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Monitoring of ground displacements and identification of trend deviations during post-processing of satellite InSAR time series

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Satellite-based InSAR (Synthetic Aperture Radar Interferometry) and PSI (Persistent Scatterer Interferometry) techniques have recently demonstrated their potentials for mapping and monitoring ground displacements associated with geological processes, with millimetre accuracy. Most of the multi-pass approaches exploit simple linear functions of phase variation through time to model the deformation phase components and to extract time series of ground displacements for the Persistent Scatterers (PS) identified in the investigated area. Although linear models are usually chosen during the PSI processing, frequently some non-linear signals can be detected inside the time series, as long as they do not compromise the phase coherence of the radar targets (with respect to the deformation function) and cause their exclusion from the subsequent processing steps or, in some cases, the ascription of these non-linear components to other phase terms (e.g. atmospheric phase screen).

We are developing innovative post-processing approaches for the analysis and interpretation of PS time series and for the identification of potential trend deviations from the deformation models employed during the processing phase. These approaches are based on the temporal undersampling of the PSI monitoring interval into two or more subsamples and the subsequent comparison of their respective registered trends, with the aim of highlighting accelerations, changes and/or anomalies occurred during the observed period. We are testing our methodology on three Italian case studies, Agrigento, Naro and Caltanissetta, all located in south-western Sicily in the Caltanissetta basin, but affected by different typologies of ground instability, i.e. landslides, tectonics and mud volcanoes respectively. We used ERS 1992-2001 and RADARSAT 2003-2008 data, processed with the PSInSAR (Permanent Scatterers InSAR) technique, which belongs to the PSI approaches. The analysis made possible a better understanding of temporal and spatial deformation patterns; in particular, despite the linear model employed during the processing, the implementation of our methodology allowed: i) detection of rapid structural displacements and accelerations in the historic buildings of the Seminary and Cathedral of Agrigento, located at the edge of the steep slope of Girgenti hill, historically affected by widespread landslide processes; ii) identification of urban sectors of Naro affected and unaffected by the tectonically induced land instability of February 2005; iii) recognition of critical zones in the eastern sector of Caltanissetta urban area, where mud volcanoes caused significant damages in August 2008. As revealed by these first applications, the reliability and suitability of our methodology are influenced – and may also be limited – by the phase model for deformation components chosen during the processing to unwrap the interferometric phases and, secondarily, by the potential aliasing of PSI measures (i.e. phase-unwrapping errors) and consequent underestimation or misunderstanding of ground displacements.

The improved temporal sampling of PSI measures achievable using new high-resolution SAR data (e.g. 3-4 acquisitions per month with COSMO-SkyMed constellation), encourages a further development of these semi-automatic approaches for the advanced exploitation of PSI time series and the consequent support for monitoring and early warning activities in the framework of risk management and mitigation.