UNIVERSITAT POLITÈCNICA DE VALÈNCIA

STAHY

iiama Research Institute of Water and Environmental Engineering

Exploring the stochastic uncertainty of Weather Generators' extreme estimates in different practical available information scenarios

By:

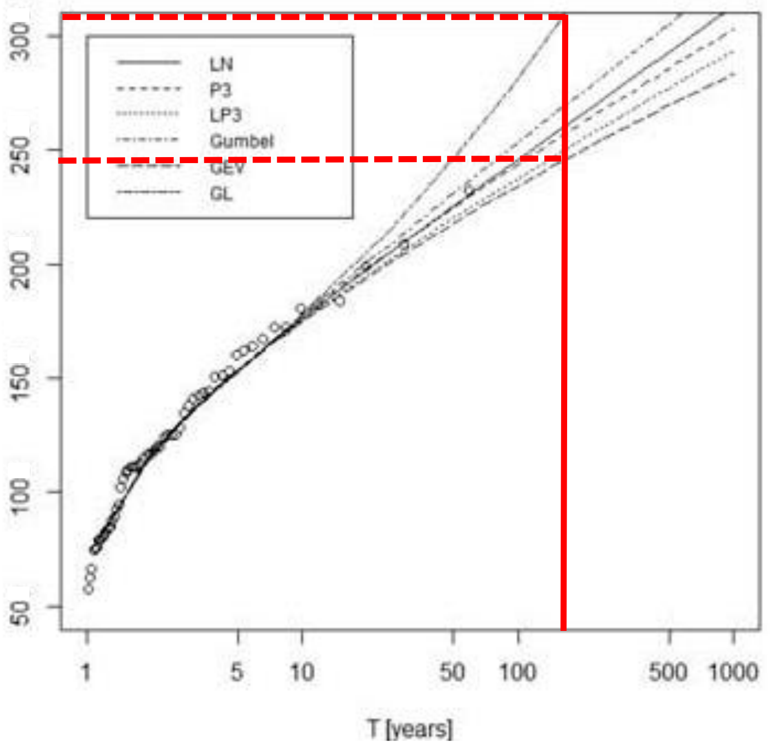
Carles Beneyto, José Ángel Aranda, and Félix Francés

Research Group of Hydrological and Environmental Modelling (GIMHA)
Research Institute of Water and Environmental Engineering (IIAMA)
Universitat Politècnica de València, Valencia, Spain

GIMHA

- **Stochastic Weather Generators (WGs)**
  - Plan and manage natural resources
  - Climate Downscaling
  - Hydrological Modeling
  - Etc..

Produce synthetic time series of weather data of unlimited length for a location, based on the statistical characteristics of observed weather at that location (*IPCC*)



- Therefore, strongly dependent upon the "quality" of the observed weather

Short available precipitation records

High Uncertainty for extreme estimates

Incorporation of additional information
Beneyto et al. (2020)

Quantify the uncertainty of the higher precipitation quantile estimates generated by a Stochastic Weather Generator for different practical information scenarios

Monte Carlo simulation over a synthetic population, measuring the uncertainty through:

- Relative Root Mean Squared Error (RRMSE)
- Relative bias (RB)
- Coefficient of Variation (CV)

