7th ADVANCED TRAINING COURSE ON LAND REMOTE SENSING
4–9 September 2017 | Szent István University | Gödöllő, Hungary

# SATELLITE REMOTE SENSING TECHNIQUES FOR EVALUATION AND ANALYSIS OF GEOLOGICAL HAZARDS ALONG LINEAR INFRASTRUCTURE NETWORKS

**Matteo Roccheggiani*, Guido Guidotti**, Marco Menichetti***

**Dipartimento di Scienze Pure e Applicate, Università degli Studi di Urbino, Campus Scientifico E. Mattei, Urbino (PU), Italy.*
***SAIPEM Spa, Via Toniolo, 1, Fano (PU), Italy*
*e-mail: matteo.roccheggiani@uniurb.it*

## ABSTRACT

**Necessity of effective and rapid solutions for the analysis and monitoring of particular geological phenomena finds in the application of modern techniques of remote sensing a valid response with a good cost/benefit ratio. In particular, in recent past, satellite SAR interferometry is one of the latest techniques for the detection and measurement of the Earth surface deformations produced by natural and anthropogenic events. The application of these techniques and the availability of updated ESA Sentinel mission's data are promising for the analysis and monitoring of geological hazards interacting with vulnerable elements such as linear infrastructure networks (e.g. pipelines, roads or railways). My research issue is to evaluate the potentials of the new generation of satellites data for safe and effective analysis of geological hazards potentially interacting with linear infrastructure networks, especially in remote or challenging areas. Attention is focused both on the interaction between natural hazards (e.g. landslides) and these infrastructures and the impact of these man-made networks on the surrounding environment. The proposed research could have high significance in the field of geological hazard assessment, suggesting reliable methodology and operational scenarios through the availability of new effective and reliable tools. This approach could reduce costs not only for the monitoring of existing infrastructures but also for the assessment of planning solutions for new constructions.**

