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A cura di: Domenico Calcaterra & Silvia Fabbrocino

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Rainfall events able to trigger shallow landslides in Calabria (Southern Italy)

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RIASSUNTO

Analisi degli eventi di pioggia capaci di innescare frane superficiali.

In Calabria, la disponibilità di oltre 45000 eventi piovosi a scala di tempo di cinque minuti ha permesso di precisare la struttura temporale e la distribuzione spaziale, da assumere come input per i modelli completi di versante. Lo studio è stato condotto proponendo un semplice ed efficace metodo di classificazione automatica dei profili di pioggia.

KEY WORDS: *Calabria, rainfall event, shallow landslides.*

INTRODUCTION

The key role of the rainfall/landslide relationship is highlighted by the increasing number of studies on rainfall triggering thresholds for shallow landslides over the last decades. Such thresholds are generally defined in terms of cumulated rainfalls in a period preceding the mobilization itself (TERRANOVA *et alii*, 2007, and references therein).

Aiming at characterising the rainfall events able to trigger shallow slope stabilities in Calabria, the temporal structure of 152,575 rainfall events characterised by different durations has been analysed by applying the approach proposed by TERRANOVA & IAQUINTA (2011). Considered events were recorded between 1989 and 2008 at 155 rain gauges, at time steps of five minutes.

Many areas of the Mediterranean basin are recurrently subject to catastrophic geo-hydrological events with high economic and social impact. In Calabria, an active tectonic region characterised by small basins with steep slopes, rainfall-induced slope movements frequently cause dramatic consequences to the environment and to population.

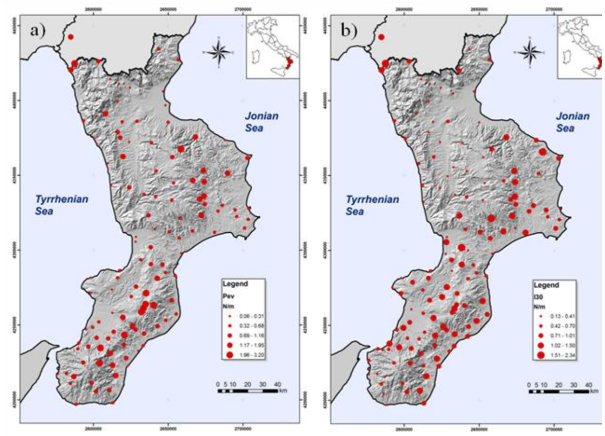

Fig.1 – Location of the rain gauges with the highest number, *N*, of events characterized by: a) P_{ev} >100 mm, b) $I_{30} \geq 44$ mm hour^{-1}. The size of the red circles indicates the ratio between *N* and the number of months with valid observations.

Proper understanding and forecasting of rainfall events is a prerequisite for the adoption of appropriate mitigation measures and for reducing the risk. Information on severe rainfall events is rarely available at the appropriate time and space scales.

Thanks to the availability of observations with high temporal detail, a considerable amount of data could be analysed to quantitatively and qualitatively characterising extreme rainfall events ("erosive events", ErEv), able to trigger shallow slope movements in Calabria.

METHOD

The hydrological analysis has been carried out to characterize, in a simple but effective way, the rainfall events with regard to: *i*) magnitude; *ii*) location of high frequency number of events per year; *iii*) locations where they are most severe; *iv*) within-storm temporal patterns.

In order to classify the rainfall events as "significant" with regard to their contribution to geo-hydrological processes, a sample of 45,534 out of 152,575 storms have been selected and analysed. According to WISCHMEIER & SMITH (1978), they include 27,501 events with total rainfall amount (P_{ev}) greater than 12.7 mm, and 18,033 events with P_{ev} < 12.7 mm but exceeding 6.35 mm in 15 minutes.

Properties of the selected sample of ErEv have been

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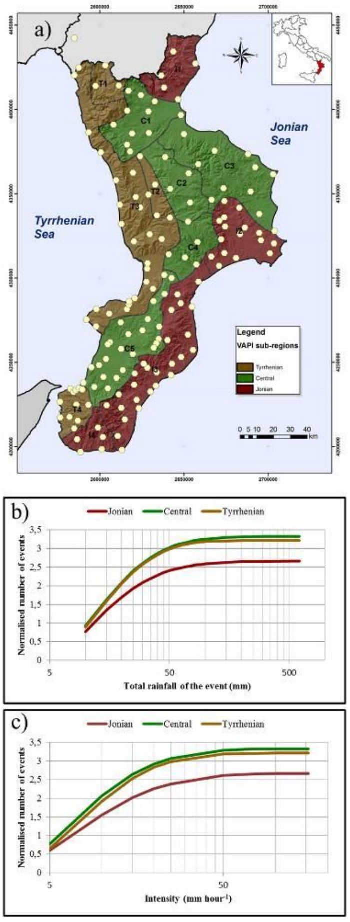

