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Long term monitoring of landslide: observation gravitational slope cycles

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Since several years of studies on landslides, we realized the role and subtle interactions that existed between the structural complexity, masses dynamics and complex internal circulation of fluids. Thus, to gain a better understanding of the processes taking place during the evolution of an unstable slope, an observational study is necessary. In this perspective, our team currently monitors slow moving landslide zones. The aim of such a monitoring is to gain a better knowledge of the links between external forcing (meteorological, seismological) and signals going out of the slope (kinematic, vibrations, electrical resistivity).
In December 2000, a dramatic event affected the sandy/clayey landslide in the Southern Alpes Maritimes (France). A 10 meters high scarp appeared at the foot of the landslide and affected private yards nearby. This area then became a major concern for local authorities and understand the processes taking place, a scientific challenge. In order to understand the land-sliding reactivations and to quantify the natural cycles of deformations, we analyse the main factors of this complex system. After 10 years of observation we are now able to highlight some of the complex behaviours by the measurement of physical parameters (geophysical monitoring). A permanent 115 m ERT line (5 meters electrode spacing) has been installed and provides an acquisition daily since 2006. The daily acquisitions are now accompanied by continuous measurements from boreholes (thermometers, piezometers, tiltmeters) and pluviometry. We are able to control the whole monitoring from the lab, and all these data are transmitted in real time.
The analysis of these large amounts of data over large time series allows the detection of seasonal cycles of surface activity. The deformation taking place can be assimilated to a near-elastic deformation and show a lateral decoupling on both sides of the fault cutting the landslide. These deformation cycles can be associated with the variations of the shallow piezometric level.
The analyze of the temporal and spatial evolution of the apparent electrical resistivity revealed: (1) different compartments in depth and the position of the fault cutting the calcareous substratum, (2) the presence of a deeper conductive area link by the fault to the landslide body and interpreted as a saturated zone. In this study we aim at showing that analyzing these different deep clusters of resistivity may help us to understand the surface dynamics of the landslide.
This new study explains the major role of the faults within the landslide, as well as the chronology of the water flow in the massif, inducing a delay between atmospheric solicitations and the movement itself. This allows a better understanding of the complex and uneven in time dynamic in such areas.

Keywords: landslide, geophysical monitoring, ERT, meteorology, dynamic cycles.