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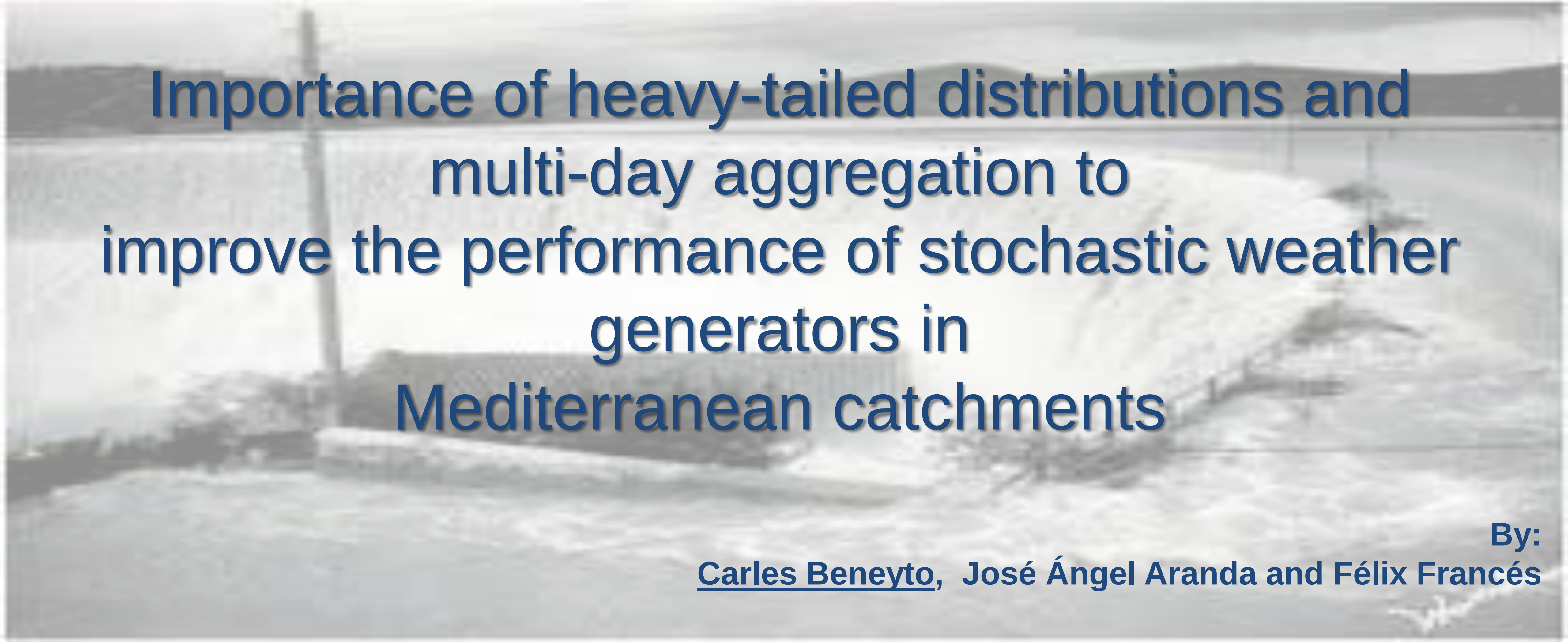

Importance of heavy-tailed distributions and multi-day aggregation to improve the performance of stochastic weather generators in Mediterranean catchments

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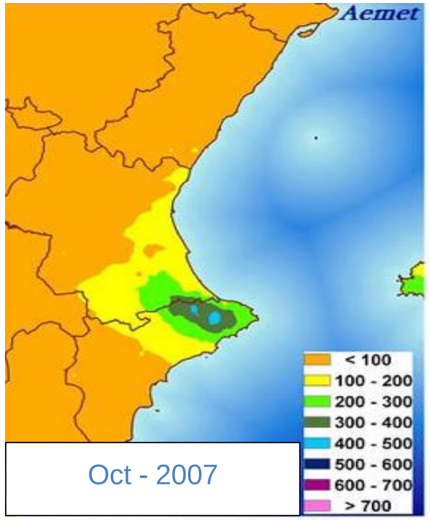
Motivation

- ❑ Long history of devastating floods as a consequence of Medicanes

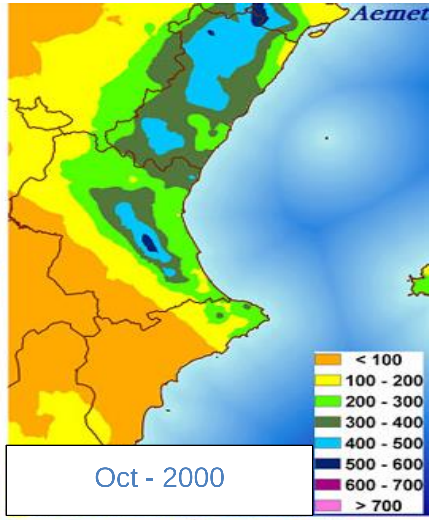
Motivation

What is a Medicane?

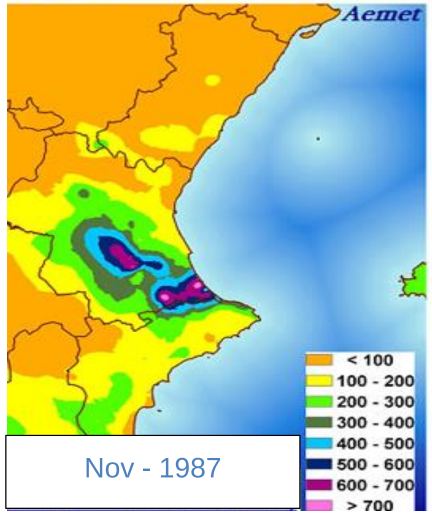
- Low frequency precipitation events
- Every 7-8 years on average
- Huge amounts of precipitation (up to 900mm in 24h)
- Over periods of time lasting between 2-3 days
- Autumn months (SON)
- COMPLEX PHENOMENA



