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Monitoring slope instability integrating InSAR, GNSS, Total Station and Levelling: a case study in the Eastern slope of the Mt. Amiata volcanic complex, Italy

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Landslides are considered one of the major hazards causing economic and human losses worldwide. Slope instability processes are affecting buildings and infrastructures in the towns of the eastern slope of the Mt. Amiata volcanic complex (Tuscany, Italy). These processes are relevant as they expose the inhabitants to risk, moreover their analysis provide hints about the mechanisms and roles of land sliding in the progressive disruption of extinct volcanic edifices.

In this study we present the first results of some monitoring and multi-temporal systems which are integrated to investigate the spatial-temporal ground displacement field in the eastern slope of the Mt. Amiata volcanic complex. In detail, we combine InSAR, GNSS, robotic total stations (TS) and levelling techniques to obtain a framework in terms of planimetric and vertical displacements. We apply the Multi-Temporal InSAR approach from 2014 to 2021 using the ESA Copernicus Sentinel-1 data. To perform the interferometry analysis, we implement the single master Stanford Method for Persistent Scatterers (StaMPS) approach for both ascending and descending geometries, and by combining both Line of Sight (LOS) results, we reveal the vertical and E-W components of the displacement. In addition, we perform multi-temporal survey-style GNSS measurements for some tens stations from 2019 to present day. About one hundred reflectors are continuously monitored by TS. Additionally, multi-temporal geometric levelling is performed to assess the vertical movements of selected relevant benchmarks. Finally, results from different monitoring systems are combined to model the ground displacements.

The InSAR results reveal mean velocity vectors with standard deviation less than 1 mm/y. The GNSS results have higher signal to noise ratio in the horizontal components with residuals lower than 10 mm. Accuracies of the geometrical levelling and TS results are ca. 1 mm and ca. 5 mm respectively. By combining the results, the magnitude of displacement field is ranging up to ca. 30 cm/y. The different systems provide results each other reasonably coherent in terms of magnitude and direction of the displacement vector. Integration of systems allows us to get solutions where one or more systems fail to provide data (i.e., when few or no PS are obtained by InSAR). Finally, we compare the results with seasonal data like rainfall. Velocities tend to reduce during summer

low precipitation periods, while they increase during winter. Long term quantitative monitoring activities will allow us to better understand the spatial-temporal evolution of the landslide processes in the perspective of developing an early warning system.