Fig.2 – (*a*) Rain gauges distribution in the 3 Va.Pi. sub-regions (VERSACE *et alii*, 1989). *(b)* Cumulative frequency of events vs. P_{ev}. *(c)*

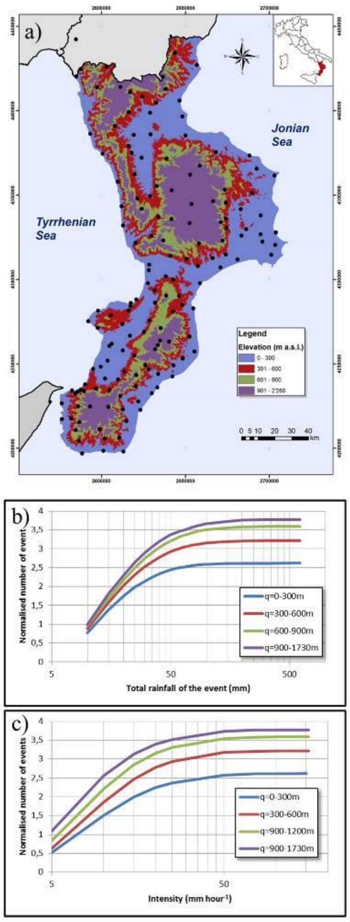

Fig.3 – (*a*) Rain gauges distribution in 4 elevation classes. *(b)* Cumulative frequency of events vs. P_{ev}. *(c)* Cumulative frequency of events vs. I_{30}.

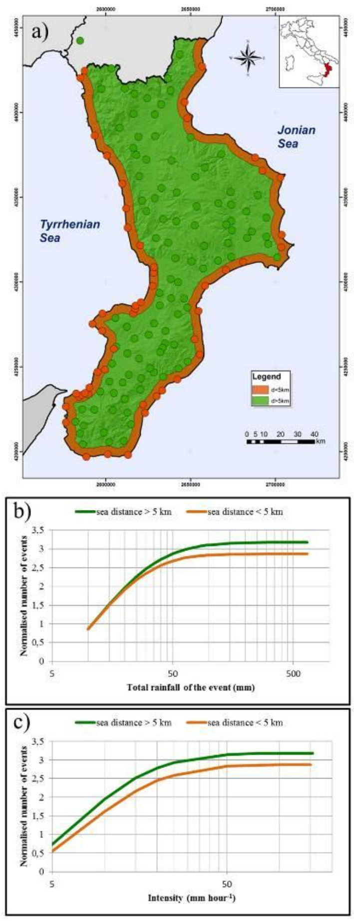

Fig.4 – *(a)* Rain gauges distribution (coastal sector vs. inland): in orange, the 5-km wide coastal strip. *(b)* Cumulative frequency of events

statistically characterized in relation to their geographical distribution. To this purpose, the most severe 2% events have been selected (Fig. 1) by considering those characterised by either P_{ev} > 100 mm or I_{30} > 44 mm h^{-1}.

In addition, a spatial analysis of the same sample has been performed with reference to *i*) the homogeneous sub-regions proposed by VERSACE *et alii* (1989) (Fig. 2), *ii*) the class of elevation (Fig. 3), and *iii*) the proximity to the coast (i.e., they belong to the coastal strip if located less than 5 km away from the sea) (Fig. 4).

As concerns the analysis of the structure of the storms, the standardized rainfall profiles (SRP) have been utilised (HUFF, 1967). The main advantage of this approach lies in the fact that it is based on actual data of regional precipitation; on the other hand, its main weakness is that a large amount of data is required to obtain regional profiles. Such analysis can be performed to either disaggregate the precipitation totals or to derive other types of information on storm characteristics (e.g. location of peaks of intensity). To this purpose, the events can be distinguished according to various criteria: duration, total rainfall, maximum intensity in a fixed time or average intensity, geographical area of occurrence, etc..

In this study, a new criterion, based on the binary shape code "BSC" proposed by TERRANOVA & IAQUINTA (2011), has also been adopted to identify the shape of the profiles (Fig. 5), based on the comparison between the areas A_1, A_2, A_3, A_4 – related to the quartiles of the SRP – and the corresponding four values of the uniform SRP (URSP).

DISCUSSION

The selected sample of rainfall events considered in this study shows the following characteristics: *i*) P_{ev} between 6.4 and 602.2 mm, with mean value of 23.5 mm; *ii*) duration D_{ev} from 10 minutes to almost 9 days, with a mean value of 15 hours and 6 minutes; *iii*) maximum intensity in 30 minutes, I_{30}, ranging from negligible values to 154.8 mm h^{-1}, with a mean value of 11.6 mm h^{-1}.