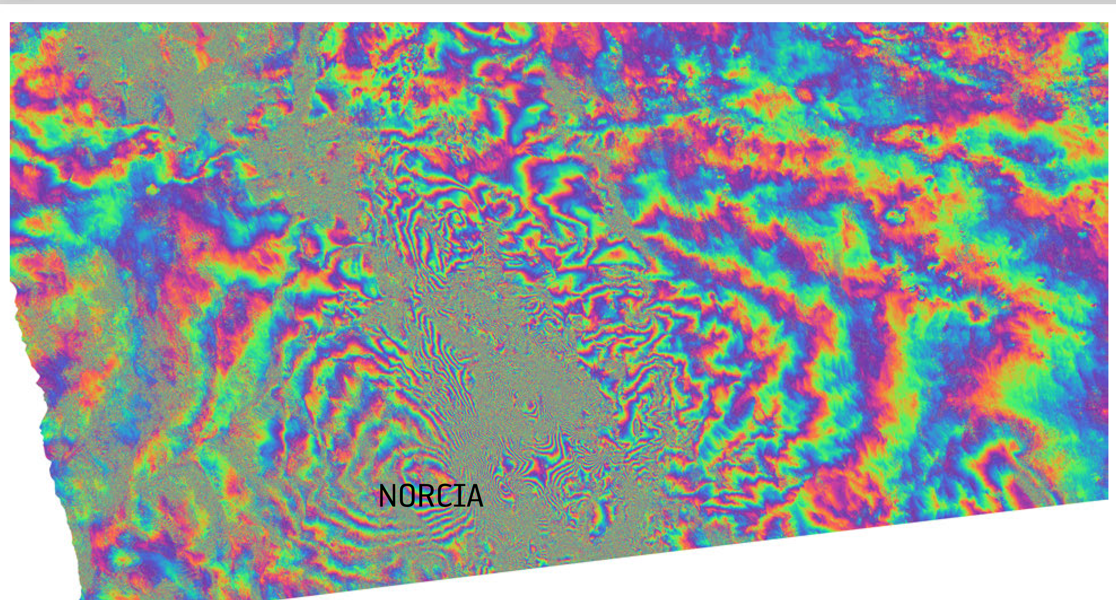
## INTRODUCTION

**The use of A-DinSAR (Advanced Differential Interferometric Synthetic Aperture Radar) techniques is considered an effective and valid tool for analyzing the evolution and seizure of geohazards phenomena since the early 1990s. The ESA Sentinel 1 A / B missions through Progressive Scans (TOPS) provide us frequently updated (6-12 days) high quality SAR acquisitions with a large ground coverage (250 X 250 km). The differential SAR interferometry (D-InSAR) is a technique that estimates the interferometric phase related to small scale (centimeter or millimeter) terrain movements happening within days, months or years by means of multiple SAR acquisitions and processing. Today, there are well-known methodologies for A-DinSAR such PS-InSAR, PSI, StaMPS and SBAS. They differ mainly on the number of tracks used, processing and phase modeling.**

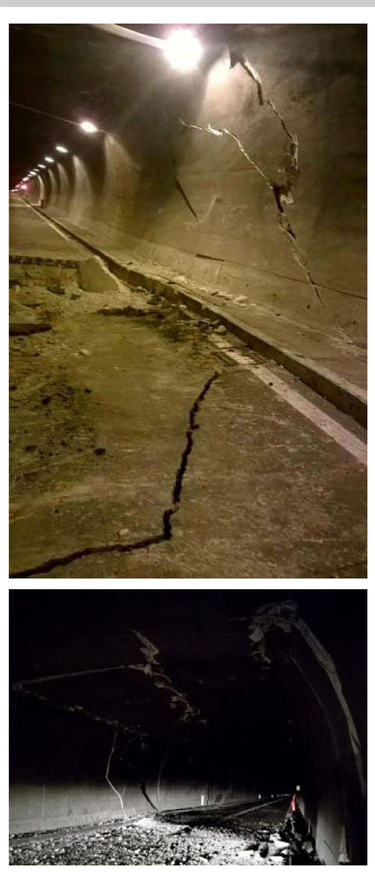
**This poster presents two examples of SAR measurements (performed with Sentinel -1 sensor) wich are related to land movements due to earthquake displacement (Visso 2016, 6.5 Mw) and landslide displacement (Sasso area, Urbino, Italy). In both cases, the deformation affected linear infrastructures. The coseismic displacement damaged the Forca Canapine tunnel (4.9 km) while in the Sasso area the land movement threatens directly part of the main access road to the old town of Urbino (Italy).**

## OBJECTIVES & METHODS

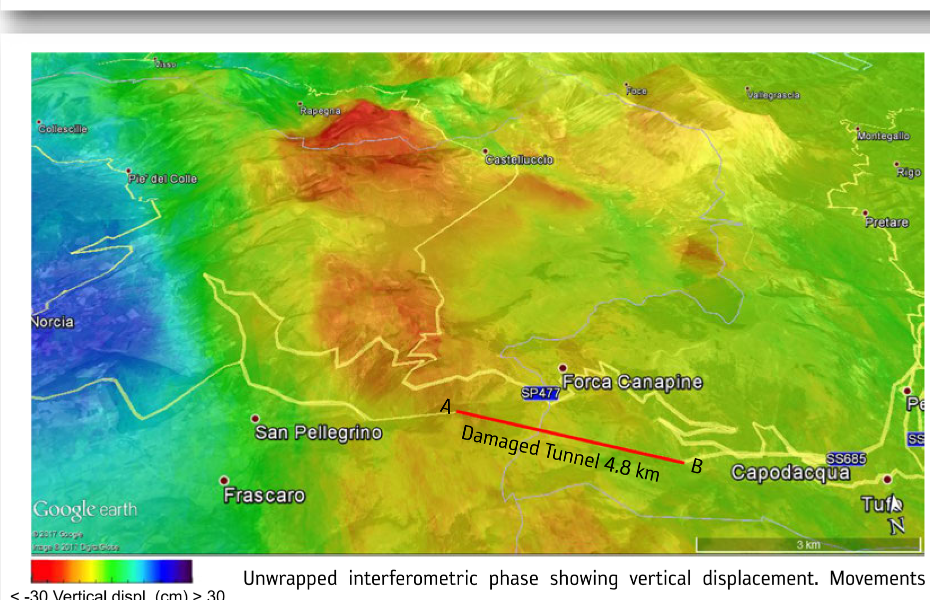
**The application of innovative remote sensing techniques is particularly promising for the analysis and monitoring of geological hazards that interact with linear infrastructure networks. The aim of my research is to evaluate the potential offered by new generation of satellites. The objective is also to develop techniques and new procedures for geological risk assessment on large areas. In particular, attention will be focused on identifying possible impacts on infrasturctures such pipelines and roads of soil deformations generated by seismic phenomena (active tectonic structures), subsidence and landslide. The methodology developed can also be extended to off-shore facilities monitoring (Platform, TopSide, Raiser, Fpso, SPM Single Point Mooring, etc.) or man-made subsidence induced by gas extraction or gas injection. The starting methodologies will be the classical ones of SAR (interferometry, amplitude anlaysis, change detection, temporary targets..), The real research goal will be then to develop statistical methods (GIS platforms) to speed up analysis in large areas by creating integrated easy-to-read risk maps of geological hazards potentially interacting with linear infrastructure networks, especially in remote or challenging areas. This approach could reduce costs not only for the monitoring of existing infrastructures but also for the assessment of planning solutions for new constructions.**