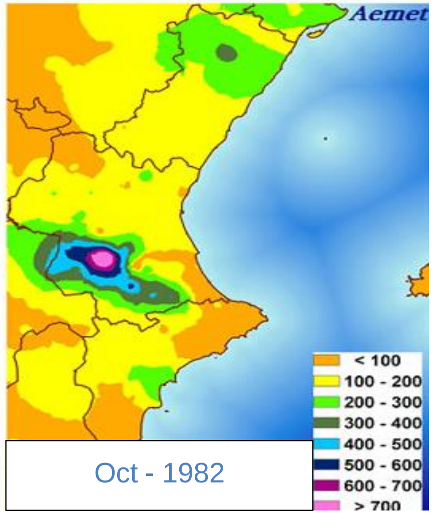
Oct - 2007



Oct - 2000



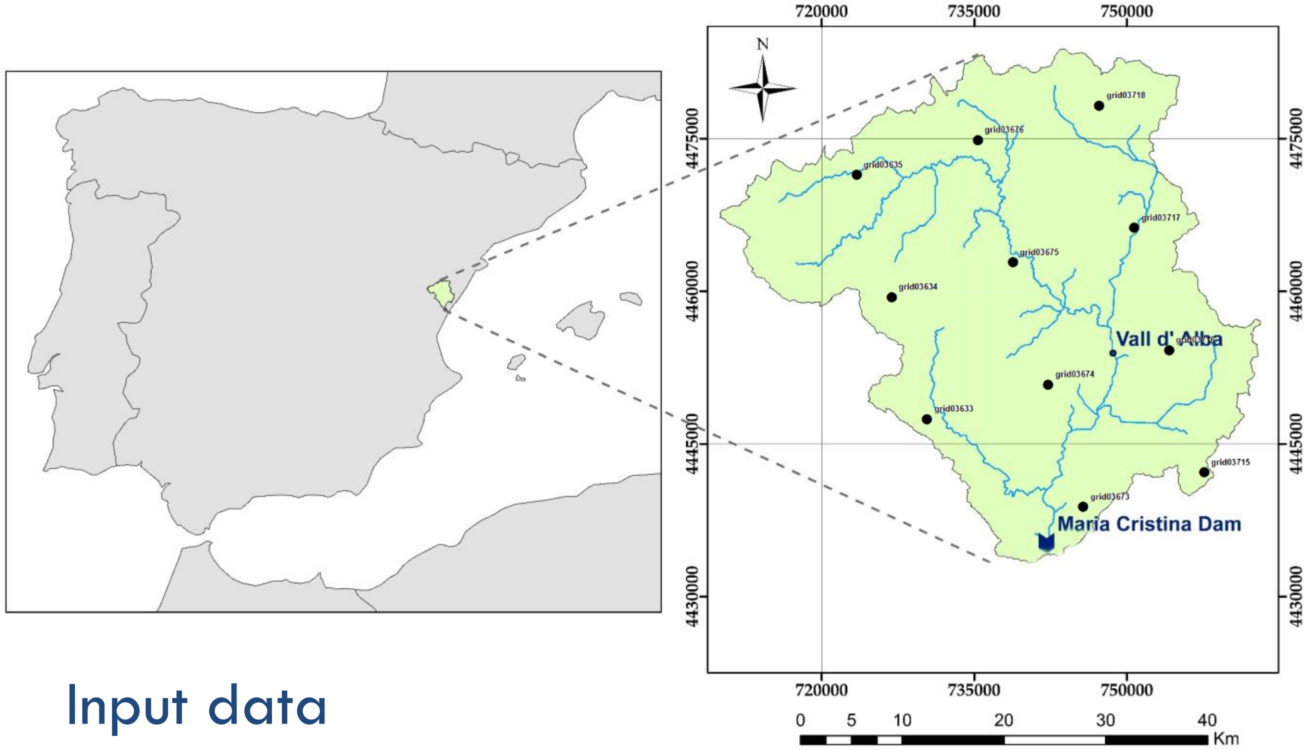
Nov - 1987



Oct - 1982

High spatial and temporal variability!!

Study area



- ❑ Rambla de la Viuda: ephemeral river
- ❑ Approx. area: 1,500 km^2
- ❑ Annual mean prec.: 615 mm
- ❑ Remarked seasonal precipitation variability (SON)

Short input data series length for high T!!

Input data

- ❑ 11 thermometers and rain gauges

SPAIN02_v4: set of daily observational interpolated data in a regular 0.1º grid from 1971 to 2007 *(Herrera et al., 2016)*

Objectives

- ❑ Compare the performance of two daily multi-site stochastic weather generators (MulGETS and GWEX) with different approaches in a Spanish Mediterranean catchment with medicanes

- ❑ Analyse the possibilities of reproducing high return period flood quantiles including historical and palaeoflood information iiama

Weather Generators Confronted

MulGETS

(Chen et al., 2014)

- Parametric Models
- Wilks approach

(Precipitation Occurrence and amounts handled separately)

GWEX

(Evin et al., 2018)

- Daily precipitation modelled by:

Multi-Gamma (or Multi-Exponential)

- Daily generation
- Matlab Based

- Daily precipitation modelled by:

Extended Generalised Pareto Distribution (E-GDP)

Estimation of the parameters

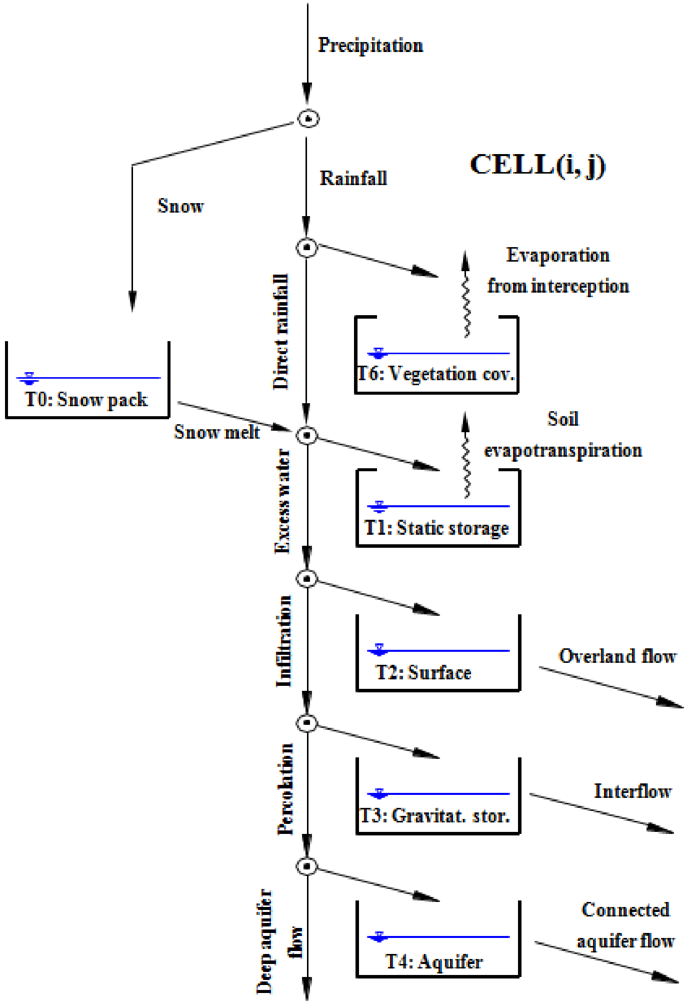
$\left.\begin{array}{l}\sigma,\\ \kappa,\end{array}\right\}$ From observations

$\xi,$ With richer information

- 3-day generation → daily
- Implemented in “R”

TETIS eco-hydrological model

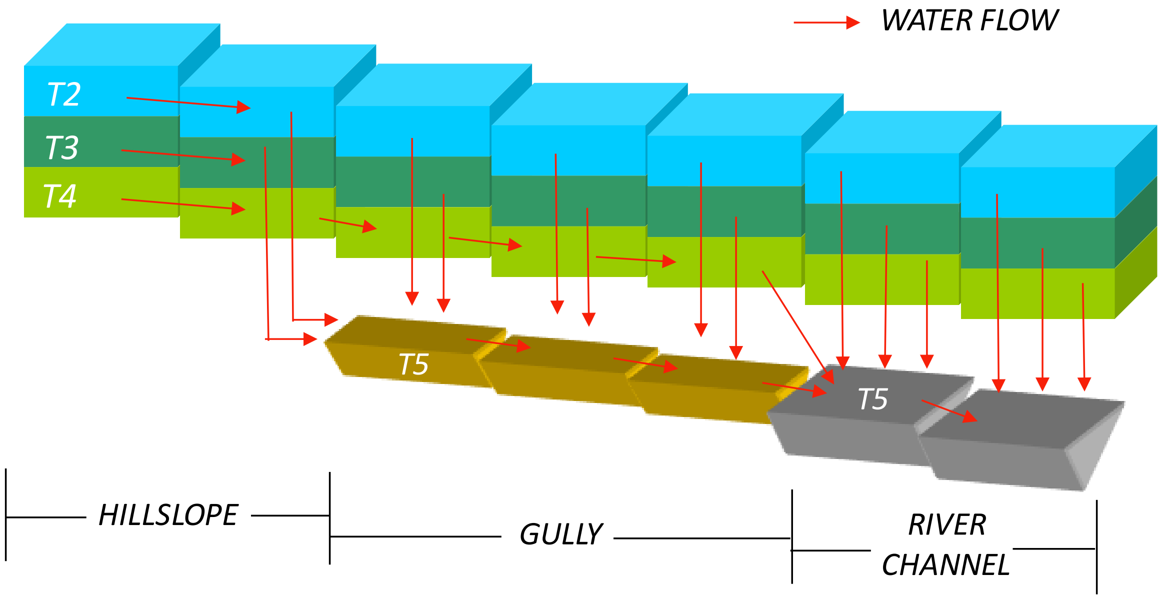
- ❑ Developed by our group since 1994 (version 9 on the web)
- ❑ Conceptual (tank structure) model, with **physically based parameters**
- ❑ **Parsimonious**: 9 parameters for hydrologic sub-model
- ❑ **Integral** model: water resources, floods, sediments, dynamic vegetation, crop production, N-C cycle, … and more to come!



