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Analysis of LiDAR derived DEM geomorphometric parameters to assess the kinematic behaviour of a DSGSD

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Slope instability processes in mountainous areas are characterized by a complex interaction between different lithological, geomorphological, structural features, and processes. Deep-seated gravitational slope deformations (DSGSDs) are largest non-catastrophic slow rock-slope deformation, that until recently, under the present climatic condition, were considered inactive and not hazardous phenomena. Generally, the entire slope affected by DSGSD can be differently deformed with millimetric-displacements, that often cannot be observed by means of field surveys. This can generate in the risk management of these phenomena non-exhaustive safety awareness strategies, which on the contrary often focus only on the more short-period localized hazardous effects. DSGSD, in fact, evolve at different time scales and could present sudden and rapid secondary minor landslides. Therefore, a complete risk assessment strategy must comprise also the analysis of deep-seated impulsive phenomena. This type of behaviour can be observed effectively only using high-resolution data obtained by means of advanced remote sensing techniques. Among all these technologies applied in landslide analysis the more effective in the DSGSD studies are: ground-based interferometric radar (GB-InSAR) and Light detection and ranging (LiDAR).
On 4th November 2010, after the October-November 2010 rainfalls, the Rotolon deep-seated gravitational slope deformation (Vicentine Pre-Alps, NE Italy) reactivated with a sudden ground movement. A 450,000 m2 mountainous area moved some meter downslope, but the undeniable signs were only connected to the triggering of a debris flow from the bulging area detrital cover, and the presence of a continuous perimeter fracture near the crown area. Therefore, the 2010 event apparently was limited to secondary and localized phenomena, so that an early-warning system (a GB-InSAR and an automatic monitoring network composed by extensometers and a robotic total station) were installed to monitor the residual risk. Moreover, a 3D landslide runout numerical model was performed to identify the source and impact areas of further debris flow, the flow velocity, and the deposit distribution within the Rotolon creek valley. Nevertheless, the analysis of the DEMs parameters, derived from two detailed LiDAR surveys (2x2 m), performed just few days before and after the event, allowed to highlight some morphological changes occurred after the 2010 reactivation, and associable not only to shallow movements but also to deeper ones. The kinematic behavior reconstruction and the geomorphometric parameters analysis were performed in a GIS environment, integrating morphometric terrain parameters (slope, aspect, surface roughness, topographic wetness index, hillshade, and curvature) with the results of an accurate geomorphological field survey. This analysis pointed out not only shallower movements in the bulging area, but also regular morphological changes occurred in six main areas of the whole DSGSD, and connected to deeper continuous displacements along the maximum slope gradient, confirming the DSGSD reactivation. Moreover, the displacements connected to the DSGSD reactivation did not cease immediately, in particular far from the break/crown zone (as shown by the integration of the morphometric terrain parameters and the GB-InSAR data), but continued with very slow deformations until the new equilibrium was reached, testifying the impulsive behavior of the landslide.