Sentinel-1 TOPS co-seismic interferogram of the Norcia earthquake in Italy (Mw 6.5) on the 30th of November 2016. Processing was performed with the ESA SNAP toolbox (http://step.esa.int/) including TOPS InSAR processing, removal of topographic phase, phase filtering and orthorectification.



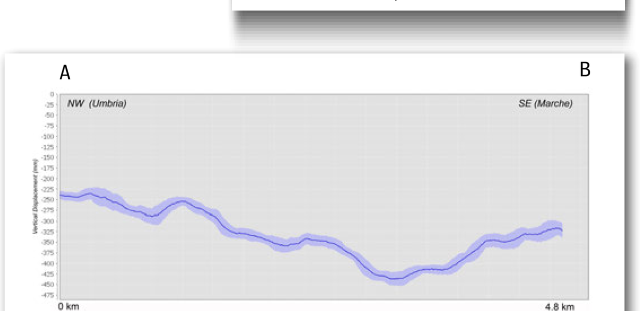
Photos of tunnel damage resulting from seismic displacement (credits: web)

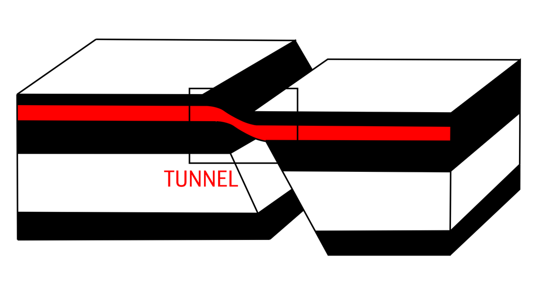



< -30 Vertical displ. (cm) > 30

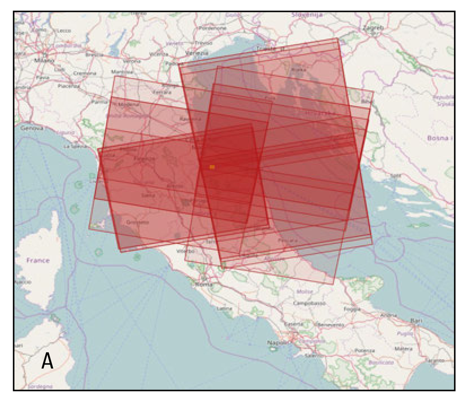
Unwrapped interferometric phase showing vertical displacement. Movements damaged the Forca Canapine tunnel (4.9 km).

A significant sequence of earthquakes occurred in the Sibillini Mountains in Central Italy from of August to October 2016. On August 24th, Mw6.1 earthquake struck the area between the town of Amatrice and Arquata del Tronto October 26th Mw6.0 earthquake nucleates in the Visso area approximately 30km northwest of the previous mentioned. October 30th, an event with Mw6.5 occurred near Norcia in an area between the former earthquakes epicenters, reactivating the existing ground fractures and producing further in a larger area. Several ground ruptures (offset between few centimeters up to 2 meters) have been distributed over a distance of more than 20km, throughout the landscape of the Sibillini Mountains chain.



