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A spatially distributed and physically based tool to modelling rainfall-triggered landslides

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Landslides are a serious threat to lives and property throughout the world. Over the last few years the need to provide consistent tools and support to decision-makers and land managers have led to significant progress in the analysis and understanding of the occurrence of landslides. The causes of landslides are varied. Multiple dynamic processes are involved in driving slope failures. One of these causes is prolonged rainfall, which affect slope stability in different ways. Water entering the ground beneath a slope always causes a rise of the piezometric surface, which in turn involves an increase of the pore-water pressure and a decrease of the soil shear resistance. For this reason, knowledge of spatio-temporal dynamics of soil water content, groundwater and infiltration processes is of considerable importance in the understanding and prediction of landslides dynamics. Many methods and techniques have been proposed to estimate when and where rainfall could trigger slope failure. In this paper a spatially distributed and physically based approach is presented, which integrates of a failure model with an hydrological one. The hydrological model used in the study is the tRIBS model (Triangulated Irregular Network (TIN-based) Real-Time Integrated Basin Simulator) that allows simulation of spatial and temporal hydrological dynamics influencing the landsliding, in particular infiltration, evapotranspiration, groundwater dynamics and soil moisture conditions. In order to evaluate the slope stability, the infinite slope model has been implemented in tRIBS, making up a new component of the model. For each computational element, the model is able to verify the stability condition as a function of the safety factor, splitting between the unconditionally stable and the conditionally stable computational cells. The amount of detached soil and its possible path are also estimated. The variations in elevation due to the landslides modify the basin morphology. The computational TIN is updated when a threshold related to the changes in elevation is exceeded.

Model performance has been evaluated carrying out a setup case in a small catchment with very steep slopes, located in the northern part of Sicily (Italy). The test has been useful to highlight weaknesses and strengths of the model as well as to enhance the formulation. Another validation test is being carried out using landslides data recorded in the island of Puerto Rico, a US territory, where landslide triggered by rainfall are the most common type with one or two events per year.