

# **Analysis of the Distribution and Variability of the Extreme Value Rainfall Events Estimation in Tuscany**

*Analisi sulla Distribuzione e Variabilità delle Stime di Eventi a Valore Estremo di Precipitazione in Toscana*

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**Riassunto:** Nel lavoro sono presentate le stime ottenute per le altezze di pioggia in funzione di durata e tempo di ritorno con tre differenti metodi di calcolo per le stazioni pluviometriche della Regione Toscana. Viene indagata l'accuratezza dei risultati con particolare attenzione al confronto tra i metodi utilizzati e alla stima dei parametri delle distribuzioni a valori estremi. Vengono inoltre illustrate due principali problematiche incontrate nell'utilizzo ai fini progettuali dei valori di altezza di pioggia forniti dall'analisi dei valori estremi effettuata.

**Keywords:** Extreme Value Distributions, Parameter Estimation Methods, Depth-Duration-Frequency Curves.

## **1. Introduction**

One of the first steps in many hydrological design projects is the determination of a design storm or event that involves a relationship between rainfall (depth), duration and the return period (Chow et al., 1988). In the study here described, the accuracy of the results obtained from an extreme value analysis of the rainfall recorded in Tuscany has been illustrated and some issues related to the output are discussed.

## **2. Analysed Distribution and Methods of Estimation**

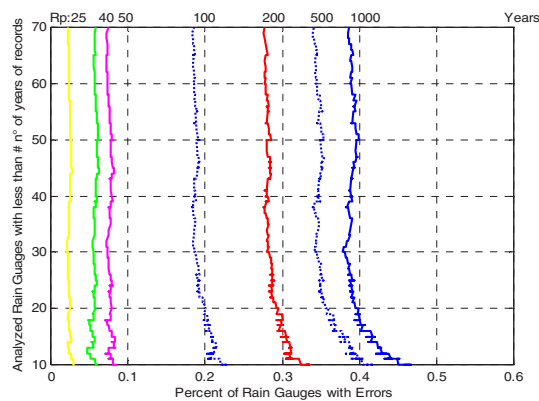
Commonly used distributions for rainfall frequency analysis are the Extreme Value Type I distribution also called Gumbel distribution and the GEV distribution, as applied by many authors (Hosking et al., 1985; Coles et al., 2003). In this study the analysis of the dataset has been carried out in three different ways. The Gumbel distribution in which the associated parameters have been determined with the Probability-Weighted Moments method, and the GEV distribution in which the three parameters have been calculated with both the PWM method (Hosking et al., 1985) and the L-Moments method (Gellens, 2002). The rainfall depth has been estimated for return periods ranging from 2 to 1000 years. These are in fact the typical values of hydrological extremes required in the engineering design activity. Nevertheless in the application further investigations have to be introduced, since the hydrological time series, generally available, are very small if compared with the return periods mentioned above.

### 3. Discussion about Problems and Accuracy of Results

The analysis has been carried out over a territory of about 22000 km<sup>2</sup> in Tuscany, on a set of 445 rain gauges. The sequence of annual maximum of rainfall depth with a storm durations: 1, 3, 6, 12, 24 hours have been investigated. The recorded time series range from 1923 to 2002.

From the investigation two main problems have been highlighted: the depth-duration-frequency curves for several rain gauges tend to be non monotonically, especially for the largest return period, i.e. the depths at shorter durations are higher than those at longer durations. This trend increases with the return period, and it is stronger in the GEV-L moments distribution than in the GEV-PWM or in the Gumbel-PWM. The analysis of this issue related to the value of the parameters has been provided.

**Figure 1:** Error analysis for the GEV-L Moments distribution.



The second issue encountered in the study of the results has been the large spread of the rainfall depth estimation, provided from the three methods, especially for return period larger than 200 years. In particular the rainfall depths calculated from the GEV-L moments distribution, when the number of data in the time series decreases, tends to become very improbable.

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