In Calabria, the SRP curves with frequencies greater than 2.5%, that can be considered to define the design storm, merely correspond to 8 out of the 16 BSC theoretically possible. Statistical analyses showed that the SRP curves that correspond to the lowest-frequency BSC (i.e. those that can be excluded) do not show, on average, high values of P_{ev}, D_{ev}, I_{30} (and then

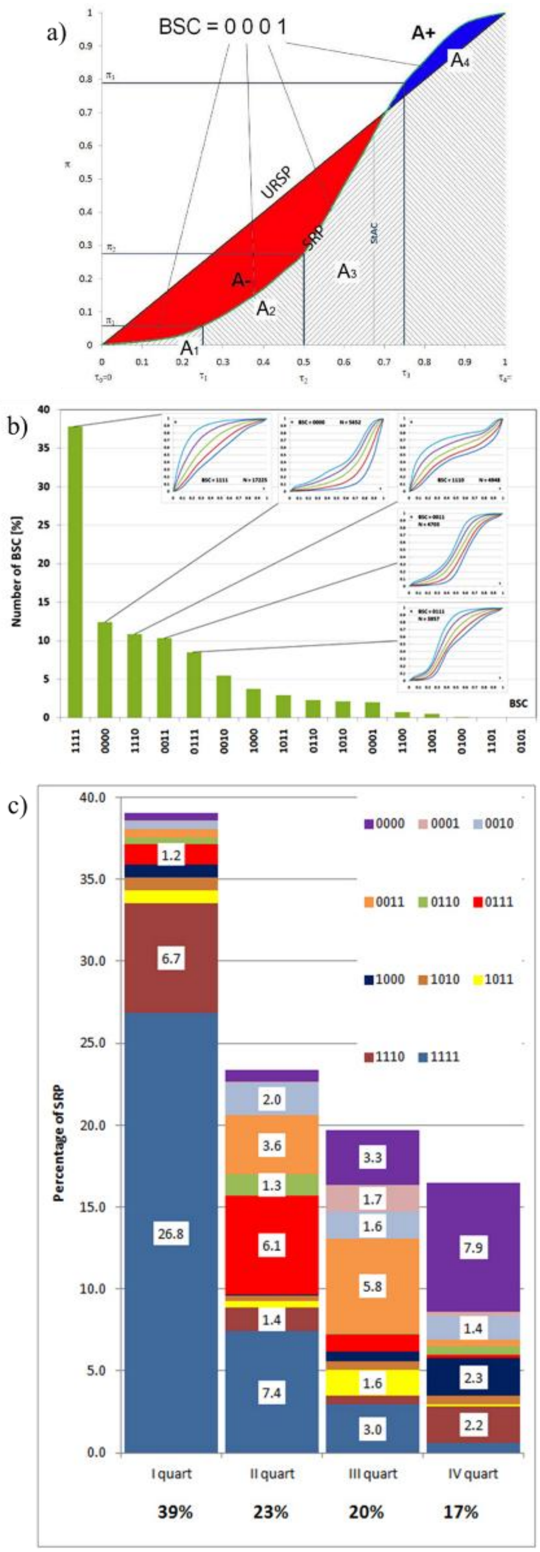

Fig.5 – *a)* Elements of a Standardized Rainfall Profile (SRP). URSP = Uniform SRP; StAC = Storm Advancement Coefficient, i.e. normalized time of occurrence of the maximum rainfall intensity; A^- = total area under the SRP below the URSP (in red); A^+ = total areas under the SRP above the URSP (in blue); BSC = Binary Shape Code. *b)* Percentage of BSC related to ErEv in Calabria, and SRP of the 5 most numerous BSC. *c)* Percentage of SRP for each quartile, distinguished on the base of BSC (percentages <1% are not shown).

are not of interest for hydrological applications).

A simple analysis of the number of SRP from the different BSC highlights:

- the numerical preponderance of SRP with BSC equal to either 1111 or 0000 (respectively, 37.8% and 12.4% of all the ErEv);
- that almost 50% of the SRP has BSC equal to either 1111 or 1110, i.e. in many cases high intensities are recorded during the initial part of the event.

Accordingly, the classification criterion of the rain profiles recently proposed by TERRANOVA & IAQUINTA (2011) allowed to improve the general knowledge on storm structures and to exclude from further analyses those characterized by very low sampling frequency.

When considering the spatial distribution of the ErEv, the Jonian sector of Calabria resulted to be the most frequently affected by severe rainstorm events (Fig. 1), despite a smaller number of total events.

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