Case study: Weather Generator

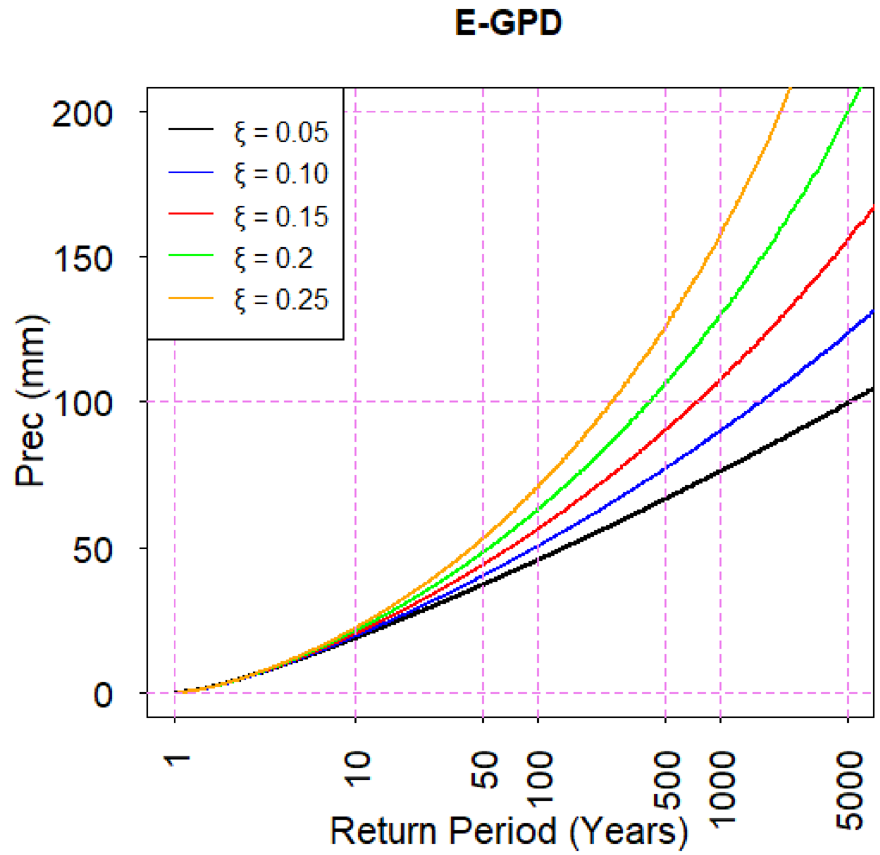
- **GWEX** *(Evin et al., 2018)*
  - Multisite Weather Generator focused on extreme events
  - Precipitation amounts: Extended Generalized Pareto Distribution (E-GPD) (*Papastathopoulos and Tawn, 2013*)

$$F(x;\lambda) = \left[1 - \left(1 + \frac{\xi x}{\sigma}\right)^{-1/\xi}\right]^{\kappa}$$

σ → Scale Parameter

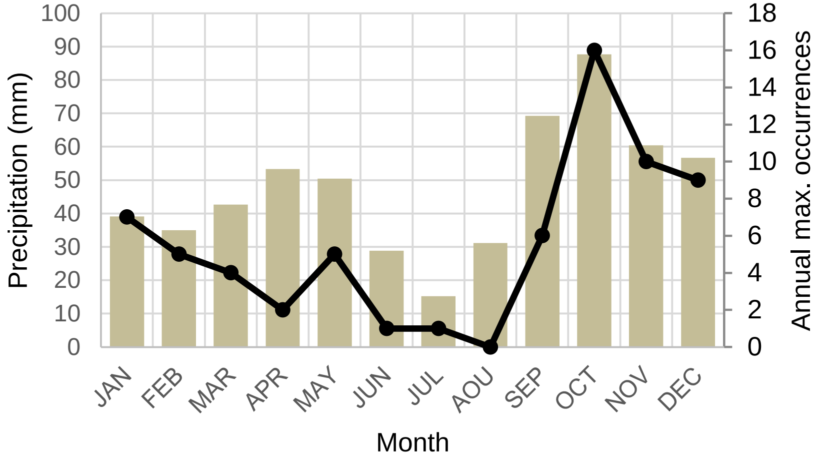
κ → Transf. Parameter

ξ → Shape Parameter (ξ directly affecting the upper tail)



Case study: synthetic study area

- One existing rain gauge (66-year length)
- Semiarid climate
- All parameters of the synthetic population estimated with GWEX
  - Shape parameter (ξ) common to all months of the year: $\xi = 0.11$
- Long precipitation data series generated with GWEX maintaining the main statistics in order to obtain the population quantiles (X_t)



Variable	Statistic	Value
Daily Prec. (Pd)	Mean	1.56 mm
	Sd	6.81 mm
	Nº Pd > 0.1	24.77 %
	Max.	206.94 mm
Annual Prec. (Pa)	Mean	569.86 mm
Annual max. Prec. (X)	Mean	73.35 mm
	CV	0.56
	Skewness	1.43
	Kurtosis	1.66

