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Comparison of IDF estimation methods at selected locations of mainland Portugal.

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Abstract

Rainfall extremes are typically represented by means of Intensity-Duration-Frequency (IDF) curves. Different estimation methods may be used, based on annual maxima series I_{max} (AMS), peak over threshold $I(d,i^*)$ (POT) values and the marginal distribution of the rainfall process $I(d)$. While annual maximum values are most directly relevant to the IDF values, they reduce one year of data to a single value. POT and marginal-distribution methods utilize the data more fully, but rely on simplifying assumptions. We compare the above IDF estimation methods at selected sites in Portugal.

Data

We studied hourly and daily rainfall data from four sites in mainland Portugal (Fig. 4). The hourly data are used to estimate the IDF curves for each site. The daily series are used for comparison because of its larger sample size. The climate in the region varies from very wet in the north to very dry in the south.

Station	Hourly N° year	Daily N° year	MAP mm
PORTO/S.PILAR	32	53	1286
COIMBRA	23	53	955
LISBOA/GEOFISICO	22	65	692
ÉVORA	18	65	609

IDF Methods

AMS method

The AMS method is very popular in hydrology. It can have different levels complexities depending on the parameterization and estimation procedure used. Here we present the formulation in [1]. I_{max} values for different durations d are pooled together and normalized as

$$Y = I_{max}(d)/b(d)$$

Where $b(d)$ is a suitable function. A Generalized Extreme Value (GEV) with k≠0 or a Gumbel distribution, k=0, are fitted on the normalized values using the Probability Weighted Moments (PWM) method [2] (Fig.1)

POT method

The threshold level of the POT method (i^*) is fixed to produce an average of λ=10 exceedance events per year. For each duration a Generalized Pareto (GP) distribution with k≠0 is fitted using the PWM method. The parameters (shape k and scale α) are then smoothed as a function of d (Fig.2)

MD method

The Hybrid/Multifractal variant described in [3] is applied to the data within the range of scaling of the moments (Fig.3). A beta-Lognormal distribution is fitted to $I(d)$.

$$F_{I_d}(i) = P_0 + (1-P_0)\cdot N\left(\frac{\ln i - \mu}{\sigma}\right)$$

Estimation of IDF values

The final IDF values $I_{max}(d,T)$ for return period T in years, are computed as:

- AMS with a GEV distribution: → $I_{max}(d,T) = F_{GEV}^{-1}(1-1/T)\cdot b(d)$
- POT with GP distribution: → $I_{max}(d,T) = F_{GP(d)}^{-1}(1-1/\lambda T) + i^*$
- MD method: → $F_{I_{max}(d)}(i) = F_{I_d}(i)^{1/d}$

References

[1] Koutsoyiannis, D., D. Kozonis, and A.Manetas (1998), A Mathematical Framework for Studying Rainfall Intensity-Duration-Frequency Relationships, *J. Hydrol.*, **206**, 118-135.

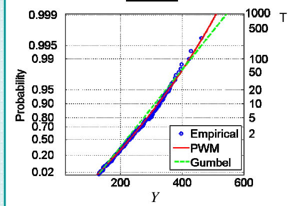
[2] Hosking, J.R.M. (1986), The theory of Probability Weighted Moments, Research Report RC 12210, IBM Research Division Mathematics, pp. 160, Yorktown Heights, NY.

[3] Veneziano, D., C. Lepore, A. Langousis, and P. Furcolo (2007), Marginal methods of intensity-duration-frequency estimation in scaling and nonscaling rainfall, *Water Resour. Res.*, **43**, W10418.

Application of IDF methods

For each method we show results for Porto and Évora. Porto represents the most humid climate and is the station with the longest sample size at the hourly resolution. Évora has the driest climate and the shortest record

Porto



Évora

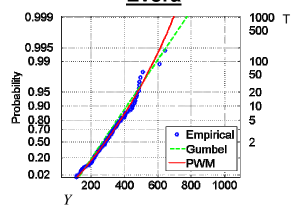
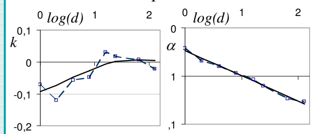


Fig. 1 – Gumbel plot of Y values for Porto and Évora, and fitted GEV and Gumbel distributions.



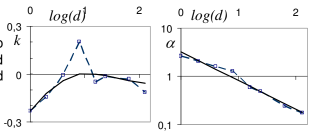
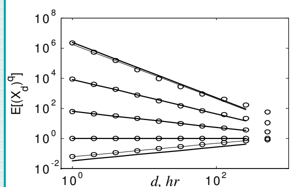


Fig. 2 – Generalized Pareto parameters, their dependence on d and smoothed results for Porto and Évora.