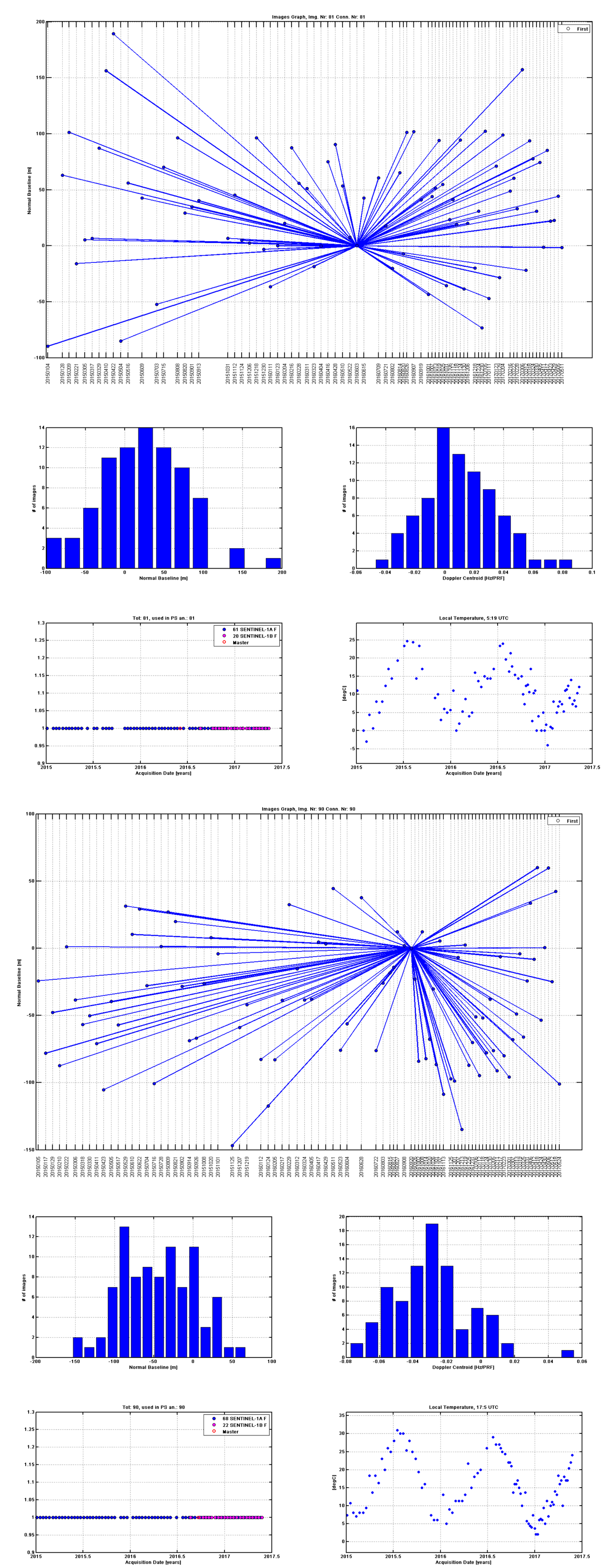




Vertical displacement profile along damaged tunnel track (retrieved by unwrapped phase) and simplified displacement model.

