INSAR TIME-SERIES ANALYSIS FOR MANAGEMENT AND MITIGATION OF GEOLOGICAL RISK IN URBAN AREA

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1. ABSTRACT

The aim of this work is to illustrate the capabilities of advanced interferometric analyses for detection and mapping of ground deformations and their suitability for geological risk management and mitigation in urban areas.

Space-borne SAR (Synthetic Aperture Radar) Interferometry (InSAR) has been successfully used in the last years to measure ground deformations associated to processes with slow kinematics [1], [2]. The recent development from the standard single-interferogram approach to advanced time-series analyses of long temporal data stacks of radar images, solved the variability of deformations with time, overcame the intrinsic limits of the standard approach (i.e. temporal and geometric decorrelation) and increased the measurement accuracy from centimeter up to millimeter [3]-[11].

Here we describe an integrated methodology for the analysis of ground deformations at local scale, based on the use of both remote sensing and conventional *in situ* data. This integration allow us to obtain a complete knowledge of the investigated area, through the study of the spatial distribution and temporal evolution of ground deformations, the improvement of the spatial coverage of measures, the overcoming of issues related to difficulties and costs for installation of ground-based instrumentation and for data acquisition in unstable areas.

This methodology is applied on two test sites affected by hydrogeological risks, Naro and Agrigento, both located in Sicily (Italy), at the edge of the Apennine-Maghrebian thrust belt, on the Plio-Pleistocene and Miocene sediments of the Gela Nappe [12].

In February 2005, the town of Naro was affected by ground instability, which caused the opening of many fractures and serious damages within the historical (Vanelle St.) and south-eastern urban area. At the beginning, the causes of this instability were unknown and the most probable hypotheses about its origin were tectonics or a major landslide. Following the development of these fractures, the Regional Civil Protection Department activated the required mitigation measures in order to reduce impact on the elements at risk. The availability of historical data stacks of SAR images allowed the reconstruction of past ground deformations starting from 1992.

The InSAR time-series analysis highlighted the development of significant deformation rates (from 2 up to 6 mm/yr) between 2003 and 2007 and allowed the identification of the buildings which moved during the event of 2005 (Figure 1). The results showed that the affected area was larger than the one detected by *in situ* observations and it included most of the town (both in the historical and in the south-eastern area). The integration between InSAR results and conventional field investigations (e.g. geological, geomorphologic and structural surveys), highlighted that the event occurred on February 2005 was related to tectonics. Moreover, three areas with different hydrogeological risk level (very-high, high and medium) were mapped and their mitigation measures were finally identified and suggested to the civil protection authorities.

As well as in Naro, an integrated analysis was also carried out in the town of Agrigento, to support the emergency management connected with the ground instabilities affecting the urban area and involving the historical buildings of its north-western side, such as St. Gerlando's Cathedral, the Bishop's Seminary and many private infrastructures. The results of the interferometric analysis showed a general stability of the whole area between 1992 and 2007. Nevertheless, very high deformation rates (up to 10-12 mm/yr) were identified in 1992-2000 in the western slope of the town, the area of the Addolorata landslide (occurred in July 1966) [13], highlighting that this phenomenon was still active in 1992-2000 (Figure 2). Additionally, the time-series analysis performed in the north-western area of the town, showed that acceleration (up to 13 mm/yr) of the deformation rates was measured by some radar targets located near the Cathedral, starting from August 2006 and persisting until the end of the monitoring period (2007). The information about the state of activity of these landslides, were discussed with the Civil Protection authorities to plan some further field investigations and structural surveys to be carried out in the areas at risk.

Both the analyses, in Naro and Agrigento, provided useful results and confirmed the capabilities of this integrated approach for detection of ground deformations and for the management and mitigation of geological risk in urban area.