Conceptual schema of the TETIS model at cell scale

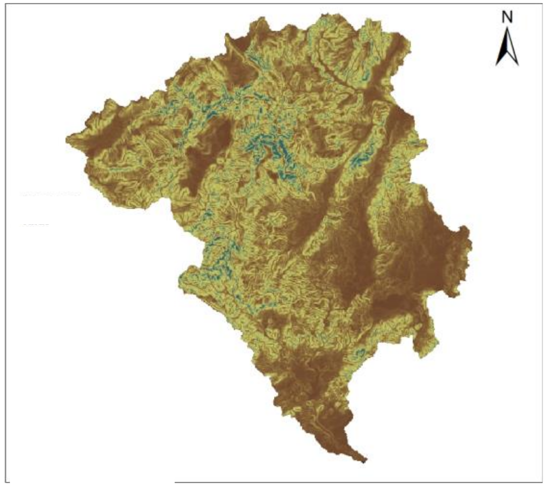
TETIS eco-hydrological model

- **Distributed** in space:
  - Reproduces the spatial variability of hydrological cycle
  - Uses all spatial information available
  - Gives results at any point

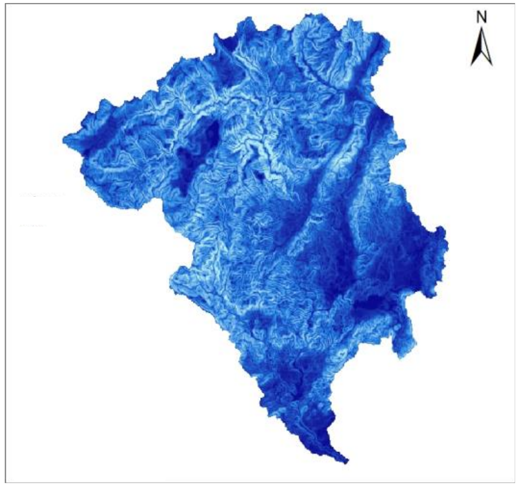


TETIS eco-hydrological model

- ☐ Incorporates an **split effective parameter structure** *(Benito and Francés, 1995; Francés et al., 2007)*



× FC1



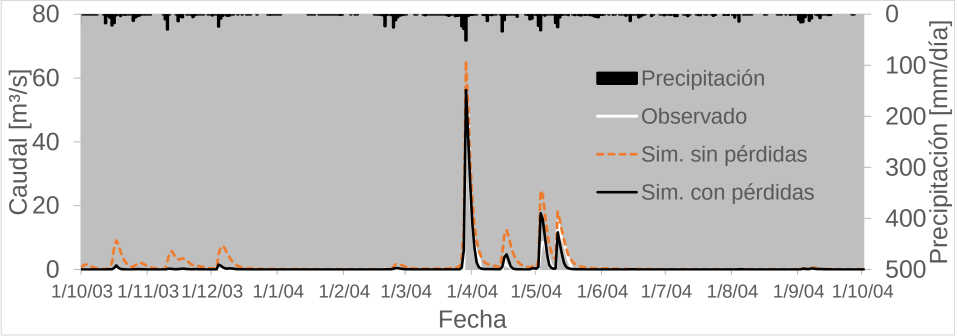
× FC2 …

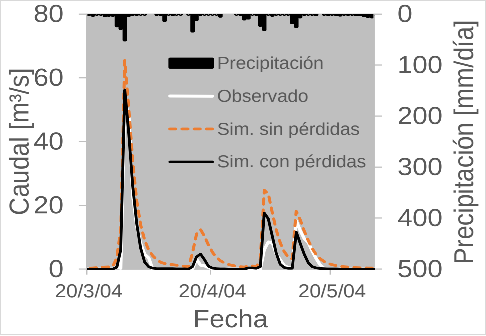
- ➢ Significant reduction of the number of variables to be calibrated => facilitates model calibration stage
- ➢ Maintains the spatial pattern of the parameter maps
- ➢ Powerful **automatic calibration** algorithm

Model Implementation

Calibration:

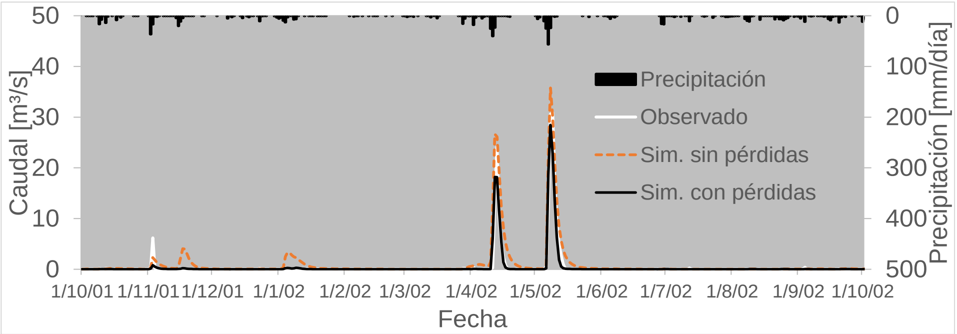
M. Cristina (2003-2004)
EF$_2$ = 0.930

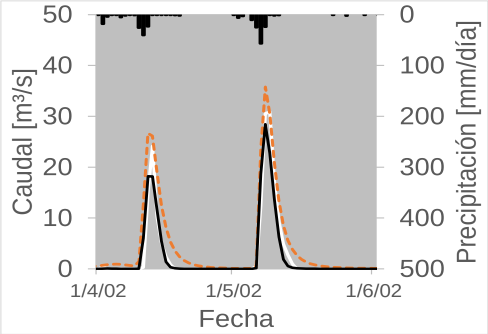




Temporal Validation:

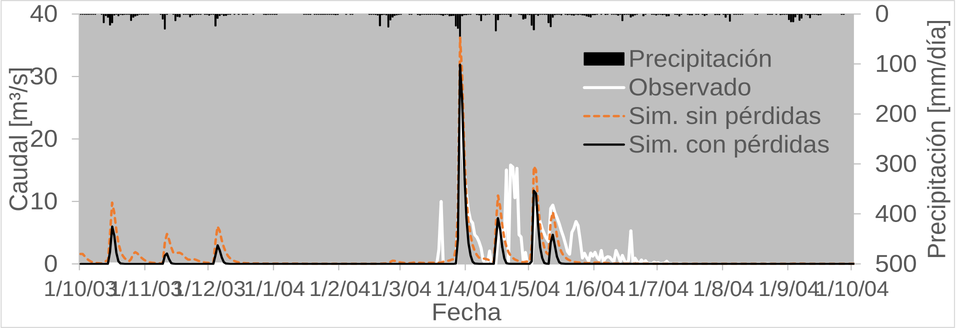
M. Cristina (2000-2001)
EF$_2$ = 0.928

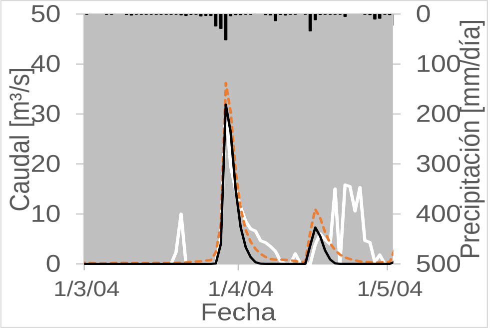




Spatial Validation:

