higher frequency = more sensitive to vegetation
Staring Spotlight concept

• ST available since October 15, 2013
• TSX extended azimuth steering up to ±2.2° to a rotation center inside the imaged scene
• The antenna footprint has to cover the entire ground scene
  – Resolution: 0.25 m (azimuth) x 0.8 m to 1.77 m (range);
  – Scene size: 2.1 to 2.7 km (azimuth), 7.5 to 4.6 km (range);
  – Single polarization: (HH, VV)
• Improved geometric and radiometric resolution

(image credit: DLR)
LoS orientation w.r.t deformation
TSX ST Experiment setup

Incidence angle w.r.t. image distortions
Experiment with TSX SL and ST data (quota 40 scenes)

Acquisition strategy:

**ST** spot_049R  
Staring SpotLight  
2014-11-24

2014-12-16

2015-01-07

2015-01-29

2015-02-20

2015-03-14

**SL** spot_050R  
SpotLight  
2014-12-27

11 d

2014-12-27

2015-01-18

2015-02-09

2015-03-03

2015-03-25
ST coherence and interferogram 12-NOV-2014 to 16-DEC-2014
STaring SpotLight - understanding coherence pattern

Mean coherence

- No. 75 road
- Natural, dense vegetation
- Fruit plantations
- Rożnów Lake embankment

Grass (cultivated)
Just landslide as seen by Sentinel-1

2015-MAR-05
2015-MAR-17
Just landslide as seen by Sentinel-1
No. 75 road reinforcement and maintenance is planned for summer 2015

- New monitoring system will be installed
- On-line data transfer
- Corner reflectors for InSAR?
- Monitoring with S1 data?
Conclusions

- Due to project delays and cancelled acquisitions at the beginning, the collected data stack does not allow yet time series analysis.
- Only preliminary results presented – small baseline interferograms.
- Due to small temporal baseline, no deformations detected.

However...

- Analysis of the first TSX TS interferograms present overall good quality.
- Time series analysis with Staring Spotlight should give a new insight into landslide deformation phenomena.

See you on FRINGE 2016!

Acknowledgements:

TerraSAR-X data provided by DLR (project GEO-2477), ERS-1/2, Envisat data provided by ESA (project DR3-10606), geological data and in-situ measurements courtesy of GDDKiA and PGI-NRI.