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Probabilistic clustering of rainfall condition for landslide triggering

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Landslides are widespread natural and man made phenomena. They are triggered by earthquakes, rapid snow melting, human activities, but mostly by typhoons and intense or prolonged rainfall precipitations. In Italy mostly they are triggered by intense precipitation. The prediction of landslide triggered by rainfall precipitations over large areas is commonly based on the exploitation of empirical models. Empirical landslide rainfall thresholds are used to identify rainfall conditions for the possible landslide initiation. It's common practice to define rainfall thresholds by assuming a power law lower boundary in the rainfall intensity-duration or cumulative rainfall-duration space above which landslide can occur. The boundary is defined considering rainfall conditions associated to landslide phenomena using heuristic approaches, and doesn't consider rainfall events not causing landslides. Here we present a new fully automatic method to identify the probability of landslide occurrence associated to rainfall conditions characterized by measures of intensity or cumulative rainfall and rainfall duration. The method splits the rainfall events of the past in two groups: a group of events causing landslides and its complementary, then estimate their probabilistic distributions. Next, the probabilistic membership of the new event to one of the two clusters is estimated. The method doesn't assume a priori any threshold model, but simple exploits the real empirical distribution of rainfall events. The approach was applied in the Umbria region, Central Italy, where a catalogue of landslide timing, were obtained through the search of chronicles, blogs and other source of information in the period 2002-2012. The approach was tested using rain gauge measures and satellite rainfall estimates (NASA TRMM-v6), allowing in both cases the identification of the rainfall condition triggering landslides in the region. Compared to the other existing threshold definition methods, the prosed one (i) largely reduces the subjectivity in the choice of the threshold model and in how it is calculated, and (ii) it can be easier set-up in other study areas. The proposed approach can be conveniently integrated in existing early-warning system to improve the accuracy of the estimation of the real landslide occurrence probability associated to rainfall events and its uncertainty.