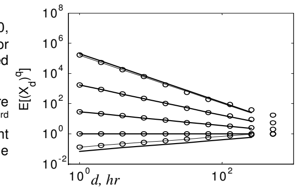
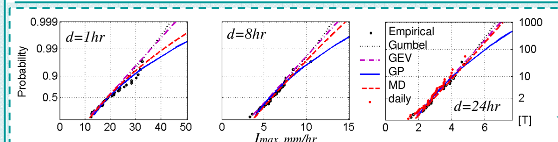


Fig. 3 – Scaling of the moments of order 0, 1, 2, 3 and 4 of the average intensities for Porto and Évora (open circles) and fitted values through the procedure in [3].

The 0th and 4th fitting (dashed lines) are extrapolated using the 1st, 2nd and 3rd moments [3]; as expected the 0th moment is over estimated when compared with the fitting on the empirical values (solid line).

Comparison of IDF



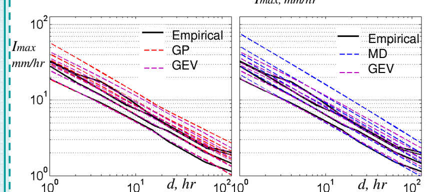


Fig. 5 – Porto

Gumbel plot for d= 1, 8, 24 hr.

IDF plots for different methods for T=2,5,16,33,100,1000 years.

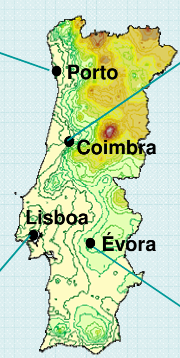
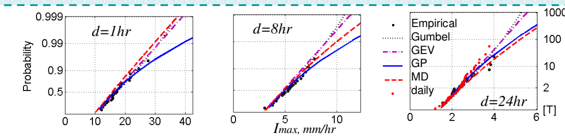


Fig. 4 – Selected stations.



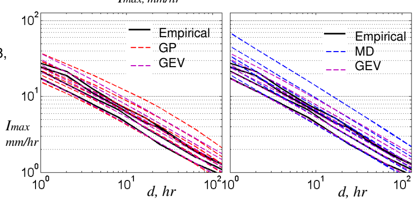
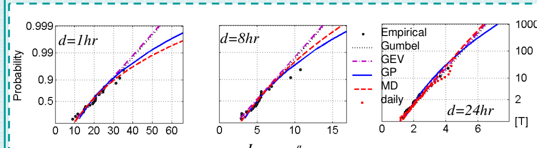


Fig. 7 – Coimbra

Gumbel plot for d= 1, 8, 24 hr.

IDF plots for different methods for T=2,5,11,23,100,1000 years.



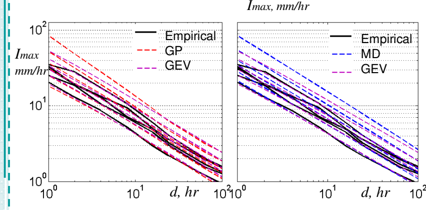
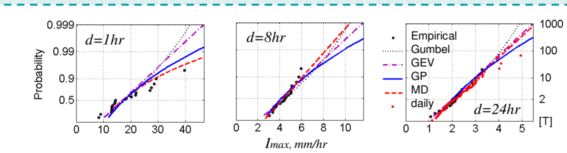


Fig. 6 –Lisboa

Gumbel plot for d= 1, 8, 24 hr.

IDF plots for different methods for T=2,5,11,23,100,1000 years.



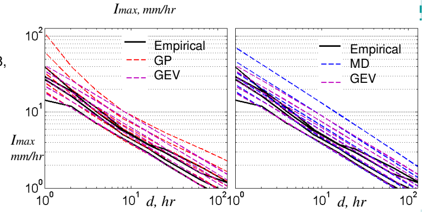


Fig. 8 – Évora

Gumbel plot for d= 1, 8, 24 hr.

IDF plots for different methods for T=2,5,10,20,100,1000 years.

Conclusion

The AMS method relies on a small sample size to estimate the distribution parameters. In our application the AMS method suggests an EV3 (upper bounded) or a Gumbel distribution (Fig. 1). The AMS methods underestimates the risk of extreme precipitation and is highly sensitive to outliers.

The POT method with GP distribution makes better use of the data, but the results are sensitive to the threshold parameter i*. The shape parameter is highly variable and hence needs to be smoothed, and the smoothing of the parameters and the choice of the threshold are somewhat arbitrary (Fig. 2). Compared to AMS, the POT method produces more stable results and more conservative estimates for risk analysis purposes. (Fig. 5 to 8).

The MD method is based on the whole data available at a station. The IDF values behave in some cases similarly to the PoT estimates (Fig. 5 to 8). Results tend to be more conservative results than in the AMS method. The MD method can be improved by using different fitting procedures .

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