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Development of a probabilistic warning model for weather-induced landslides using openly available satellite rainfall estimates and spatio-temporal data on landslide occurrences

Gaetano Pecoraro (1) and Michele Calvello (2)

(1) University of Salerno, Department of Civil Engineering, Fisciano, Italy (gpecoraro@unisa.it), (2) University of Salerno, Department of Civil Engineering, Fisciano, Italy (mcalvello@unisa.it)

Landslide early warning systems (LEWS) represent a significant option for addressing weather-induced landslides worldwide. The structure of LEWS can be schematized as an interrelation of three main modules: landslide model, warning model, and warning system. Warning models developed for weather-induced landslides are mainly based on correlation laws, for which thresholds are defined considering one or more combinations of measured rainfall that have led (or not led) to slope movements. However, the distinction between triggering and non-triggering rainfall conditions is not trivial, thus conventional methods adopted to this aim are often highly subjective. Moreover, data on landslide occurrences and rainfall measurements are often either not available or accessible only to a restricted number of scientists.

In this study information from an open-access non-conventional landslide inventory and rainfall data from satellite monitoring have been employed within a conceptual framework for the development of a probabilistic warning model. The main steps of the proposed approach are: collection of input data, correlation between landslides and rainfall combinations, and probabilistic analysis. Data on landslide occurrences are derived from the FraneItalia catalog (https://data.mendeley.com/datasets/zygb8jygrw/1), a landslide inventory based on information retrieved from online Italian news. The database currently spans from 2010 to 2017 and contains 8931 landslides, most of them triggered by rainfall. Rainfall measurements are derived from the satellite-based NASA Global Precipitation Measurement (GPM) database, which contains gridded precipitation and precipitation-error estimates, with a half-hour temporal resolution and a 0.10-degree spatial resolution, covering most of the earth starting from March 2014. Successively, an algorithm approach based on a reduced set of parameters has been applied to reconstruct the rainfall events, to identify the rainfall conditions that resulted in landslides and to measure the duration and the cumulated rainfall for the events. Finally, a Bayesian methodology has been developed to determine landslide conditional probabilities associated to each rainfall combination.

The proposed procedure has been tested by analysing the reported landslides from March 2014 to December 2017 within the eight warning zones defined for hydrogeological risk management in the Campania region (Italy). Although this study is only in a preliminary phase, the results achieved herein demonstrates the potential of the proposed probabilistic method to define objective and reproducible rainfall thresholds for landslide early warning purposes.