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Integration between laser-scanner image and geophysical data for large landslide analysis

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The large slow slope movements are a particular typology of alpine landslide; they are very difficult to analyse because of the lithological and kinematical complexity, connected to the local geological postglacial evolution that often determined an high degree of instability in the quaternary cover. Synergic approaches can be used to characterise the physical parameters of these large landslides and to monitoring their activity. The mainly of these methods involves the imaging of the surface morphology, the analysis of hydrological processes, the geo-mechanical and geophysical investigation of the subsoil. The goal of this paper is to describe the adopted integrated approach using LIDAR survey and geophysical techniques to estimate the morphology and the subsurface condition of one representative large landslide in the western Alps, near the Pleyne village in the Varaita valley. The instability processes involve a quaternary detrital cover, more of 30 metres thick, made up of morainic and colluvial materials characterised by coarse soils with abundance of boulders and erratics, overlying the schistose bedrock. The landslide activity is monitored by means of several inclinometers; the registered movements differ in the various parts of the slope, with an average velocity of some decimetres in the last ten years. The metric survey techniques usually describe the shape of a surface using a set of points located in a 3D reference system. In landslide application, the density and the accuracy, the cost and the acquisition speed are usually contrasting properties. In the last decade, the technological advances overcome these gaps. The digital photogrammetry, LIDAR and SAR techniques allow to obtain a data set of points with high densities (e.g. 10 or more points/m2) and high accuracy levels (e.g. few centimetres). The methods permits to describe the shape of the slope by means of simple (e.g. TIN) or complex surfaces (e.g. NURBS): the accuracies are today at a sufficient level in order to satisfy the most

of the geological and geo-morphological applications requiring these kind of basic geometrical models. In the specific context of the landslide of Pleyne, the application of a terrestrial LIDAR technique was adopted. The landslide surface was modelled by using the set of points acquired and geo-referenced in the cartographic reference system: the achieved accuracy for the three coordinates is of about 2 cm. The shape model was used as the basis for the preliminary geo-morphological analysis; profiles and sections useful to understand the phenomenon have been reconstructed from the modelled surface. The position of the geophysical measurement station were located with the accuracy of 0.2 m. The surface model permitted to image the surface of the slope for the application of the water run-off and for estimating the volumes of the slope potentially unstable. Moreover, the model could be used as the reference surface in the long-term monitoring activity to evaluate and locate the landslide movements. According to the accuracy of the technique, a new survey of the slope will be useful to estimate the new surface morphology only if average movements of at least 5 cm are expected. Therefore, the monitoring by the inclinometers is performed in order to check the velocity of the slope movements and decide the new extensive LIDAR survey. The geophysical survey involved the application of seismic tomography and surface wave analysis to estimate the mechanical properties of the glacial-till overburden. The application of electrical resistivity tomography on the slope detected the spatial distribution of the more conductive layers potentially hosting the groundwater. The results were calibrated by the comparison with stratigraphy and by the monitoring of the groundwater level in the boreholes.

The density distribution of the overburden was estimated by laboratory analysis on boreholes samples; the application of semi-empirical relationship between density and depth allow the vertical density profiles to be estimated. The integration between the compressional and shear wave results permitted to reconstruct the vertical distribution of the Poisson coefficient up to a depth of 10 meters. Finally starting from the seismic characterisation and the estimated density profiles the bulk and shear modulus were evaluated. An attempt to determine the skeleton properties of the material in dry condition has been performed, by the application of non linear correlation between the seismic parameters, the porosity and the estimated water content.