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High Performance Computing for probabilistic distributed slope stability analysis, an early example

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The term shallow landslides is widely used in literature to describe a slope movement of limited size that mainly develops in soils up to a maximum of a few meters thick. Shallow landslides are usually triggered by heavy rainfall because, as the water starts to infiltrate into the soil, the pore-water pressure increases so that the shear strength of the soil is reduced leading to slope failure.
We have developed a distributed hydrological-geotechnical model for forecasting the temporal and spatial distribution of shallow landslides to be used as a real time warning system for civil protection purposes. The stability simulator is developed to use High Performance Computing (HPC) resources and in this way can manage large areas, with high spatial and temporal resolution, at useful computational time for a warning system . The output of the model is a probabilistic value of slope instability.
In its current stage the model applied for predicting the expected location of shallow landslides involves several stand-alone components. The base solution suggested by Iverson for the Richards equation is adapted to be used in a real time simulator to estimate the probabilistic distribution of the transient groundwater pressure head according to radar detected rainfall intensity. The use of radar detected rainfall intensity as the input for the hydrological simulation of the infiltration allows a more accurate computation of the redistribution of the groundwater pressure associated with transient infiltration of rain. A soil depth prediction scheme and a limit-equilibrium infinite slope stability algorithm are used to calculate the distributed factor of safety (FS) at different depths and to record the probability distribution of slope instability in the final output file. The additional ancillary data required have been collected during fieldwork and with laboratory standard tests. The model deals with both saturated and unsaturated conditions taking into account the effect of soil suction when the soil is not completely saturated.
Two pilot sites have been chosen to develop and test this model: the Armea basin (Liguria, Italy) and the Ischia Island (Campania, Italy). In recent years several severe rainstorms have occurred in both. In at least two cases they have triggered numerous shallow landslides that have caused casualities and damaged roads, buildings and agricultural activities.
To test the effectiveness of the model, near-real time simulations have been performed in the two test sites using data measured during the past rainfall events: December 2006 for the Armea basin and April 2006 for the Island of Ischia. The landslides triggered by rainfall during these two events were known thanks to the data collected during the fieldwork and to the photo-interpretation performed on satellite images. Through the analysis of the factor of safety maps obtained during these simulations, it has been possible to evaluate the behavior of the model in response to different and complex rainfall patterns. Moreover, the comparison of the results with the new landslide inventory map, has provided a spatial validation of the model for the Armea basin.