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Effect on the flash-floods distribution of a rainfall stochastic model in a simple rainfall-runoff model

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Introduction

In this study a simple lumped hydrological model, that include the dynamic of the soil saturation, evapotranspiration and base flow, is used as test-model for a statistical analysis based on a stochastic rainfall model. Given a set of rainfall time series generated basing on hourly rainfall heights observed in different raingauges, these time series were used as input of the model (configured on a small catchment) in order to study the effects of the different input probability distribution of rainfall on the final probability distribution of discharge flows. In particular, the effect of the different rainfall regimes on the extreme flows distribution was investigated. The rainfall stochastic model was based on the fit of the distributions of the rainfall height, of the no-rain interval length, and of the rainy interval length, assuming a simple hyetograph for each rain event. The analysis was performed basing on the rain time series observed in the Italian raingauges network in the period 2006-2012.

1. The model

A simple lumped hydrological model was implemented in order to evaluate the effects of different rainfall regimes. The model simulates rainfall infiltration, evapotranspiration, simple groundwater dynamics, small and large pore soil moisture dynamics, adsorption, percolation, hypodermic flow, base flow and hillslope flow. (see Figure 1). The model is able to simulate either a single rainfall-runoff event and the hydrological balance for a period of several years. The simple implemented numerical schemes (linear reservoirs, threshold infiltration, etc.) require in total four scalar parameters.

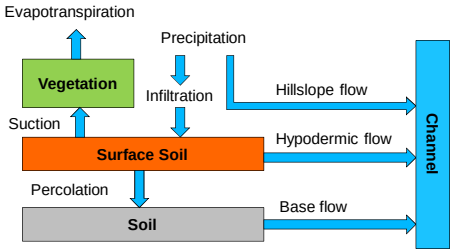


Figure 1. Schematic representation of the employed model.

2. Rainfall generation

The rainfall synthetic time-series were generated fitting the distributions of the rainfall height, of the no-rain periods length, and of the rainy interval length, assuming a simple hyetograph form for each rain event. The analysis was performed basing on the rain time series observed in the Italian raingauges network in the period 2006-2012 (Figures 1 and 2). It resulted that all three variables were distributed as exponential distributions.

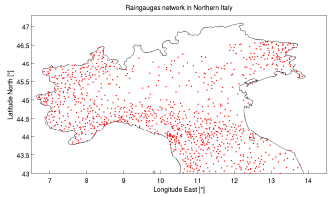


Figure 1. Raingauge network in North Italy.

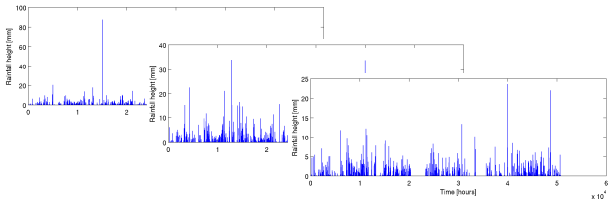
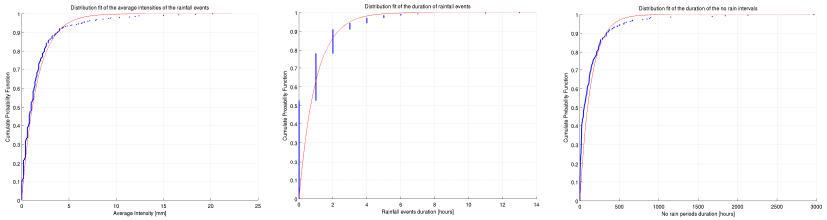


Figure 2. Observed rainfall time series.



Exponential Distribution PDF and CDF

$$f(x) = \lambda e^{-\lambda x}$$

$$F(x) = 1 - e^{-\lambda x}$$

Figure 3. Distribution fit of rainfall events duration, average intensity and intervals for one of the observed time series.

3. Statistics comparison

Basing on the synthetic time series of rainfall, the corresponding time series of discharge flows were computed by mean of the simplified hydrological model. In the following Figures, the corresponding statistics are computed for the flood events, defined as time intervals in which the flow values are above 5 m3/s. In the last Figures, the distributions of the averages of the parameters (intensities, durations and intervals) are compared between rainfall and corresponding flows.

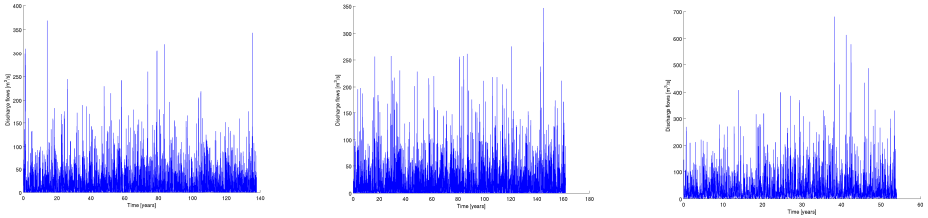


Figure 4. Discharge flows time series generated by the rainfall synthetic time series. The duration of the simulation period is about 150 years.

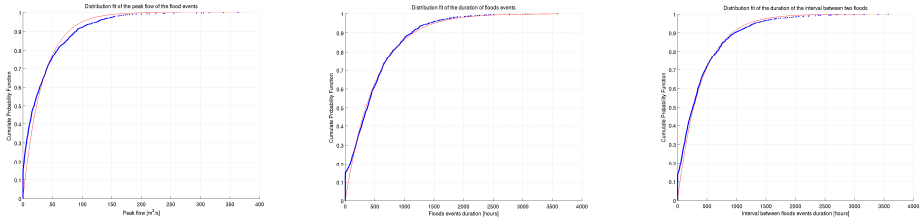


Figure 5. Distribution fit of flood events duration, average intensity and intervals for one of the simulated time series.

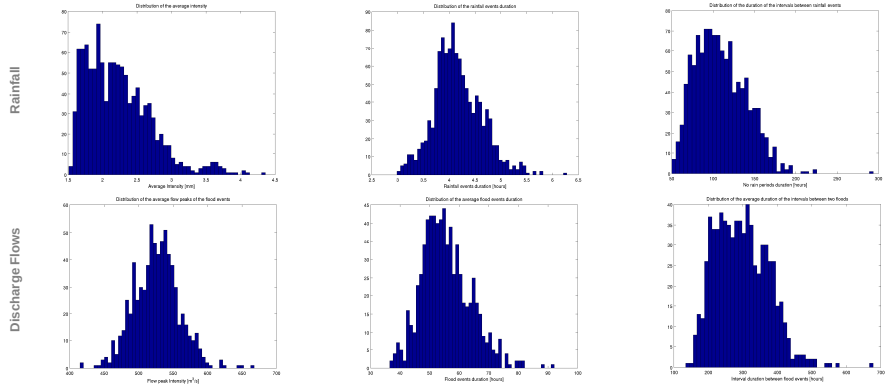


Figure 6. Distribution comparison of the average parameters for rainfall time series (upper panels) and discharge flows time series (bottom panels).