Methodology

15,000 yrs synthetic precipitation

Monte Carlo Simulation

- Four information scenarios with:
- 50 realizations
- Different ξ (0.05-0.25)
- Different sample lengths (30 to 300 yrs)

T	Population P (mm)
T = 2 yrs	55.7
T = 5 yrs	81.3
T = 10 yrs	100.7
T = 25 yrs	125.8
T = 50 yrs	146.7
T = 75 yrs	158.8
T = 100 yrs	168.4
T = 200 yrs	192.0
T = 500 yrs	238.1
T = 1,000 yrs	262.8

$$RRMSE(\hat{X}_T) = \frac{\sqrt{1/n\sum(\hat{X}_{T,i} - X_T)^2}}{X_T}$$

$$RB(\hat{X}_T) = \frac{1/n\sum(\hat{X}_{T,i} - X_T)}{X_T}$$

$$Cv(\hat{X}_T) = \frac{\sqrt{1/n\sum(\hat{X}_{T,i} - \overline{X_T})^2}}{\overline{X_T}}$$

T	Estimated P (mm)
T = 2 yrs	53.2
T = 5 yrs	78.2
T = 10 yrs	105.2
T = 25 yrs	126.4
T = 50 yrs	151.3
T = 75 yrs	160.8
T = 100 yrs	165.6
T = 200 yrs	198.9
T = 500 yrs	235.1
T = 1,000 yrs	254.6

Information Scenarios

- No additional information

  0. For each realization, the ξ parameter value is set to 0.05 (default) as proposed in Evin et al. (2018)

  1. For each realization, the value of the parameter ξ is estimated by fitting an E-GPD to the available observations

- There exists a regional study of maximum daily precipitation

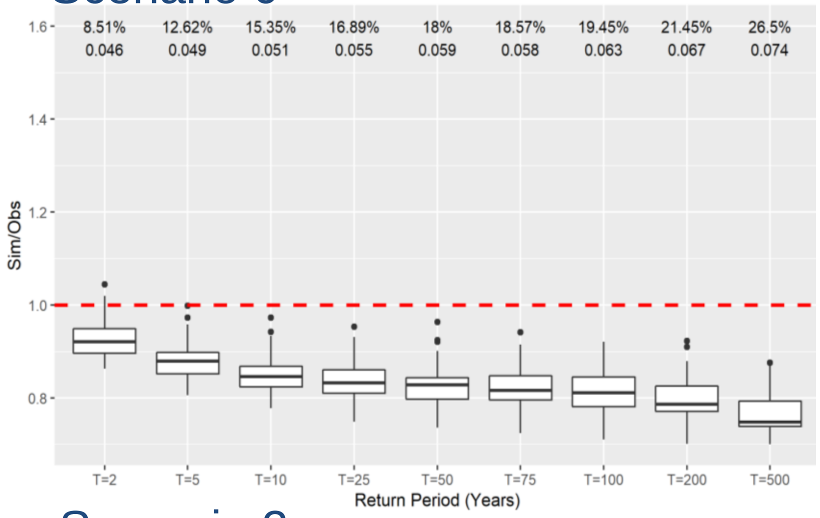
  2. Parameter ξ is estimated with one high T regional quantile for each realization (if not regional E-GPD)

  3. The parameter ξ is set to the regional value for each realization (if regional E-GPD)

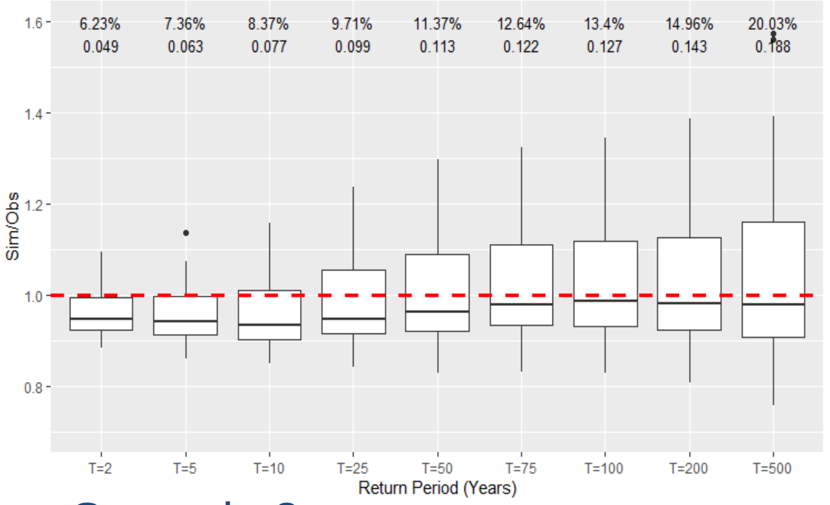
For simplicity, we will assume that the regional study is "perfect" – no uncertainty

