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On the use of rainfall intensity-duration-frequency curves for estimating the return period of landslide triggering

David Johnny Peres (1) and Antonino Cancelliere (2)

(1) University of Catania, Department of Civil Engineering and Architecture, Catania, Italy (djperes@dica.unict.it), (2) University of Catania, Department of Civil Engineering and Architecture, Catania, Italy (acance@dica.unict.it)

Return period of landslide triggering is commonly estimated by coupling a physically based landslide triggering model (hydrological and slope stability) with rainfall intensity-duration-frequency (IDF) curves. Such a consolidated approach implicitly assumes: (1) prefixed pressure head initial conditions, with no regard to their probability of occurrence, and (2) constant intensity-hyetographs.

The aim of the work is to assess the relevance of the two above mentioned simplifying assumptions. The issue is tackled by using a Monte Carlo simulation approach, based on coupling a stochastic rainfall time series generator with a physically based hydrological and slope stability model in which the initial water table depth at a given event is linked to inter-arrival time between storms and antecedent precipitation. Long datasets of synthetic rainfall events and the corresponding pressure head response are generated, and return period of landslide triggering is computed as the mean inter-arrival time of the exceedance of critical pressure head (corresponding to a factor of safety for slope stability less than one). Applications are carried out with reference to field data measured in the Peloritani Mountains, Sicily, Italy, one of the most highly landslide-prone areas of the Mediterranean region. The return periods obtained by Monte Carlo simulation are assumed as reference values for evaluating the traditional IDF-based approach, which is implemented consistently to the data of the case study area and the most common assumptions used in literature to derive the IDF curves.

Results indicate that both the two above mentioned assumptions of the IDF-based approach may imply significant overestimations of landslide-triggering return period, i.e. non conservative hazard assessments. In particular, the common assumption of an initial water table depth at the base of the pervious strata may lead in practice to an overestimation of return period up to one order of magnitude, while the assumption of constant-intensity hyetographs may yield an overestimation by a factor of two or three. Hence, it may be stated that the traditional IDF-based approach is generally valid only for preliminary assessments of landslide-triggering hazard.