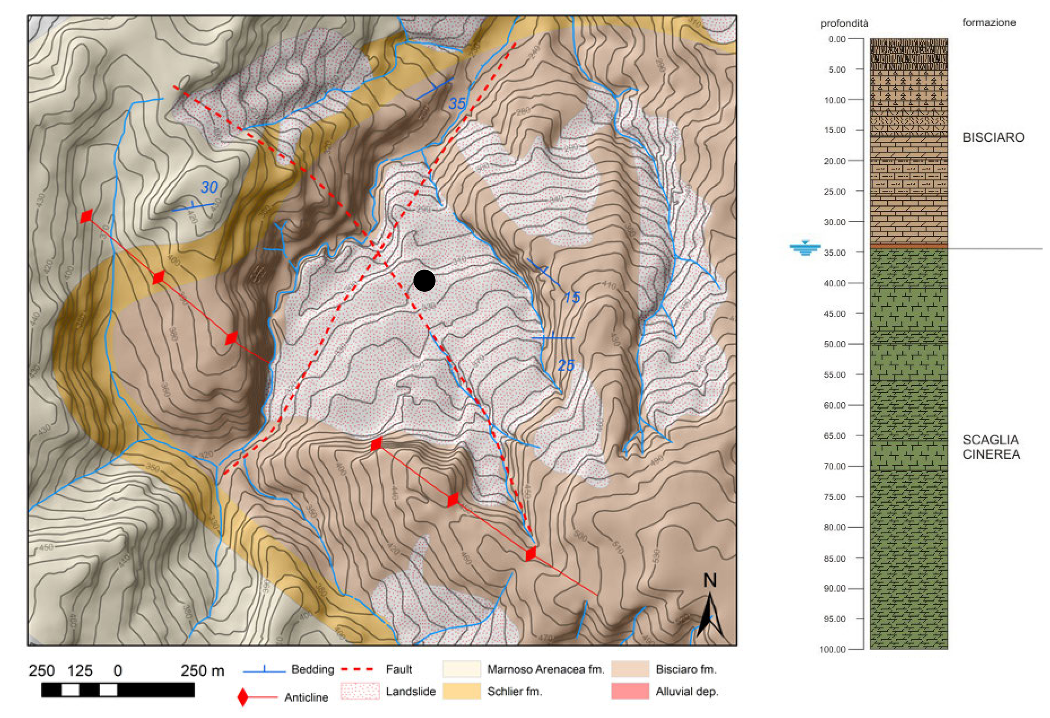




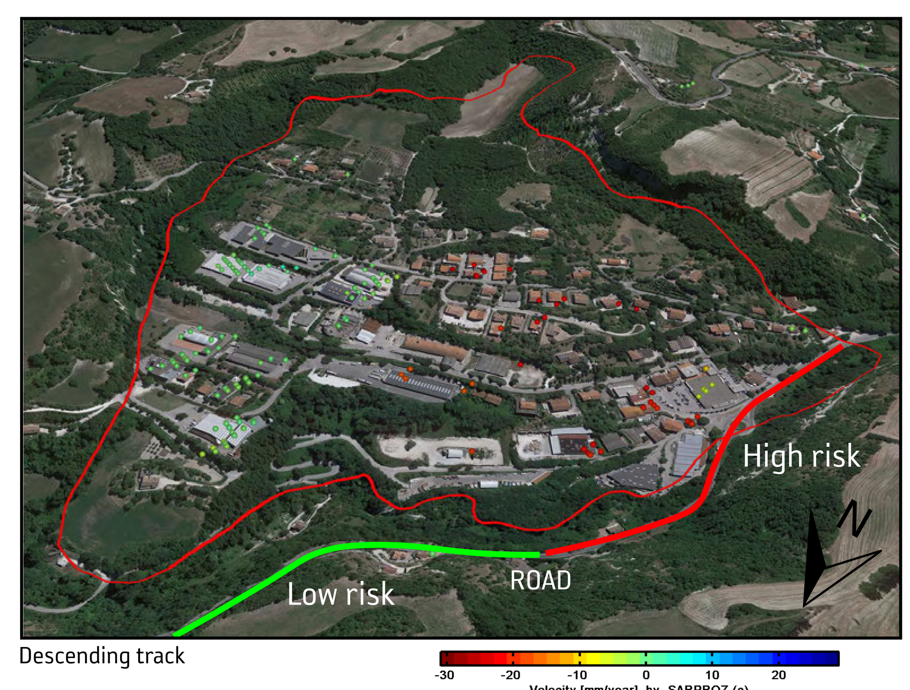
A. Sentinel-1 TOPSAR IW data for Central Italy.
B. Frontal view of the "Sasso area", a landslide area of Urbino (Italy).



