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High-frequency HYDRO-geophysical observations for an advanced understanding of clayey landSLIDES: the HYDROSLIDE research project

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As a consequence of change in hydrological cycles and the increase of exposed goods, the risk of landslides is globally growing all over the world. As a consequence, short-time landslide prediction is a fundamental tool for risk mitigation. To this aim, real-time monitoring and interpretation methods aiming at a full exploitation of the available landslide information are needed, including further development of sensor technology and use of advanced numerical modeling.

The most commonly used warning parameters are direct measurements of slope displacement and pore-water pressures. However, recent research on landslide controlled by slope hydrology has shown that other parameters (e.g. soil moisture) can be used and other methods (e.g. electrical resistivity tomography, electrical spontaneous potential) are available, which might give indications on triggering even before an actual displacement is measureable and thus could possibly be used as physical precursors for short-term warning.

The CNRS – Ecole et Observatoire des Sciences de la Terre (EOST) and the Geological Survey of Austria – Geophysical Division (GBA) started successfully to evaluate time-lapse resistivity measurements for monitoring changes in water content/flows in landslides at different monitoring sites. At the same period, CNRS also started to establish the French Observatory on Landslides (OMIV: omiv.unistra.fr), which task is the long term monitoring and data sharing of landslide parameters (geodesy, hydrology, seismic).

Results from these projects proved that electrical resistivity monitoring can be successfully applied to detect changes in water storage and to understand water circulation in complex landslide bodies. However, especially for clayey landslides, this method is only applicable with limitation, since the resistivity of clays shows almost the same values as the resistivity of the saturated soil (15-20 O.m). Consequently, the change in water content expressed in the electrical resistivity is difficult to identify.

Therefore the extension of the concept of resistivity to Induced Polarization (IP) (both in the time and spectral domains) is proposed in order to better understand the relationships between physical and hydro(geo)logical properties of the slope material. To understand the landslide triggering mechanisms, surface and in-depth deformation have to be monitored. Up to now, most of the landslides monitoring sites are equipped with GNSS receivers and total station benchmarks at the surface or inclinometers at depths, which provide only point (1D) information and/or have limitations at high displacement rates. To solve interpretation ambiguities and to account for spatial changes, not only point information, but also horizontally and vertically (borehole) distributed displacement/strain observations are necessary. New approaches are suggested in the project, namely temperature and strain monitoring at high frequency
with Fiber-Optic (FO) cables both at the surface and in boreholes, sensing of surface deformation with Ultra-High Resolution (UHR, 20 cm) optical images (time-lapse ground based cameras). The combined application of these methods for landslide monitoring is very rare and has not been tested rigorously.

Further, the joint interpretation of electrical resistivity, soil temperature, hydrological and strain data need to be supported by coupled multi-physical modelling in order to quantitatively establish petrophysical relationships for several slope configurations, material properties and groundwater conditions.

The applicability of the approach is discussed for landslide sites representative of different hydrological forcings: La Valette (South French Alps; Alpes-de-Haute-Provence) and Lodève (South Central Massif, Hérault).