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Monitoring water flows with time-lapse Electrical Resistivity Tomography on the Super-Sauze landslide

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This work presents results of a permanent hydro-geophysical monitoring of an active landslide developed in clay-shales. Hydrology has been proved to be a major factor controlling the Super-Sauze earthflow behavior, but it knowledge still limited mainly because of the importance of spatial heterogeneities. The geometry of the bedrock creates internal crests and gullies that can guide waterflows or create a lock and engender an excess of pore water pressure; the soil surface characteristics plays also a large role in the surface hydraulic conductivity, and therefore, on the infiltration pattern. To understand in detail these processes, it is therefore important to monitor spatially at large scale (with high resolution) those phenomena and to overcome the monitoring difficulties inherent to a fast-moving clayey earthflow.

The objectives of the survey are to identify and characterize spatially and temporarily the water flow circulation within the landslide body over a period of one year. The studied profile measures 114 m long and is surveyed with 93 electrodes spaced from 0.5, 1 or 2 meter according the soil surface cracking. Four resistivity datasets of 4300 measurements are acquired each day using a gradient array since May 2011. The monitoring is performed with the GEOMON4D system, developed by the Geological Survey of Austria. To facilitate the interpretation, humidity, conductivity, temperature, and piezometer sensors are placed along the profile. Two dGPS antenna placed upstream and downstream the profile allow to correlate the results with soil displacement. Lefranc tests and granulometry results realized on several samples have shown the important heterogeneities of the near surface.

The objective of this work is to present the data processing strategy for the analysis of long periods time-lapse ERT survey of natural rain events taking into account changes through time of the position of the electrodes, changes in the soil surface state and important changes in sub-surface soil temperature.

Two high-resolution optical cameras are installed on stable crests on the side of the cross-sections and time-lapse stereoscopy is used to reconstruct the displacement field to locate the electrodes in space and time (in order to take into account changes in the dipole geometry). The apparent electrical resistivity values were inverted with a time-lapse approach using an initial model constructed from statistical analysis of resistivity data and a priori knowledge on the landslide structure from a previous geotechnical model. The near surface apparent resistivity can vary of ten percent without any input of water. This shows the importance of temperature effect on the measurement. The temperature correction is handled from a complete study of the soil temperature propagation solving the heat equation with several temperature probes placed at different depths in soil and in the water table. The results are interpreted in combination to hydrological data (rain, water table level).

The acquisition of 8 ERT all over the studied area, in different directions permits to create by interpolation a 3D electrical resistivity model of the area. This model shows the importance of the bedrock topography because high water content areas are visible at the theoretical hydrological network computed from the 3D geotechnical model of Travelletti and Malet (2011). Transversal waterflow circulation not predicted are also visible and permit to interpret the results taking into account the 3D structure of the landslide.

A 250 m long P-wave tomography acquired on the studied profile and inversed with a quasi-Newton algorithm that uses Fresnel wavepaths and the finite bandwidth of the source signal, specially developed for the study of very heterogeneous soils, shows a very good correlation with electrical resistivity and permits to propose a geotechnical model of the profile.

Spatially heterogeneous water flow patterns are identified and the presence of a deep water supply is hypothesized downstream of the investigated profile. The presentation will focus on some key factors and parameters to take

into account for the analysis of time-lapse resistivity data.

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