

Multivariate Approach for Rainfall Extreme Value Estimation in Tuscany

Approccio Multivariato per la Stima degli Estremi di Precipitazione in Toscana

E. Cavigli⁽¹⁾, S. Fatichi⁽¹⁾, E. Caporali⁽¹⁾, A. Petrucci⁽²⁾

⁽¹⁾ Dipartimento di Ingegneria Civile e Ambientale, e-mail: enrica.caporali@unifi.it

⁽²⁾ Dipartimento di Statistica “G. Parenti”, e-mail: alex@ds.unifi.it

Università degli Studi di Firenze

Riassunto: Attraverso l’analisi regionale dei valori estremi di pioggia di massima intensità e breve durata, si individuano raggruppamenti di punti di misura pluviometrica per i quali la distribuzione di probabilità è caratterizzata da alcune proprietà comuni. Individuato il raggruppamento, si fa l’ipotesi che le distribuzioni di probabilità della grandezza pluviometrica osservata alle stazioni di misura siano identiche tra loro, a meno di un fattore di scala caratteristico di ogni stazione, detto pioggia indice. A partire dalla proposta di un metodo per il calcolo della pioggia indice campionaria viene sperimentata un’analisi multivariata per la modellazione della relazione spaziale tra pioggia indice e caratteristiche del territorio.

Keywords: Rainfall, Regional Frequency Analysis, Multivariate Model.

1. Introduction

Aim of the study is to combine spatial data methods with regional frequency analysis of rainfall extremes to estimate the spatially distributed rainfall value for a given return period and precipitation duration in an investigated region. The geostatistics, which is based on regional frequency analysis (Goovaerts, 1997), applies the spatial correlation among near observed data to improve the estimated precision in unmeasured sites.

2. The Sample Index Rainfall

The analysis has been carried out over the Tuscany region on a set of 445 rain gauges. The time series of annual maximum of rainfall depth (storm durations of 1, 3, 6, 12, 24 hours) recorded from 1923 to 2002 have been used.

In the index variable method of regionalization (Dalrymple, 1960) the studied territory is divided, by means of hypothesis tests (Gabriele and Arnell, 1991), in a given number of statistical homogeneous zones, which have the same probability distribution and the same growth factor k . The index variable is defined as a scale factor for each site as in: $X_{Tr} = k \cdot \mu(X_{Tr})$, where X_{Tr} is the rainfall depth at return time Tr , and $\mu(X_{Tr})$ is the index rainfall at return time Tr .

For each storm duration, the growth factor k , at the first and second level of a hierarchical regionalization procedure (Fiorentino et al., 1987), is calculated. The Two

Components Extreme Value (TCEV) distribution (Rossi et al., 1984) is applied on the five dataset of short duration rainfall annual maxima. Considering the rainfall local extreme inference, at the gauge site, given by the estimated regional extreme value, the index rainfall at gauge site has been assumed equal to the ratio between the estimated GEV and the growth factor (Cavigli et al., 2006).

3. The Multivariate Model

For each homogeneous zone and each rainfall duration, a multivariate model for the index variable has been developed using the expression:

$$\mu = a_0 + a_1 \cdot \ln(MAP) + a_2 \cdot z + a_3 \cdot \left[\sin\left(\frac{Asp}{2} - \frac{\pi}{2}\right) + \pi \right] \cdot [Asp \geq 0] + a_4 \cdot hm \quad (1)$$

where: μ is the index rainfall, a_i are the parameters of the model, MAP is the Mean Annual Precipitation value, z is the elevation, Asp is the aspects and hm is the sample average of extreme time series at gauge sites.

The adjusted R^2 and the Fisher information matrix confirm the accuracy of the estimation. The goodness of estimates have been verified also with a Jackknife procedure. For each rain gauge the difference between the rainfall depth estimated in that location with the multivariate model, excluding the rain gauge data itself, and the rainfall value calculated with the GEV, has been quantified to extend the approach to ungauged sites. The accuracy of results has been confirmed.

References

- Cavigli E., Caporali E., Moro A. (2006): Analisi regionale delle piogge di breve durata e massima intensità in Toscana. *XXX Convegno di Idraulica e Costruzioni Idrauliche*, <http://www.idra2006.it/referee/files/L187.pdf>.
- Dalrymple T. (1960) Flood Frequency Analysis, U.S. *Geological Survey Water-Supply Paper*, 1543-A, GPO, Washington D.C..
- Fiorentino M., S. Gabriele, F. Rossi, P. Versace, (1987) Hierarchical approach for flood frequency analysis, in: *Hydrologic Frequency Modeling*, Singh, V. P. (Ed.), Reidel Publications Co.
- Gabriele S., and N. Arnell, (1991). A hierarchical approach to regional flood frequency analysis. *Water Resources Research*, 27 (6), 1281-1289.
- Goovaerts P. (1997) *Geostatistics for natural resources evaluation*, Oxford University Press, New York.
- Rossi F., Fiorentino, M., Versace P., (1984) Two-Component Extreme Value Distribution for Flood Frequency Analysis, *Water Resources Research*, 20(7), 847-856.