ξ =0.11, sample 60yrs

Scenario 0



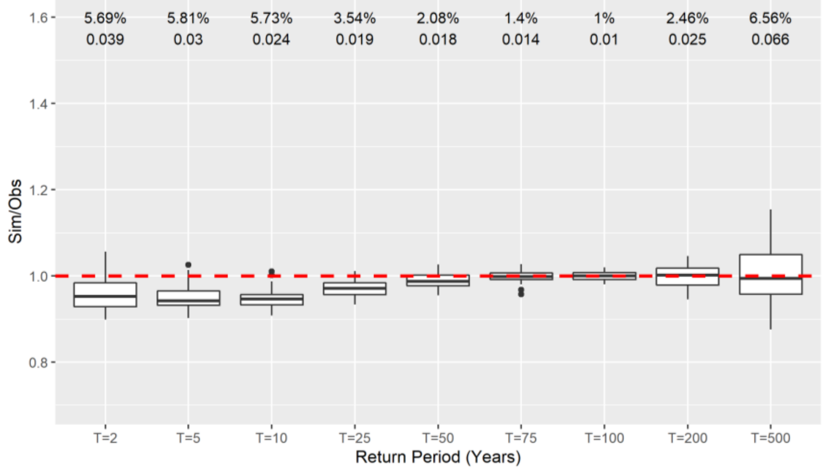
Scenario 1



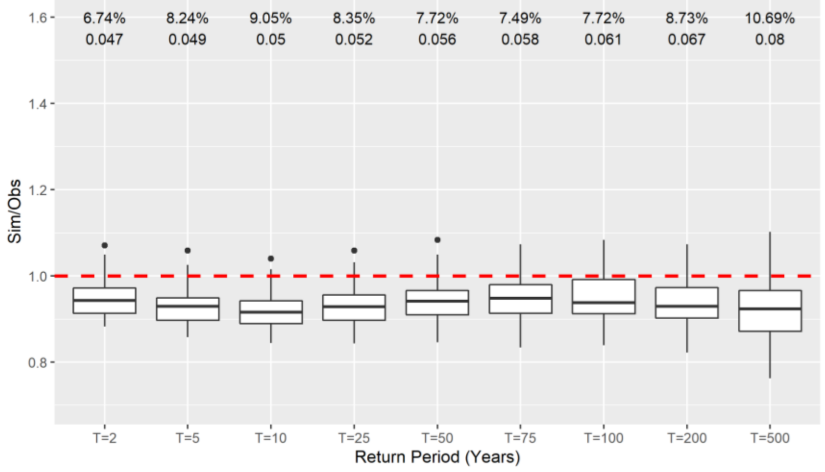
$RRMSE(\hat{X}_T)$
$Cv(\hat{X}_T)$

No additional Information

Scenario 2

