Plinius Conference Abstracts
Vol. 15, Plinius15-74, 2016
15th Plinius Conference on Mediterranean Risks


# Diversity of rainfall thresholds

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In early warning systems, different kinds of rainfall thresholds are adopted, which vary from each other on the basis of adopted hypotheses. In some cases they represent the occurrence probability of a landslide, in other cases the exceedance probability of a critical value for an assigned mobility function $I$ (a function of rainfall heights), and in further cases they only indicate the exceeding of a prefixed percentage a critical value for $I$, indicated as $I_{cr}$. For each scheme it is usual to define three different critical levels (ordinary, moderate and severe), denoted in the following as $LC_1$, $LC_2$ and $LC_3$, respectively, that are associated to warning levels, according to emergency plans.

This work briefly discusses four different schemes of rainfall thresholds. In details:

The simplest scheme, indicated with A, considers: i) a single value for $I$; ii) occurrence probability of landslide P[$E|\quad I$] is modelled with the following step function:

$$P\left[E|\, I\right] = \begin{cases} 0 & se \;\; I < I_{cr} \\ 1 & se \;\; I \geq I_{cr} \end{cases} \tag{1}$$

and iii) only the measured rainfall heights are used. In this case, only the comparison between $I$ and $I_{cr}$ is allowed, and $LC_1$, $LC_2$, $LC_3$ are assumed as prefixed percentages of $I_{cr}$.

In scheme B, P[$E|\quad I$] is defined as:

$$P\left[E|\, I\right] = \begin{cases} 0 & se \;\; I < I_1 \\ g(I) & se \;\; I_1 \leq I \leq I_2 \\ 1 & se \;\; I > I_2 \end{cases} \tag{2}$$

where $g(I)$ is a monotonic non decreasing function, and Eq.(1) is a particular case when $I_1 = I_2 = I_{cr}$ is assumed. Like case A, a single value for $I$ is consider and only the measured rainfall heights are used. A specific values of P[$E|\quad I$] is assigned to each critical level, which corresponds to a particular value of occurrence probability for a landslide.

Scheme C considers a probability distribution of $I$, due to parameter uncertainty associated to the model which provides $I$ from rainfall heights. The step function in Eq.(1) is adopted for P[$E|\quad I$], and only the measured rainfall heights are used. In this case, each critical level is equal to a prefixed value of exceedance probability of $I_{cr}$, which corresponds to $P[E]$.

Scheme D constitutes an extension of scheme C, as rainfall predictions (from meteorological or stochastic models) are also used and are an ensemble of realizations. In this case, on the basis of the theorem of total probability, $P[E]$is defined as:

$$P\left[E\right] = \sum_{i=1}^{k} P\left[E|\, F_i\left(I\right)\right] \cdot \alpha_i\left(F_i\left(I\right)\right) \tag{3}$$

where $k$ is the number of rainfall realizations, $F_i\left(I\right)$ is the probability distribution of $I$ associated to the i-th realization, $\alpha_i\left(F_i\left(I\right)\right)$ is the weight related to the i-th $F_i\left(I\right)$. Like scheme C, critical levels are assumed equal to assigned values of $P[E]$ , which corresponds to $P[I>I_{cr}]$.

As case study, Gimigliano municipality (southern Italy) was chosen.