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FIELD MONITORING OF HYDRAULIC SOIL CONDITIONS IN A LANDSLIDE-PRONE TERRACED SLOPE: INSIGHTS FROM MONTEROSSO AL MARE (ITALY)

Matteo Fiorucci[1], Giacomo Pepe[2], Gian Marco Marmoni[3], Jagadish Kundu[3], Diego Di Martire[4], Giuseppe Bausilio[4], Luigi Guerriero[4], Enza Vitale[4], Emanuele Raso[5], Luca Raimondi[2], Andrea Cevasco[2], Domenico Calcaterra[4], Gabriele Scarascia Mugnozza[3]

[1]University of Cassino and Southern Lazio, Civil and Mechanical Engineering, Cassino, Italy, [2]University of Genova, Department of Earth Environment and Life Sciences, Genova, Italy, [3]Sapienza University of Rome, Earth Sciences Department and CERI Research Centre for Geological Risks, Roma, Italy, [4]Federico II University of Naples, Department of Earth, Environmental and Resource Sciences, Napoli, Italy, [5]Cinque Terre National Park, Riomaggiore, Italy

Purpose: Shallow landslides due to heavy rainfall represent a common geological hazard that frequently interferes with the anthropic component of the environment, especially in mountainous and hilly regions. In recent years, the frequency of strong rainfall events has increased due to global climate changes amplifying their impact on the environment regarding landslides and other natural disasters. Thus, the importance of understanding cause-to-effect relations between the meteo-climatic stressors acting on soil cover and the induced hydraulic response and failures is evident to mitigate the related geological risk and to calibrate adequate trigger thresholds suitable for early-warning systems.

Methods: With this purpose, a multi-sensor monitoring station devoted to recording both meteorological forcings and hydraulic parameters of the soil has been operating since 2018 on a typical terraced slope located within the Pastanelli-Morione stream catchment in Monterosso al Mare (Cinque Terre, Liguria region, Italy). The Cinque Terre are well-known worldwide and represents a clear example of a man-made shaped area made-up of century-old agricultural terraces retained by dry stone walls. For this reason, a National Park was established in 1999, two years later by its declaration as a World Heritage Site by UNESCO. In the past, several landslide events occurred in this area like the 25th of October 2011 flash flood event, when hundreds of shallow landslides were triggered by extreme rainfall. The installed multi-sensors monitoring system consists of: i) a fully equipped weather station; ii) soil temperature sensors; iii) soil moisture sensors; iv) soil water potential sensors. The devices are installed at different depths to reconstruct a vertical log of the monitored data. All sensors are cable-connected to a datalogger with a 10-minute sampling step and transmitted to a local server by a GPRS wireless connection system that enables remote control of datasets by the users. Before the installation of the monitoring sensors, an engineering geological characterisation of the soil cover was performed through laboratory tests, geotechnical investigations, and geophysical field surveys.

Results: Deductions on hydraulic soil behaviour as a response to meteorological conditions were inferred from the time series acquired over these first years of monitoring, considering a typical geological cross-section of the slope in which the thickness of the soil covers was determined through seismic refraction surveys and dynamic probing tests. In particular, the rainfall regime was characterised in terms of extreme events and prolonged ones and specific cause-to-effect relations with the soil moisture and soil water pressure were derived over two different time scales: i) single rainfall event (i.e., hydraulic response of soil to a specific pluviometric input); ii) seasonal time scale (i.e., typical seasonal oscillation over a year). Soil Water Characteristic Curves (SWCCs) were also reconstructed to estimate how hydrological hysteresis processes affect the investigated soils.

Conclusions: In the future, the monitoring series' systematic analysis will help define the hydromechanical soil behaviour, both in saturated and unsaturated conditions, even in this context of terraced slopes, and evaluate pluviometric thresholds for slope stability purposes at the catchment scale.