Val d’Alba (2003-2004)
EF$_2$ → 0.428



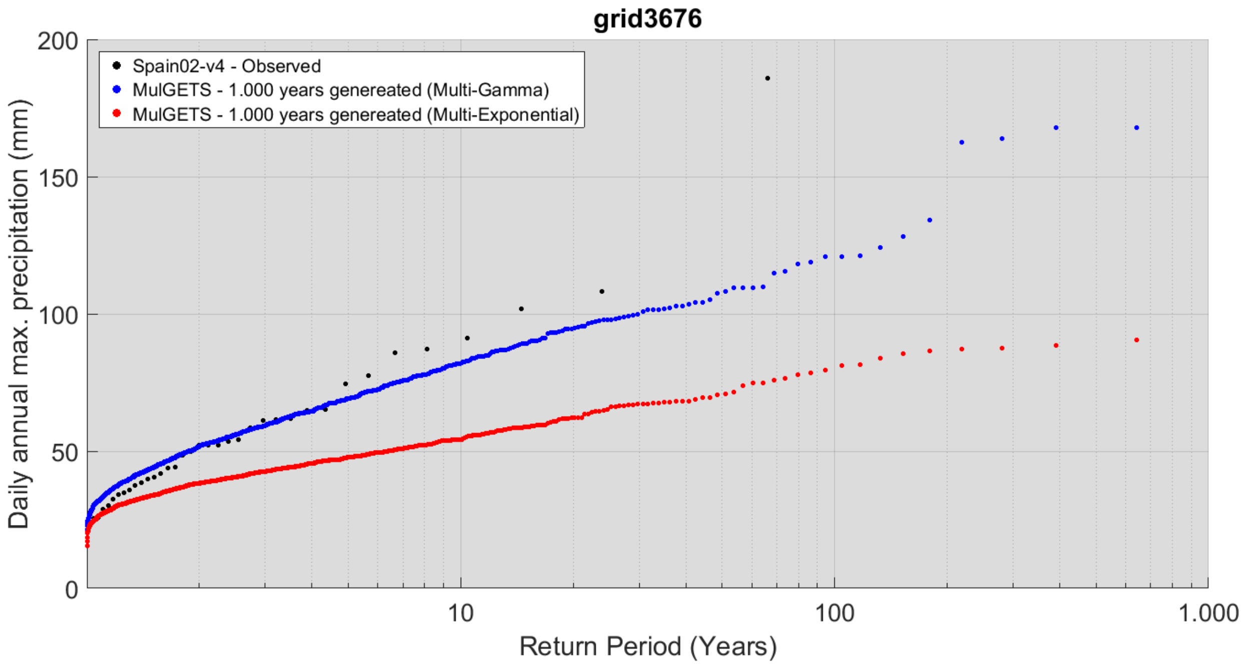


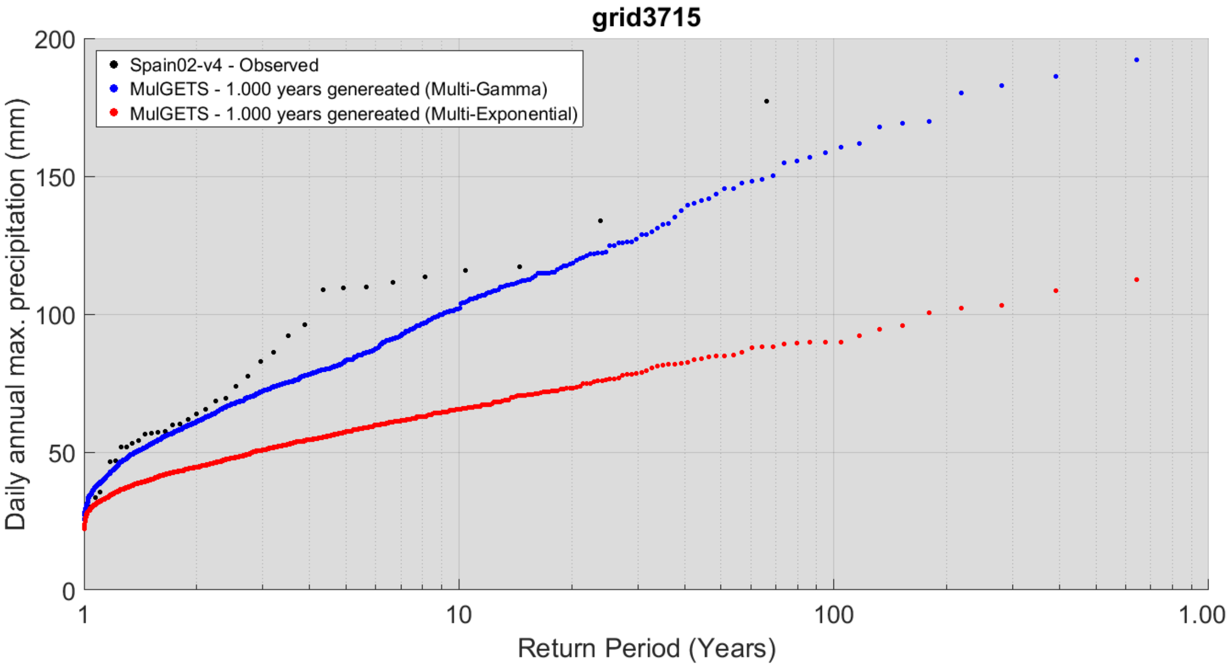
MulGETS Vs GWEX

MulGETS Multi-Gamma

~~Multi-Exponential~~

Simulation using SPAIN02_v4 precipitations

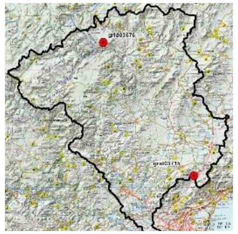




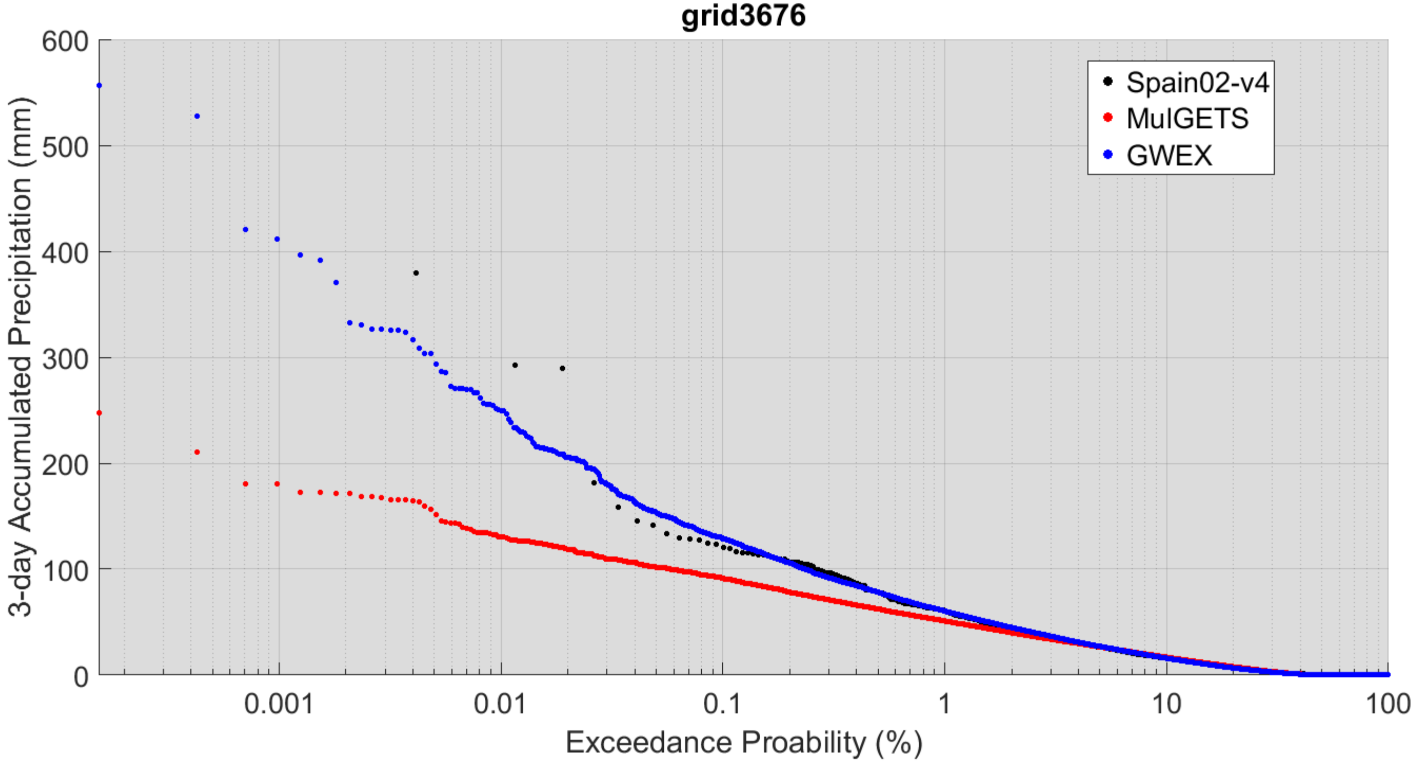
MulGETS Vs GWEX

MulGETS Vs GWEX

(Leaving default shape parameter)



Simulation using SPAIN02_v4 precipitations

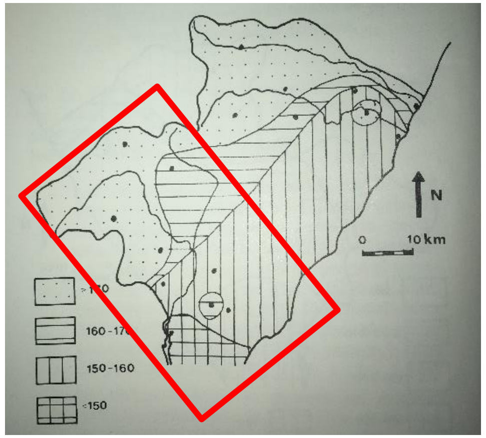


