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Monitoring of slow-moving landslides. The importance of integration between surface and depth measurements

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In landslide monitoring, the attention is mainly focused on rapidly evolving phenomena. However, slow and very slow landslides are equally significant as they often involve settlements and infrastructures. Additionally, they are characterized by remarkable extension and depth. Due to their low displacement rate, often they are underestimated as impacting events; but in a longer timespan, their continuous and slow activity may lead to damages to buildings and roads thus worsening the living conditions of the involved area. In order to assure a peaceful coexistence between phenomena and inhabitants, a multi-source monitoring network is recommended, by integrating surface data with subsoil ones in order to better understand the whole and real kinematic. Moreover, the data acquisition rate should be high enough to detect early any increases in displacements rate. Surface monitoring approaches are extremely wide (GNSS, remote sensing, InSAR…); on the contrary subsoil measurement systems, are few and limited to in-place inclinometers. Concerning them, the Geohazard Monitoring Group (IRPI-CNR) has developed and manufactured a robotic measuring system for the acquisition of deep-seated ground deformations and, particularly, deep horizontal displacements. The instrumentation combines the advantages of the traditional measurement technique (double readings 0/180˚) with a robotized approach improving the results in terms of revisit time, repeatability and accuracy. The robotized device also called “Automated Inclinometer System” (AIS) allows the automatic check of all the length of the borehole (up to 120m tube length) with just one inclinometer probe. The traditional cable (including probe signal and power supply) is replaced with a thin polyethylene cable (φ 2mm) for sustaining and moving the probe up/down into the standard inclinometer borehole. AIS is completely automatized, but can be also controlled by a remote web interface and, with the same mean, transmits measurement results and system diagnostic messages, such as alerts, warnings, etc. The described system is, currently and extensively, employed in landslide monitoring networks in European mountain ranges obtaining interesting results. In fact, thanks to the described features it is able to rapidly define the deep and surface kinematics of the observed phenomena and, consequently, evaluate the displacements accelerations. Furthermore, due to its high-frequency measurement, it is possible to find a relationship between rainfalls/snow melting and piezometric water levels measured by nearby stations. AIS represents a trustworthy option to realize a more complete integrated network for landslide interpretation and monitoring.