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Integration of the PSI technique and conventional ground-based methods for landslide characterization and monitoring: the case study of Santo Stefano d'Aveto; Northern Apennines, Italy

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Santo Stefano village is located in the Northern Apennines (Italy) and is built up on an ancient landslide, defined as a complex phenomenon that is an earth rotational slide evolving into a flow. The landslide has an extension of 1,3 km2 and a volume of about 10 million of m3. The landslide can be defined as active and according to Cruden & Varnes (1996) nomenclature the velocity range from very slow to extremely slow. The landslide poses and high risk to the buildings and infrastructures causing extensive direct damages.
The Santo Stefano d'Aveto village is located inside a glacial valley made mainly of ophliotic rocks, sandstones and marls and filled with glacial deposits. The landslide occurred in the glacial deposits composed of debris in a sandy-clayey matrix.
Santo Stefano d'Aveto landslide has been monitored through radar interferometry, in particular with the PS-InSAR technique (Ferretti et al., 2001) and through ground-based instruments such as inclinometers and piezometers.
The PS-InSAR analysis has been performed using ascending SAR scenes and descending SAR scenes from ERS-1/-2 (1992-2001), and ascending and descending SAR scenes from ENVISAT (2002-2008). All the datasets have been processed in the advanced mode APSA that means for each PS has been provided deformation time series relative to a reference date (zero). The target points within the Santo Stefano landslide have a high density. In general for all the analysed datasets it has been observed a decrease of velocity from upslope portion to the downslope one of the landslide. The maximum velocity recorded in the ERS dataset is around 38 mm/y, while the maximum velocity recorded in the ENVISAT dataset is around 20 mm/y.
The APSA analysis has provided information about the temporal evolution of target points. Both the majority of ERS and ENVISAT time series have shown a seasonal trend related to the variation of the water table level, which rises during rainfall season and decreases during dry season. The time series analysis show that the landslide deformation pattern is strongly controlled by the pore water pressure condition as demonstrated by the piezometric measurements. As usual an increase of water pressure condition led to a decrease of shear strength of the soil causing an increase of movement.
Six inclinometric instruments have been installed in 2001 and measurements have been acquired until 2006. A comparison between the deformation measured by the PS techniques and the inclinometric acquisitions has been performed examining the velocity measurements along the same line of sight. In particular in order to perform the comparison, the displacements of the inclinometers, taken along the maximum slope angle direction have been plotted along the line of sight of the satellite. The results show that the displacements measured by the two different type of techniques are consistent.
The PSI analysis performed has contributed to a more in depth investigation of the phenomenon, in particular the PS measurements and geomorphologic interpretation have allowed to redefine better the boundaries of landslide and the state of activity while the time series analysis has allowed to better understand the deformation pattern and its relations with the causes of the landslide itself.
Once the relationship between actual displacements vectors (measured by in-situ instrumenation) and l.o.s. components is known, the APSA analysis can provide a much larger dataset on ground movement allowing a better modelling of the surface displacements field.