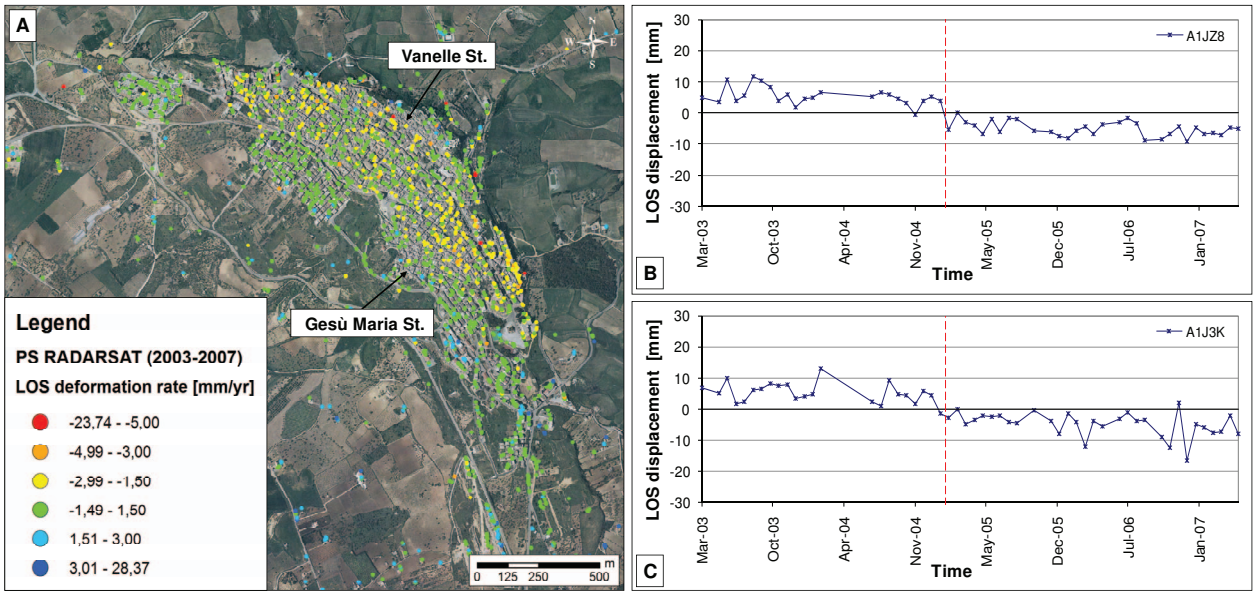

Figure 1 - A: PS ground deformation rates in the town of Naro in 2003-2007, measured along the Line Of Sight (LOS) of RADARSAT-1 satellite along ascending orbits (negative values indicate movement towards the satellite, while positive values indicate movement away from the sensor). B and C: Examples of InSAR time-series for two PS located over the buildings of Vanelle St., affected by ground deformations in February 2005 (red dashed line).

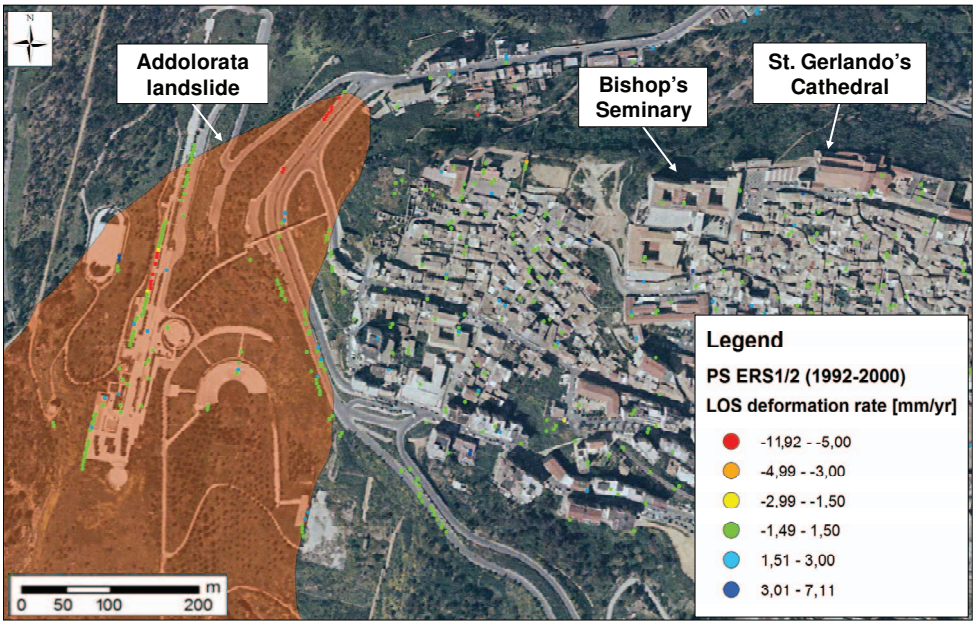

Figure 2 – PS ground deformation rates in the western and north-western areas of Agrigento in 1992-2000, measured along the Line Of Sight (LOS) of ERS1/2 satellites along descending orbits (negative values indicate movement towards the satellite, while positive values indicate movement away from the sensor). Time-series of some PS located in the crown area of Addolorata landslide show a mean annual deformation rate of about 8 mm/yr away from the satellite, confirming that this phenomenon was still active in 1992-2000.

2. REFERENCES

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