Monitoring landslide-induced deformation with TerraSAR-X Persistent Scatterer Interferometry (PSI): Gimigliano case study in Calabria Region (Italy)

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Landslide phenomena represent a major geological hazard worldwide, threatening human lives and settlements, especially in urban areas where the potential socio-economic losses and damages are stronger because of the higher value of the element at risk exposure and vulnerability. The impact of these natural disasters in highly populated and vulnerable areas can be reduced or prevented by performing a proper detection of such ground movements, in order to support an appropriate urban planning. Mapping and monitoring of active landslides and vulnerable slopes can greatly benefit from radar satellite data analysis, due to the great cost-benefits ratio, non-invasiveness and high precision of remote sensing techniques.

This work illustrates the potential of Persistent Scatterer Interferometry (PSI) using X-band SAR (Synthetic Aperture Radar) data for a detailed detection and characterization of landslide ground displacements at local scale. PSI analysis is a powerful tool for mapping and monitoring slow surface displacements, just particularly in built-up and urbanized areas where many radar benchmarks (the PS, Persistent Scatterers) are retrieved.

We exploit X-band radar data acquired from the German satellite TerraSAR-X on Gimigliano site located in Calabria Region (Italy). The use of TerraSAR-X imagery significantly improves the level of detail of the analysis and extends the applicability of space-borne SAR interferometry to faster ground movements, due to higher spatial resolutions (up to 1 m), higher PS targets density and shorter repeat cycles (11 days) of X-band satellites with respect to the medium resolution SAR sensors, such as ERS1/2, ENVISAT and RADARSAT1/2.

27 SAR scenes were acquired over a 116.9 Km2 extended area from the satellite TerraSAR-X in Spotlight mode, along descending orbits, with a look angle of 34°, from November 2010 to October 2011. The images were processed by e-GEOS with the Persistent Scatterers Pairs (PSP) technique, providing the estimation of annual velocities of LOS (Line Of Sight) ground displacements and related deformation time series for the whole acquisition period.

The methodology performed is based on the integration of recent radar PS data in X-band with historical SAR archives derived from ERS1/2 and ENVISAT data in C-band, and with geological and geomorphological evidences resulting from the existing auxiliary data (e.g. landslide databases, thematic maps and aerial orthophotos), finally validated with field checks and in situ observations in the study area. This operative procedure led to the detailed study of the spatial distribution and temporal evolution of ground movements phenomena in Gimigliano site.

The outcomes of this work represent a valuable example of detection and characterization of landslide-induced phenomena identified in detail by PSI analysis in X-band at local scale. This approach showed that PSI technique has the potential to improve the quality and timeliness of landslide inventories and consequently help for the implementation of best strategies for risk mitigation and urban-environmental design.