- ❑ 3-day accumulated rainfall clearly underestimated with MulGETS

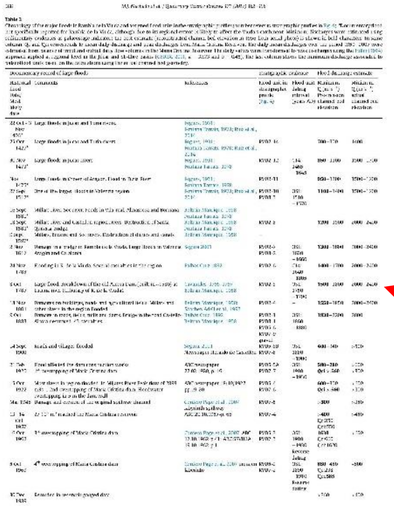
Information for High Return Periods

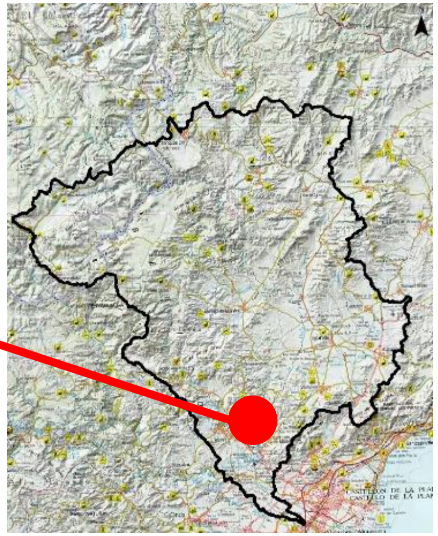
Sources

- ❑ Precipitation
  - ➢ Regional analysis of P_d at a country level *(CEDEX, 1994)*
  - ➢ Regional analysis at catchment level *(Segura, 1990)*
- ❑ Flow
  - ➢ Palaeofloods, confirmed with systematic data and historical information *(Machado et al., 2017)*



