# High return period annual maximum reservoir water level quantiles estimation using synthetic generated flood events.

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## 1 - Introduction

*Limitations of the "**Design Flood**" concept for dam design:*
-The **flood** exceedance **probability** is assumed to be **equal** to the exceedance **probability of the total accumulated precipitation**;
- The representation of the **space-time structure** of real storms is not correct.

*Aim of the work:*
In this work we propose a new methodology for hydrological dam design based on a trivariate statistical model, whose variables are:

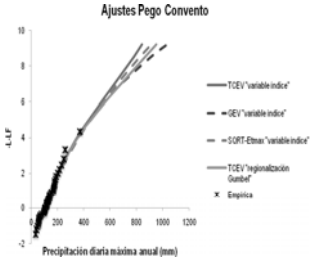
- -**Annual maximum daily precipitation**
- -**Basin initial soil mositure**
- -**The variable of interest** (reservoir level, volume, inflow/outflow discharge, …)

*Case-study:* Marina Alta and Marina Baja (Alicante – Spain)

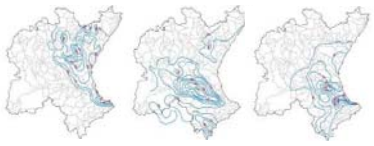
## 2 - Annual max daily rainfall analysis

Frequency analysis of maximum daily precipitation in a regional framework:
-Regional **homogeneity** has been checked.
-Regionalization methods:
-the index-variable method, for the GEV, SQRT-ETmax and TCEV distribution functions;
-the local Gumbel regionalization with the TCEV distribution function (Rossi et al., 1984);

The **TCEV with Gumbel regionalization** was selected, because the physical meaning of the TCEV basic assumption of two different populations (ordinary and extraordinary events), and higher number of extraordinary events detected by the Gumbel regionalization.



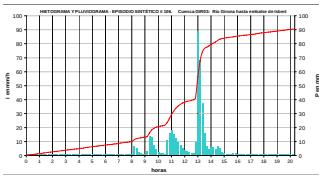

## 3 - Generation of synthetic storms



Real storms (gauged data) for model parameters estimation.

**RAINGEN** (Salsón and García-Bartual, 2003)

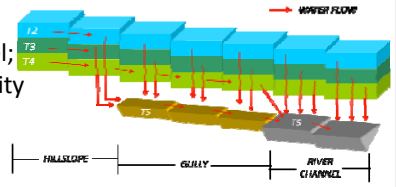
The rainfall stochastic model (Rodriguez-Iturbe and Eagleson, 1987) represents **space-time patterns** and internal structures of Mediterranean rainfall fields.



-368 space-time rainfall events
-10-mins time aggregation
-1x1 km$^2$ space aggregation
-Return period assigned based on **daily averaged precipitation**.

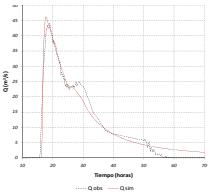
## 4 - Hydrological modeling

**TETIS 8.1 model** (Francés et al., 2007):
-distributed and conceptual model;
-reproduction of spatial variability of the hydrological cycle;
-space scale effect reduction;
-easily coupled with RAINGEN.

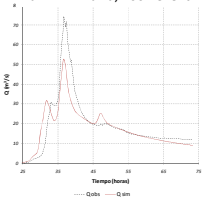



**5 minutes time-step modeling:**
Calibration and validation:
-7 flood events, 6 stream gauges
- Calibration NSE index: 0.87, Validation NSE index: 0.6 – 0.9

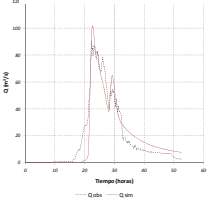
Calibration in Isbert, 2003 event



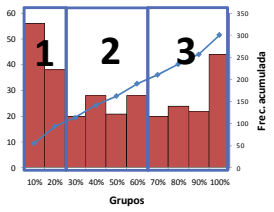
Val. in M. Baixa, 2002 event



Val. in Guadalest, 2007 event

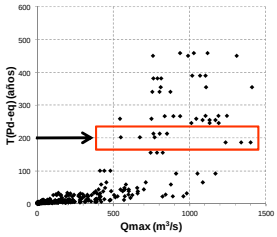


**Daily time-step modeling:**
Basin soil moisture frequency analysis by continuous simulation of 67 year.
3 representative **initial moisture states**: (1) **DRY** (P=0.3), (2) **MEDIUM** (P=0.4), (3) **WET** (P=0.3)




**Result:** 368 storms x 3 initial state = 1104 hydrographs

## 5 - Probability estimation

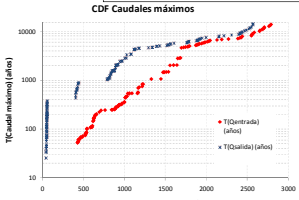



The max discharges corresponding to storms with the **same daily precipitation** (Pd) **ranges** depends on **space-time storm structure** and **initial basin moisture** conditions.

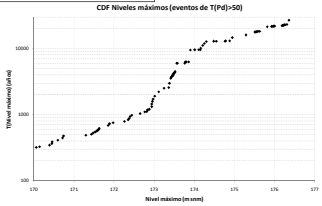
Multivariate statistical model of R (precipitation), X (variable) and M (moisture state), given that R and M are independent and their marginal distributions are known:

$$F_X(a) \approx \sum_{j=1}^{3}\left\{ Pj \sum_{i=0}^{\infty} \frac{n_{ij}(a)}{N_{ij}} \left[F(R_{i+1}) - F(R_i)\right]\right\}$$

CDF Caudales máximos




CDF Niveles máximos (eventos de T(Pd)>50)




Empirical cdf of: max discharge (in/out), max reservoir level, …

## 6 - References

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- Rossi, F., Fiorentino, M., and Versace, P., 1984. Two-Component Extreme Value Distribution for Flood Frequency Analysis. *Water Resour. Res.*, 20 (7), 847-856.
- Salsón, S. and R. García-Bartual, 2003. A space-time rainfall generator for highly convective Mediterranean rainstorms. *Natural Hazards and Earth System Sciences*, 3, 103-114.

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