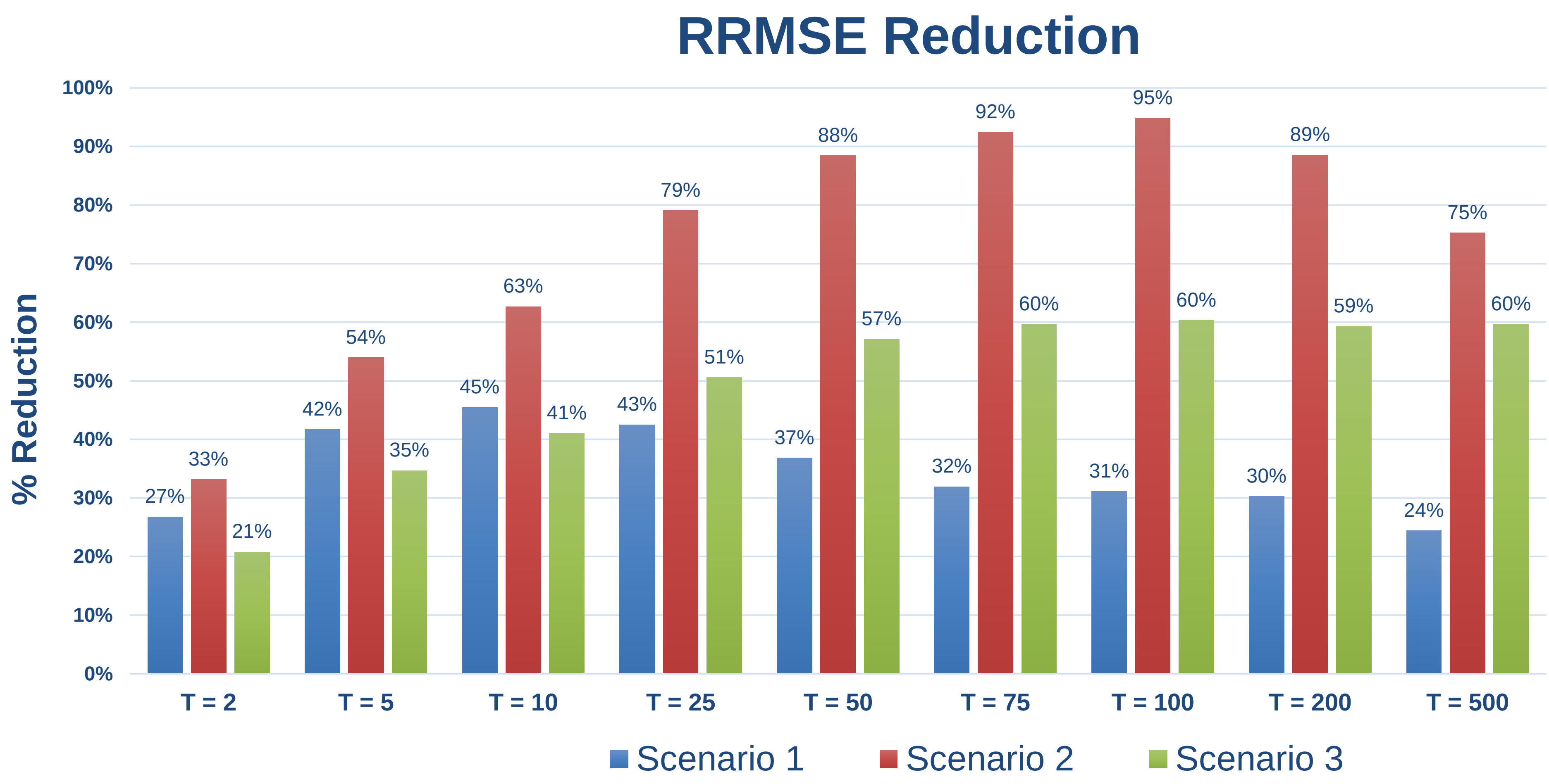


Scenario 3



Regional study of maximum daily precipitation

Reduction of RRMSE



Scenario 0: the ξ parameter value is set to 0.05

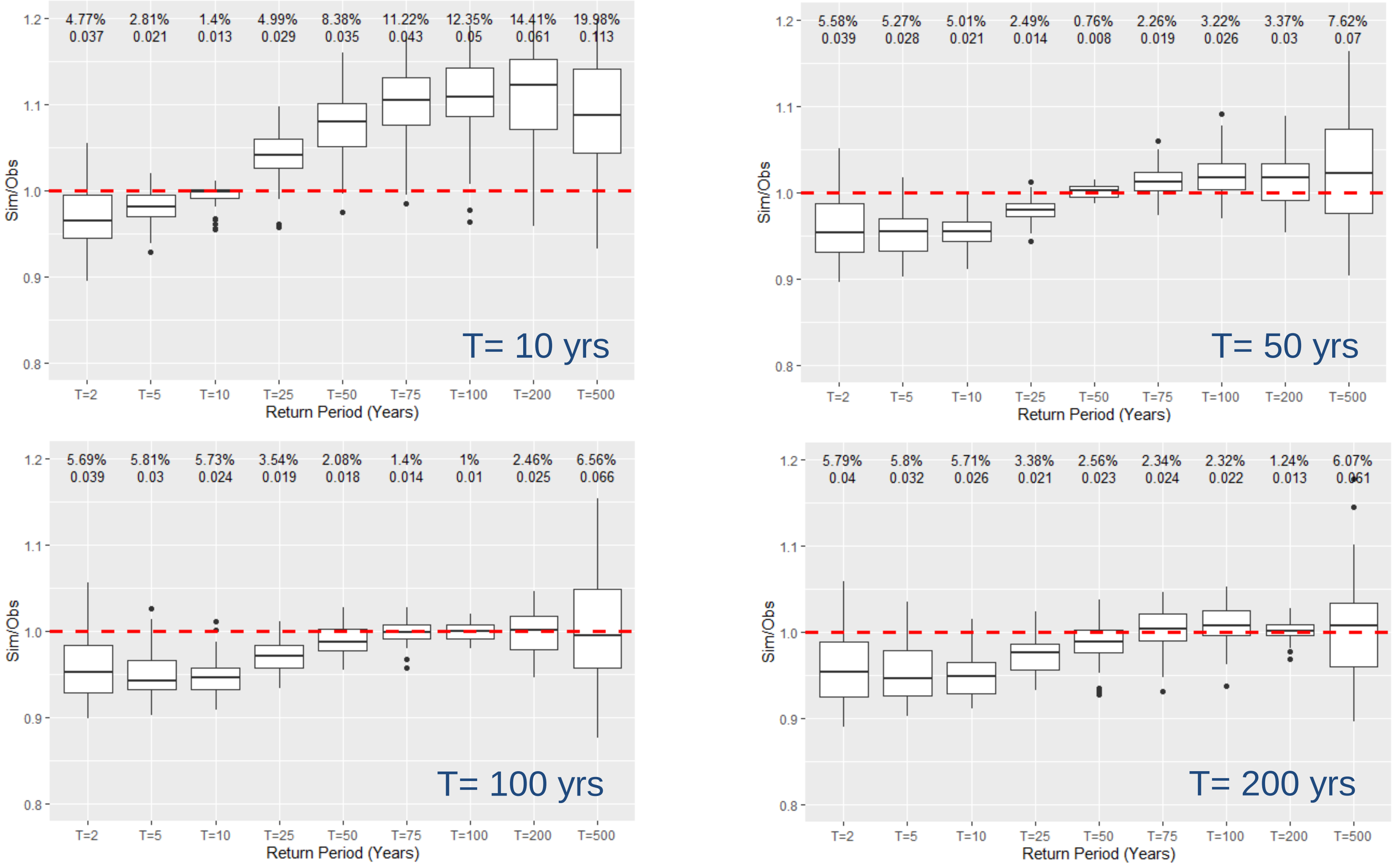
Scenario 1: the value of the parameter ξ is estimated by fitting an E-GPD to the available observations

Scenario 2: ξ estimated with one regional quantile (X_{100})

Scenario 3: The parameter ξ is set to the regional value (ξ = 0.11)