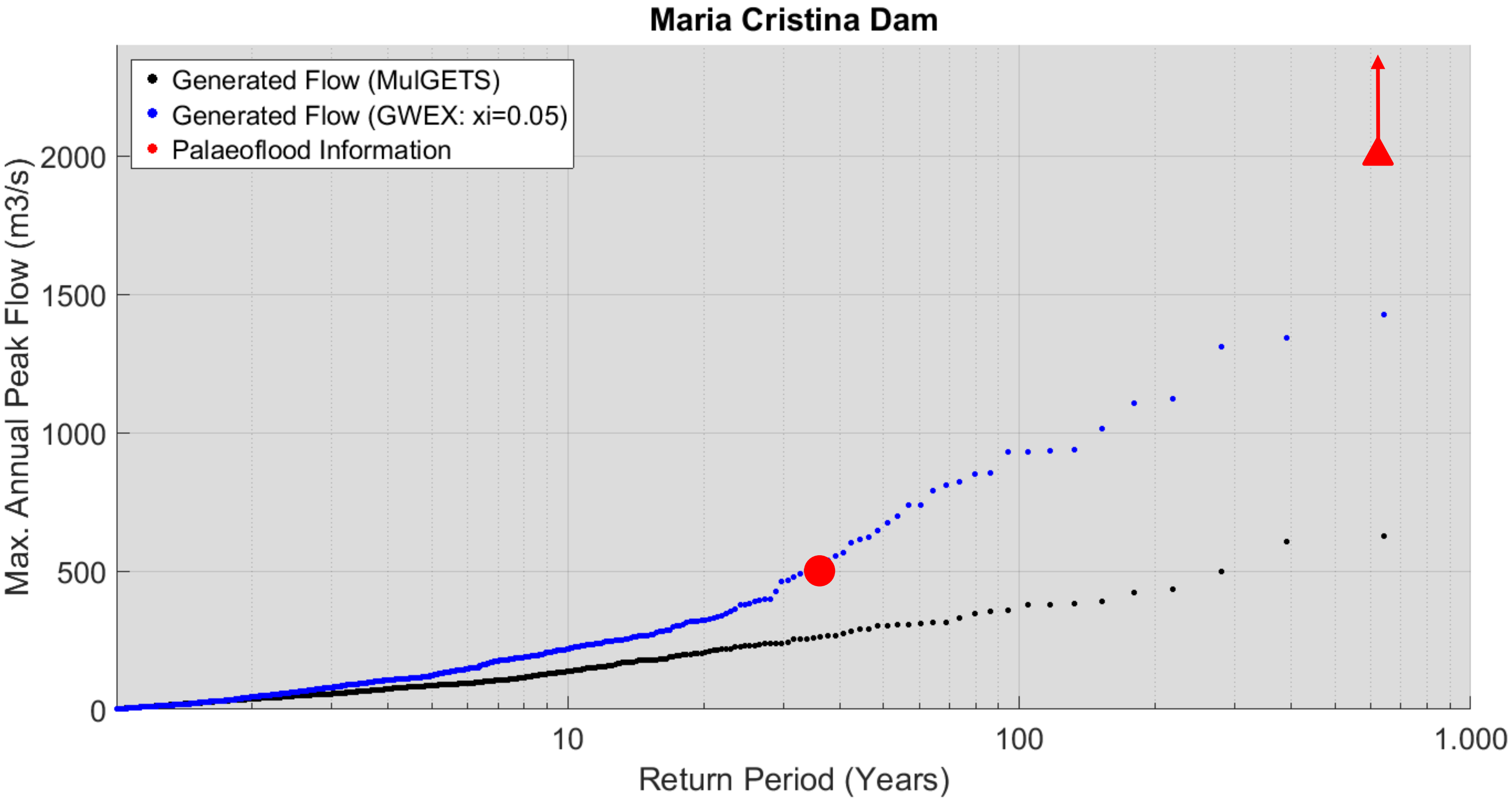
Max. daily prec for T = 50 years





Flows simulated with precipitation from MulGETS and from GWEX

(Leaving default shape parameter)

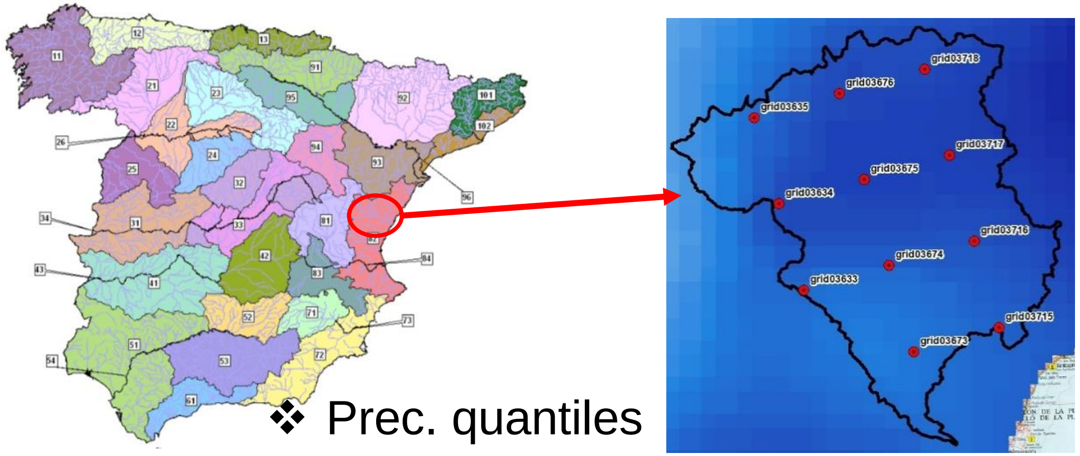


- ❑ Sim. flow with precipitation from MulGETS far from the validation points
- ❑ Sim. flow with precipitation from GWEX ok for low quantiles
- ❑ Upper quantiles are clearly underestimated in both models

Estimation of the shape parameter

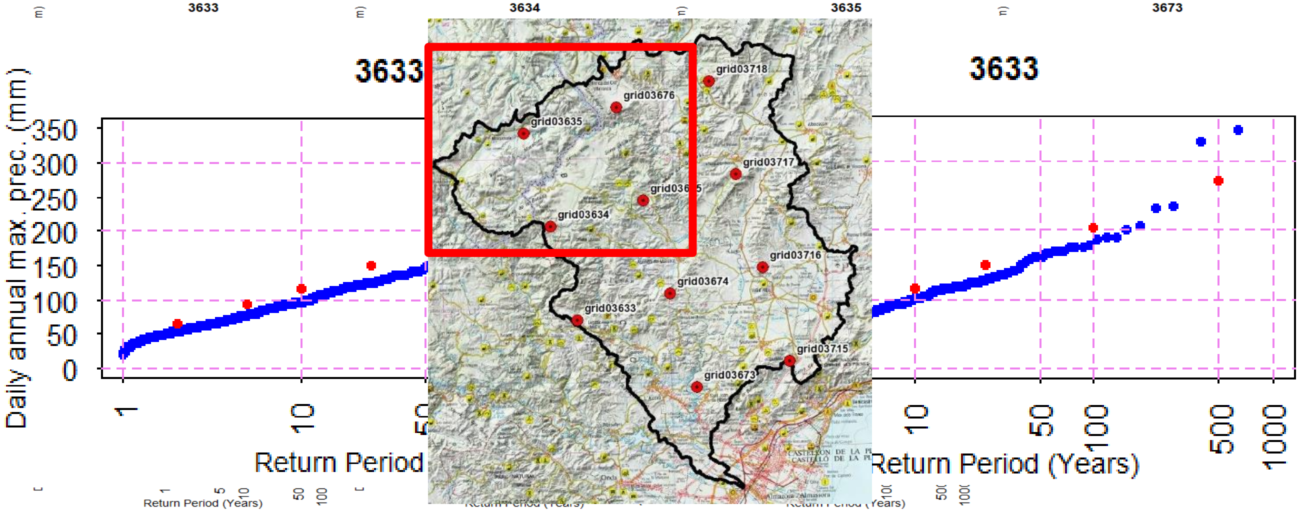
1st Estimation

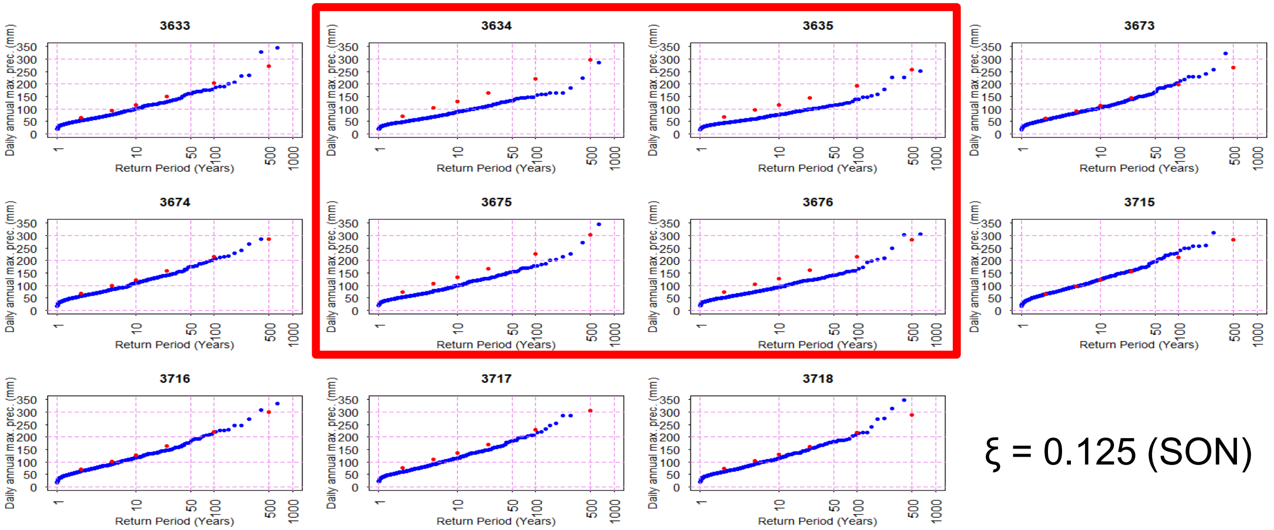
- ❑ CEDEX study (1994)
  - ➢ Different homogeneous regions (Rambla de la Viuda in one of them)
  - ➢ 2 populations
    - Prec. in SON -> To calibrate
    - The rest -> Default value



