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Field hydrometeorological monitoring of a slope covered with shallow pyroclastic deposits

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Many mountainous areas in Campania, Southern Italy, are characterized by steep slopes covered by layered granular pyroclastic deposits, usually in unsaturated conditions, mainly consisting of ashes (sand to loamy sand) and pumices (sandy gravel), with total thickness between 2.0 m and 2.5 m, laying upon fractured limestone bedrock. Such covers originate from the deposition of materials from several eruptions of the two main volcanic complexes of Campania (the Somma-Vesuvius and the Phlegrean Fields) occurred during the last 50000 years. The equilibrium of such slopes, up to inclination angles of 40°-50°, is usually guaranteed by the contribution of soil suction to shear strength. Shallow landslides are frequently triggered by intense and persistent rainfall events, often turning into destructive debris flows that cause huge damage and casualties. To capture the main effects of precipitation on the stability conditions of these slopes, hydrological monitoring activities have been carried out at the slope of Cervinara, around 40 km northeast of Naples, since 2001, by measuring precipitation depth, soil volumetric water content and capillary tension. This slope was involved in a catastrophic flowslide on 16 December 1999, triggered by a rainstorm of 325 mm in 48h.
Since December 2017, new monitoring activities started. An automatic hydro-meteorological station was installed at the elevation of 600m a.s.l., near the scarp of the 1999 landslide. The meteorological station is equipped with a rain gauge, a thermo-hygrometer, a thermocouple for soil temperature, an anemometer, a pyranometer, and a barometric sensor. Moreover, hydrological monitoring equipment was installed, including six jet-fill tensiometers (depths between -0.6m and -3.0m below the ground surface) and six metallic TDR probes (depths between -0.5m and -2.1m) for measurements of soil suction and volumetric water content. A data logger ensures the automatic acquisition and storage of data, with a time resolution of 1h. Aiming at the assessment of the hydrological balance of the slope, the water level in two streams located at the foot of the slope is also manually monitored every two or three weeks.
The current monitoring activities will be useful to deepen the knowledge about the hydrological processes involving the unsaturated pyroclastic deposits, to understand the water exchanges between the slope cover and the surrounding hydrological systems (i.e. with the atmosphere through the plants, with the groundwater through the soil-bedrock interface, with surface water circulation through overland runoff and subsurface drainage). In this respect, a mathematical model of the hydrological behavior of the slope of Cervinara, that takes into account these water exchanges, is proposed. The model, which has been developed on the basis of the monitoring data, consists of the 2D Richards' equation, written for a single homogeneous soil layer, and assumes that the water potential at the soil-bedrock interface is affected by the water level in an ephemeral aquifer developing within the underlying fractured limestone bedrock during the rainy season. In fact, coupled modeling of the vadose zone and the shallow groundwater system provides a better description of the behavior of the unsaturated soil cover, than uncoupled approaches with static boundary conditions.