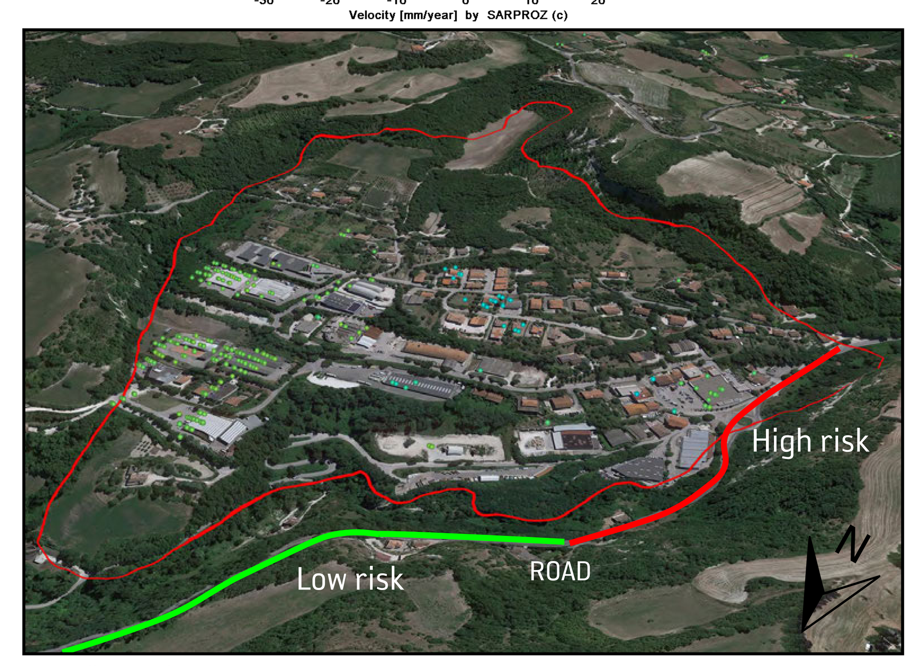
Interferometric PSI anlaysis parameters, descending track (top) and ascending track (bottom)



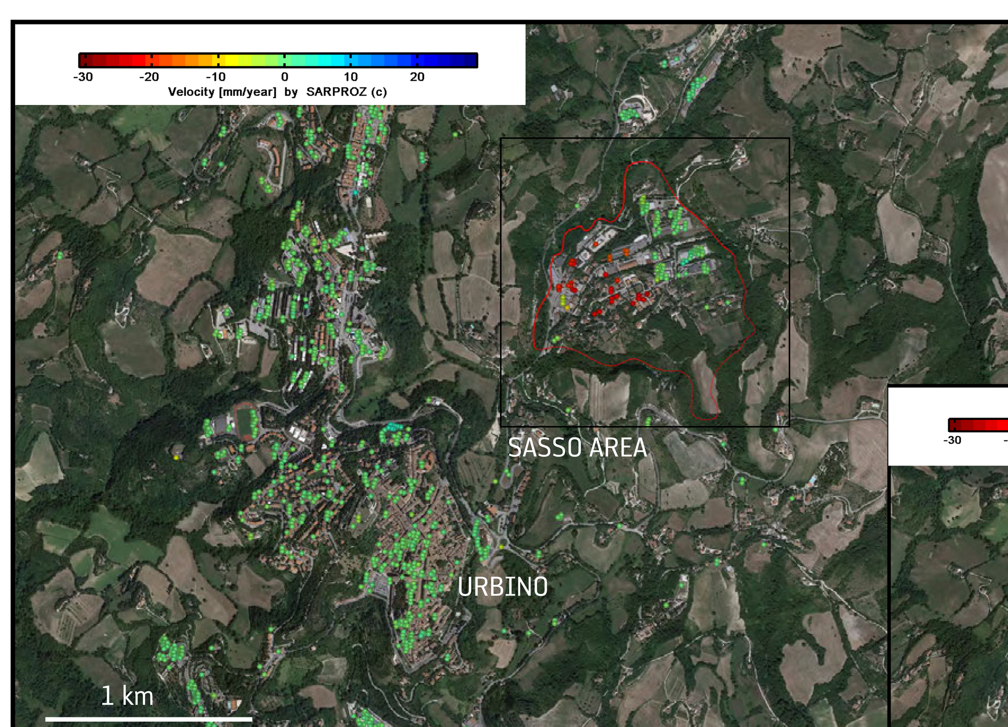

Geological map of Sasso area, Urbino (Italy)