❖ Prec. quantiles

T= 2, 5, 10, 25, 100, 500



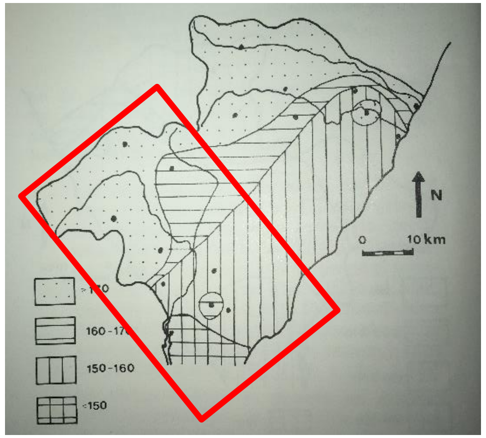


ξ = 0.125 (SON)

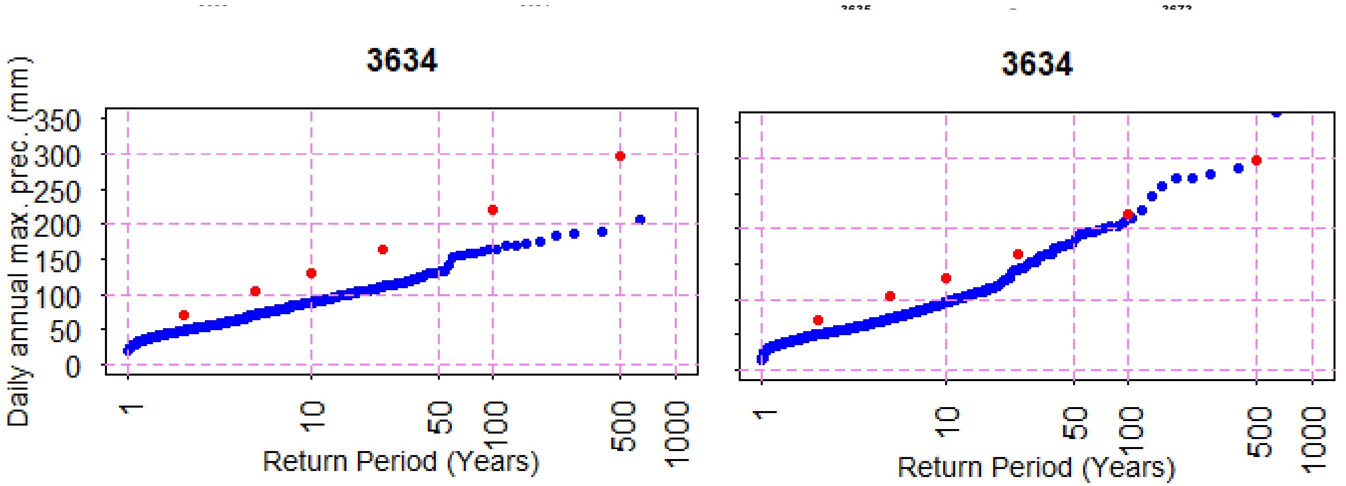
Estimation of the shape parameter

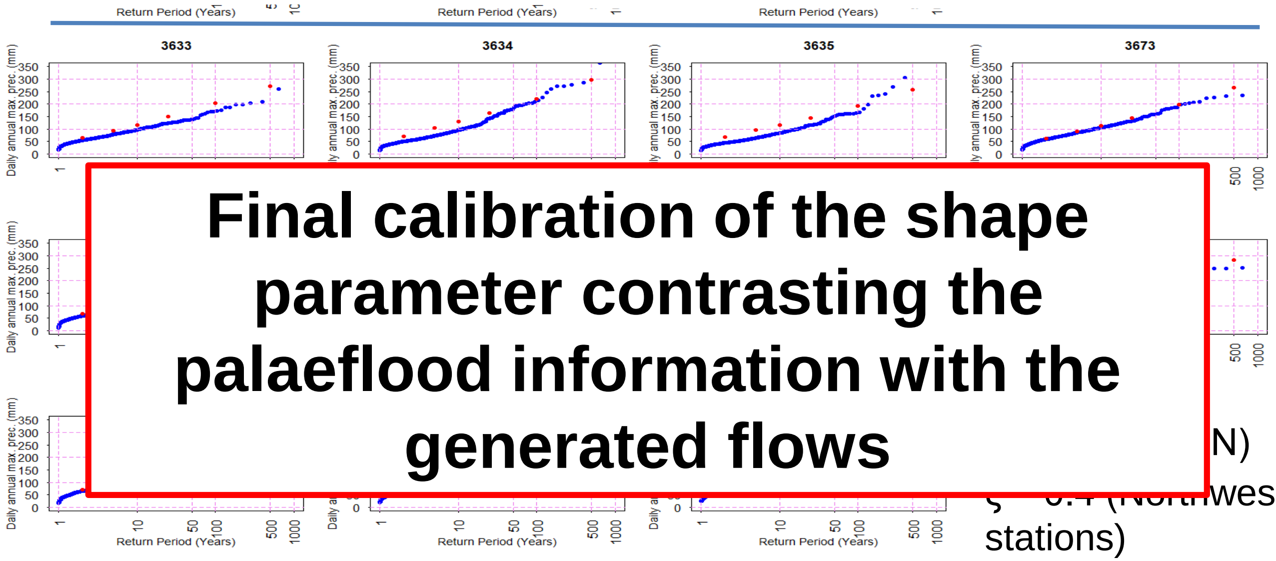
2nd Estimation

- Study at a catchment scale *(Segura, 1990)*
    - Keeping two populations
    - Calibrating ξ at the 4 most north-westerly stations
    - Keeping ξ = 0.125 (SON) for the other stations



