HOW MEANINGFUL IS FLASH FLOOD RISK MAPPING?

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Abstract

Flood hazard and risk mapping is one of the most significant tasks of River Basin Authorities in Italy. In the production line of this analysis attention was always focused on the basin scale, i.e. on the simulation of large scale flood events, in critical condition and duration of event calibrated for the primary river channel and the main tributaries. Nevertheless, flash flood events are constantly recorded with a relevant amount of damages and number of victims. The proposal of a similar approach of hazard and risk mapping for flash flood events is discussed, with a survey strategy based on Depth-Duration-Frequency available models, and a spatial distribution analysis of model parameters or assigned frequency values for short duration rainfall. The results in term of hazard and subsequent risk classification are presented and discussed, evaluating both urban exposure and geomorphological vulnerability.

1 Introduction

Hydrologic and hydraulic modelling is being used to identify the areas with high hydraulic hazard and to evaluate the effects of structural and non-structural actions programmed by the Plan on hydraulic hazard on the basin. With the aim to apply a similar procedure to flash flood mapping, the approach is based on the following statement: spatial and temporal

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scale limit of flash floods are clearly defined, and the attention is focused on rainfall-driven events. The flash flood definition used in this paper is based on a fixed rainfall intensity value and a threshold basin dimension of 500 km^2. We realize that such assumptions can oversimplify the complexity of phenomena. The aim of this research, however, is to explore and evaluate the possibility and the effectiveness of a consistent, wide applicable mapping procedure, dealing with a previous established set of flash flood characteristics or parameters. Some preliminary results are shown for the Arno river basin.

2 Data

Rainfall depth-duration-frequency (DDF) relationship is defined in a consistent and homogeneous manner all over the national territory (Calenda et al., 1994). The calibration of DDF curves has been based on extreme rainfall time series, typically on a normal duration varying from 1 hour up to 24 hours, providing therefore the parameter of the equation:

$$h = a \cdot t^n \cdot Tr^m , \qquad (1)$$

where h is the rainfall depth, in mm; t the rainfall duration, in hour; Tr the return period, in year. The a, n, m parameters reported for a dense network of rain gauges, allow the calculation of spatial distribution of equal return period curves with fixed rainfall intensity. For example, assuming 50 mm rainfall in 1 hour as a threshold value for the occurrence of flash flood phenomena, it is possible to map on a fixed grid the corresponding return period evaluation (fig. 1). This map shows the spatial distribution of short, heavy rainfall events - a sort of simplified hazard distribution for flash flood events.

3 Methodology

The rainfall-discharge transformation develops flash flood characteristics only if the recipient body (i.e., the river basin) shows some geomorphological characteristics that produce a single, very high peak discharge. Therefore, a basin threshold of 500 km^2 has been taken into account, and for each basin the susceptibility to a flash flood response is synthesized by the basin "corrivation time". This is given by the characteristic temporal scale of the hydrological response of the basin, and is here classified in 4 intervals (fig. 2), ranging between minutes and 6 hours.

It seems possible to derive the spatial distribution of a potential flash flood response, or the tendency of small scale basin to transform heavy, short precipitation events in very high discharge levels, by overlapping the above mentioned heavy rainfall map and spatial data on basin corrivation time. By clustering the return period distribution for assigned rainfall threshold in 4 classes, it is possible to classify the basins where the combination of rainfall hazard and short hydrological response time causes the most likely situation for flash floods to happen. It is interesting to point out that preliminary results for the Arno River (fig. 3) show a complex distribution over the basin, not necessarily following clear morphological or geographical patterns: for example, exposition, presence of mountain relief and distance from the coast.

The availability of a high resolution vector map of buildings and infrastructures or a low resolution land use map can help identify the risk areas, and can quantify the amount of potentially damaged goods (fig. 4).

4 Conclusions

Even if the simplified initial hypothesis of the procedure (use of DDF curves, fixed rainfall threshold, unique parameter for basin characterization) can oversimplify the phenomena, the suggested maps show some interesting characteristics, in order to identify a spatial differentiation of flash flood predisposition. Moreover, an attentive calibration of the procedure should be carried out, and should also take a large number of historical events of each basin with different geomorphological characteristics into consideration.

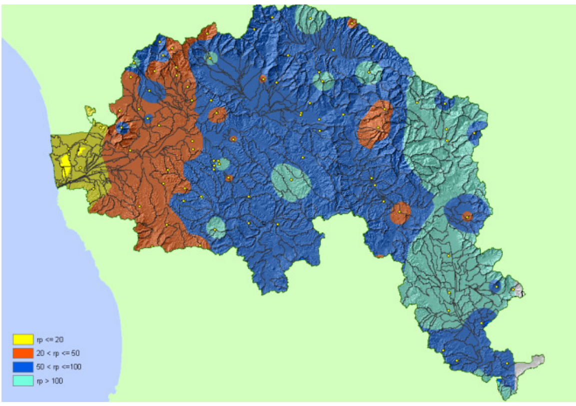

Figure 1. Heavy rainfall hazard map (return period distribution for 50 mm/hr)

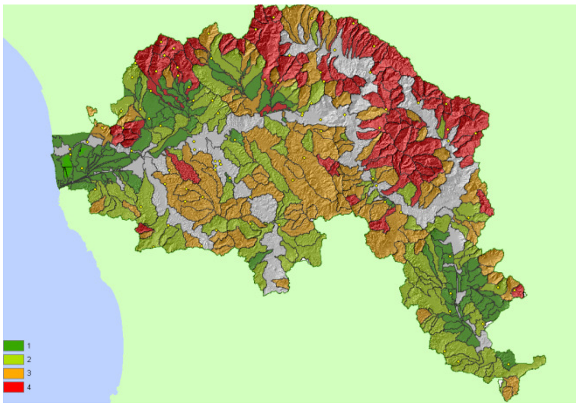

Figure 2. Classification of small size basin depending on "corrivation time" (1=longest – 4=shortest response time)

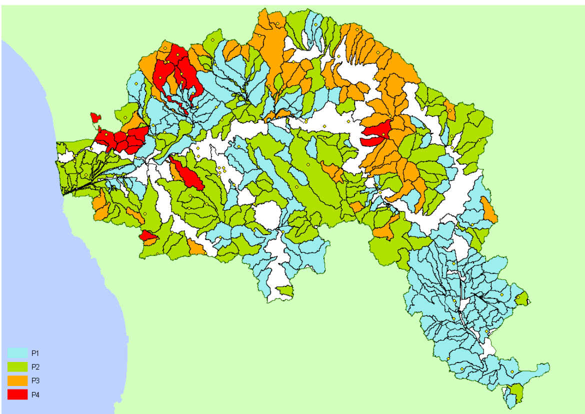

Figure 3. Map of flash flood hazard (1=lowest – 4=highest hazard)

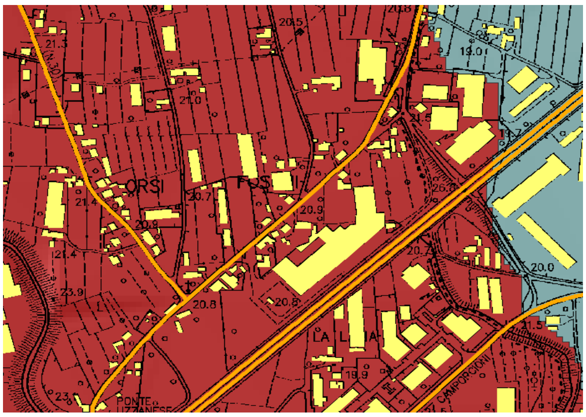

Figure 4. Risk map example (portion across two different hazard classes)