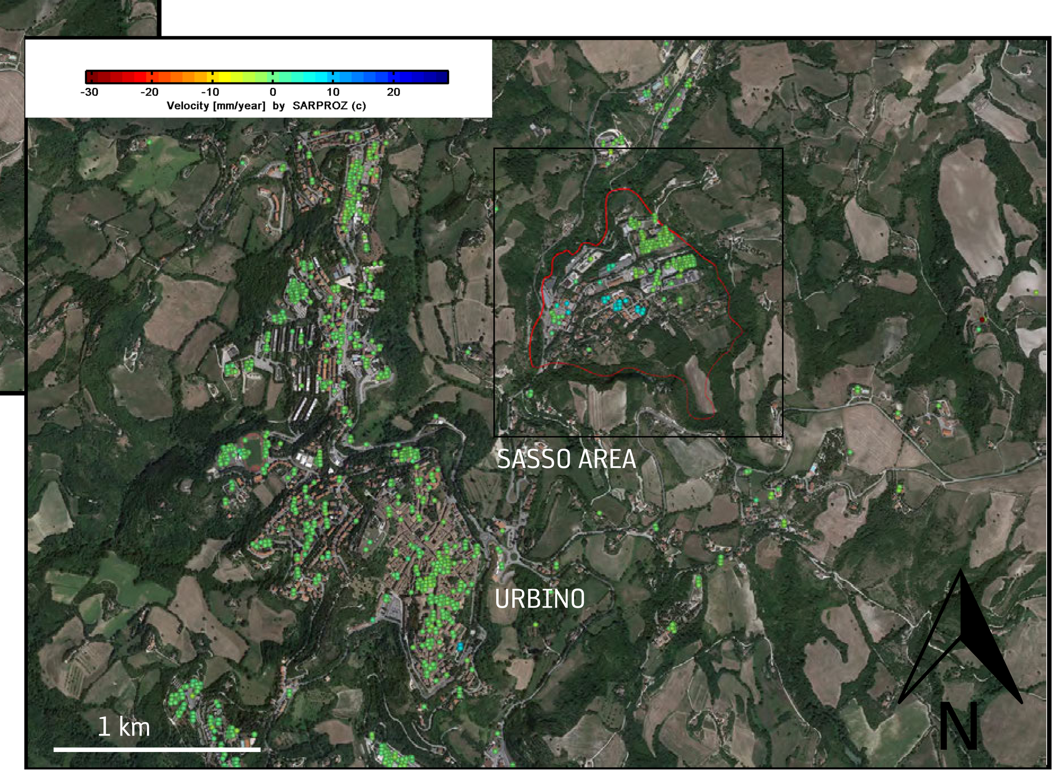

Descending track




Ascending track




Descending track




Ascending track

PSI analysis (2015/2017) of Urbino (Italy) conducted with Sentinel-1 data and SARPROZ software (Perissin et al., 2011). While the area of the historic center presents no deformation, the Sasso area is is characterized by a large unstable area which affects several buildings and threatens part of the main access road to Urbino. PS analysis shows northwest sliding movements in the order of 20 mm/years and allows to split the landslide area into an active sector and a non-active sector.

REFERENCES

**Menichetti M. , Piacentini D., De Donatis M., Roccheggiani M., Tamburini A., Tirincanti T. (2016)** Virtual Outcrop And 3D Structural Analysis Of Monte Vettore Extensional Active Faults. 35° Convegno Gruppo Nazionale di Geofisica della Terra Solida, Lecce 22-24 Novembre 2016

**Perissin D., Wang Z., Wang T., (2011)** The SARPROZ InSAR tool for urban subsidence/manmade structure stability monitoring in China. Proceedings of the ISRSE, Sidney, Australia.

**Roccheggiani M., Mantovani M., Perissin D., Tamburini A., Tirincanti E., Menichetti M., (2017)** Dati Sentinel-1 per l'analisi dell'evoluzione e il monitoraggio di fenomeni franosi in aree urbane, 12° Convegno Nazionale del Gruppo di Geologia Informatica, Gavorrano (GR) - 12/14 Giugno 2017