Max. daily prec
for T = 50 years





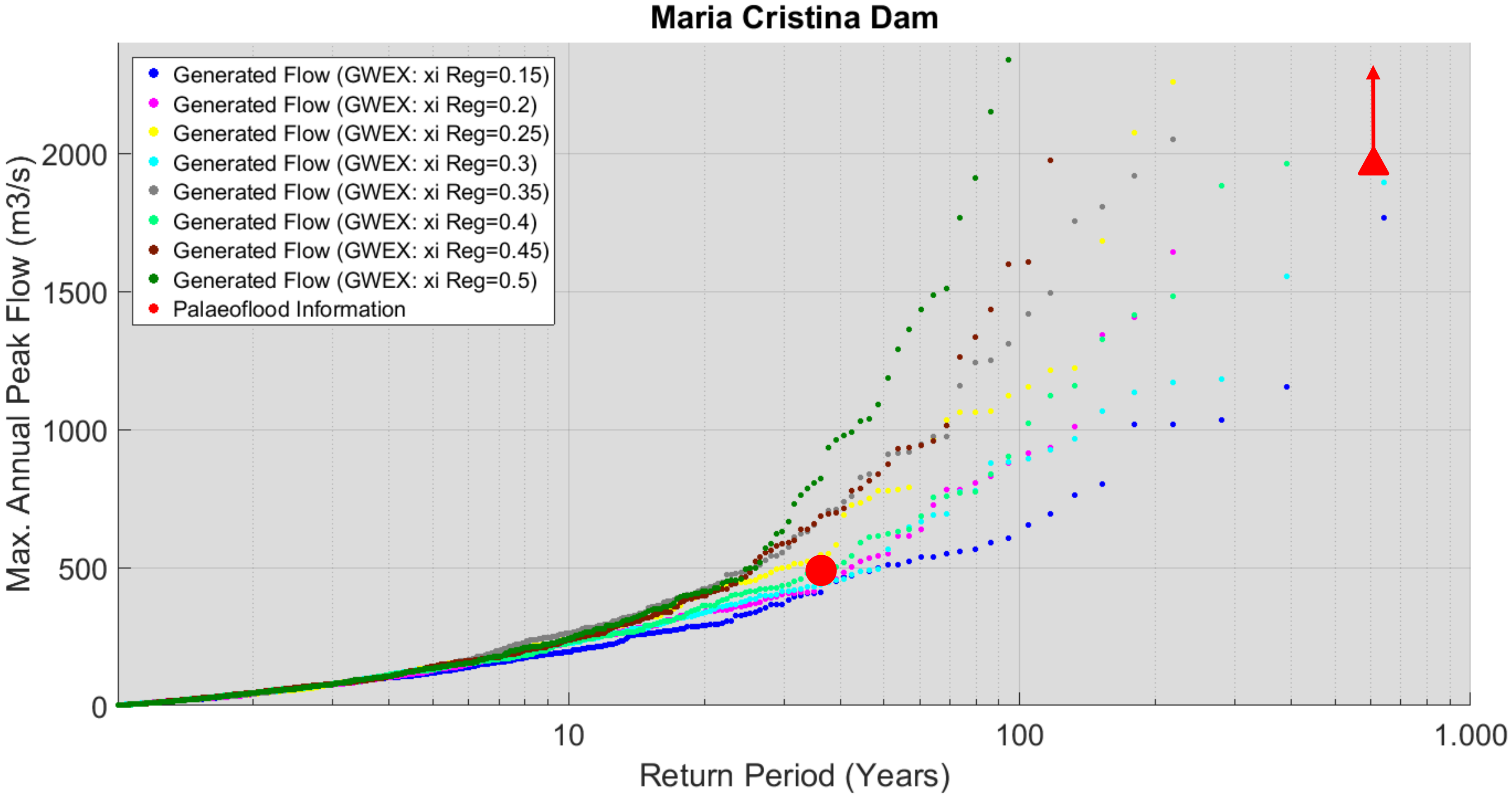
Final calibration of the shape parameter contrasting the palaeflood information with the generated flows

N)

ξ 0.4 (Northwest stations)

Discharges: sensitivity analysis

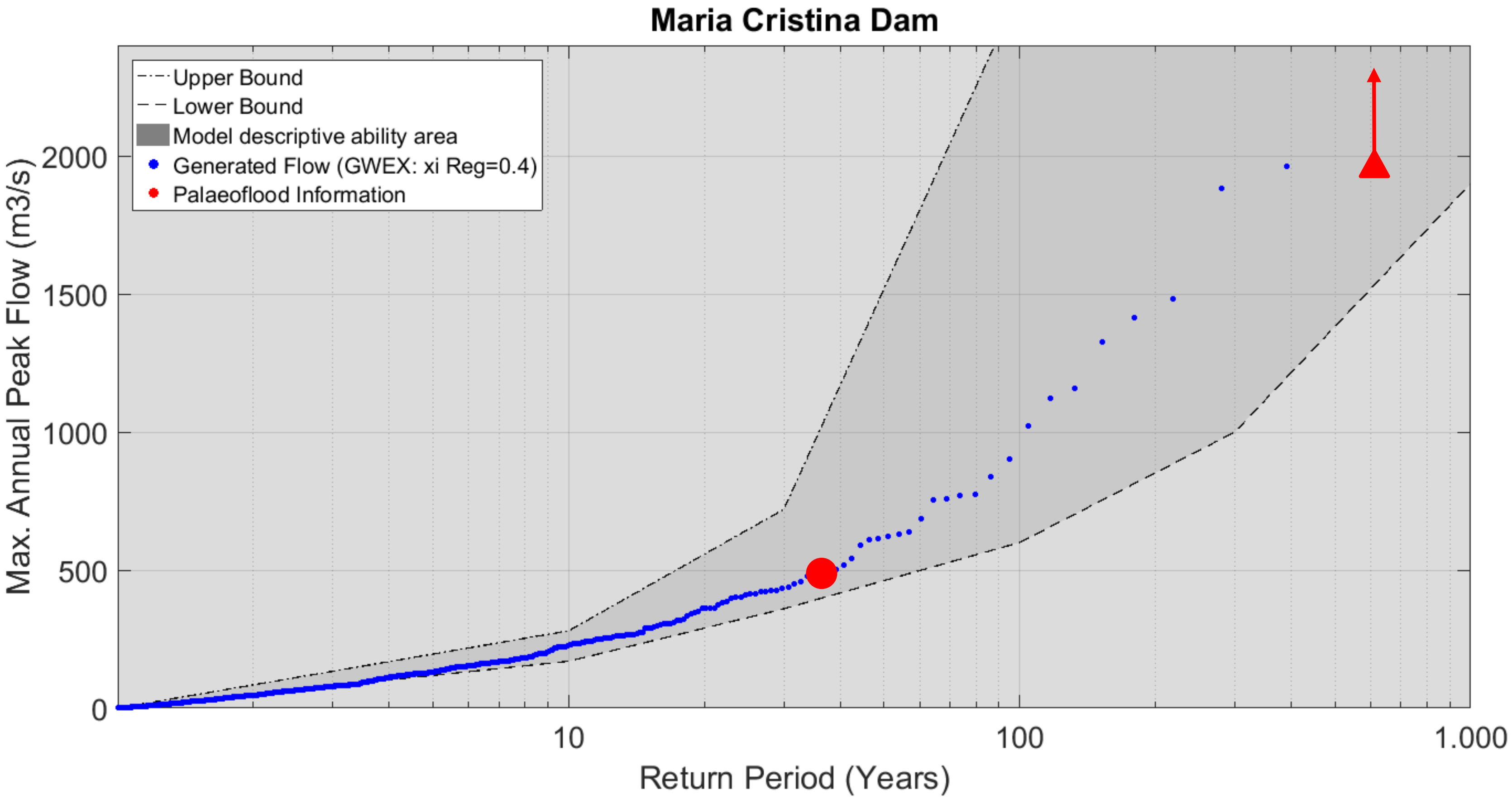
Flows simulated with precipitation from GWEX for different values of the shape parameter applied only to the four most north-westerly stations leaving the rest with ξ=0.125



- ❑ Low quantiles without significant changes
- ❑ High variability for high quantiles

Discharges: sensitivity analysis

Flows simulated with precipitation from GWEX for different values of the shape parameter applied only to the four most north-westerly stations leaving the rest with ξ=0.125



- ❑ Model descriptive ability changing the shape parameter to the four stations

Conclusions

Precipitation

- ❑ Multi-Gamma distribution outperformed Multi-Exponential distribution when simulating with MulGETS
- ❑ Although still underestimating the highest precipitations, GWEX was shown to perform better than MulGETS in terms of extremes generated by medicanes
- ❑ The accumulated amounts of rain fallen over 3-day periods (characteristic of medicanes) were clearly better simulated when using GWEX

Discharges

- ❑ Although this cannot be solely attributed to the Weather Generator, extreme flood quantiles were better simulated when using the precipitation generated with GWEX
- ❑ Furthermore, when palaeoflood information was included, variations to the shape parameter in GWEX resulted in important changes in flows, indicating that the model has a great descriptive ability of representing high return periods

Thanks for your attention

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