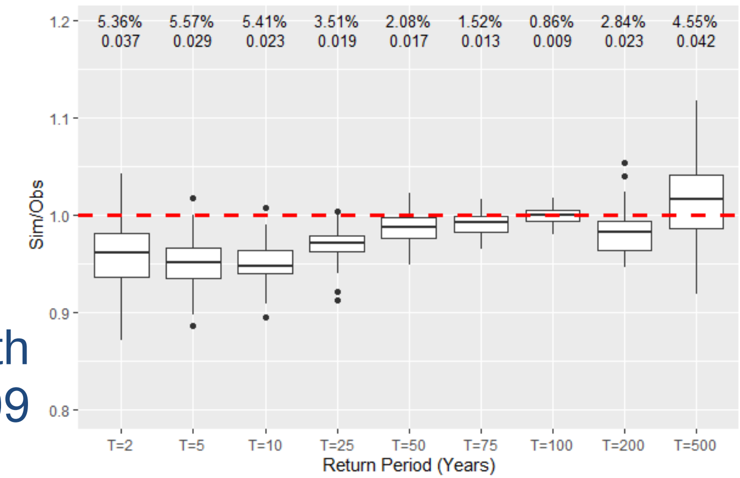
Sensitivity analysis to regional X_t

Population ξ = 0.11
Scenario 2: ξ estimated with one regional quantile

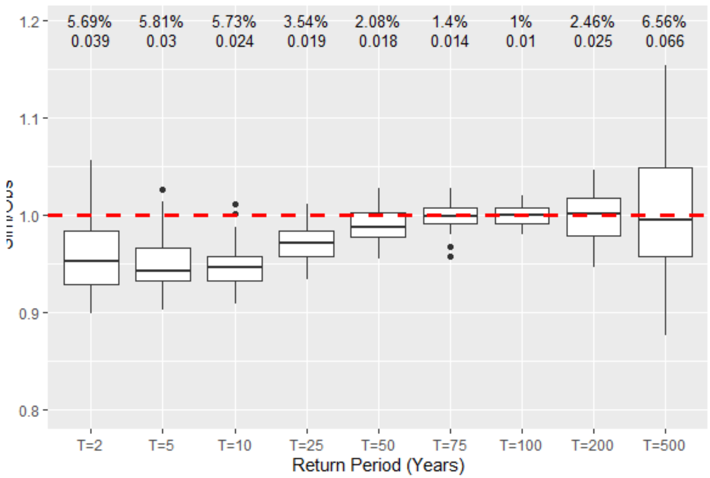


Sensitivity to population ξ (extremality of the population)

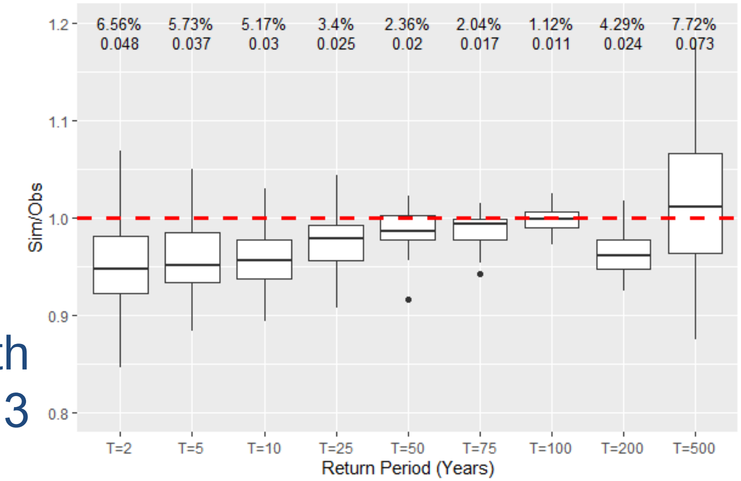
Scenario 2: ξ estimated with one regional quantile T = 100 yrs



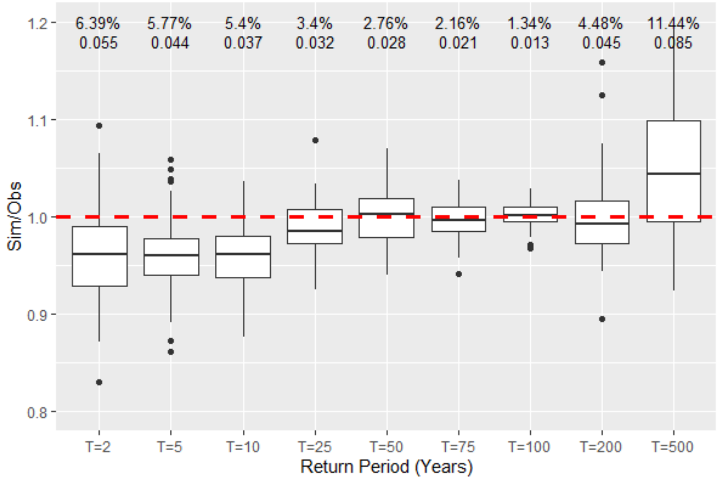
Population with ξ = 0.09



Population with ξ = 0.11



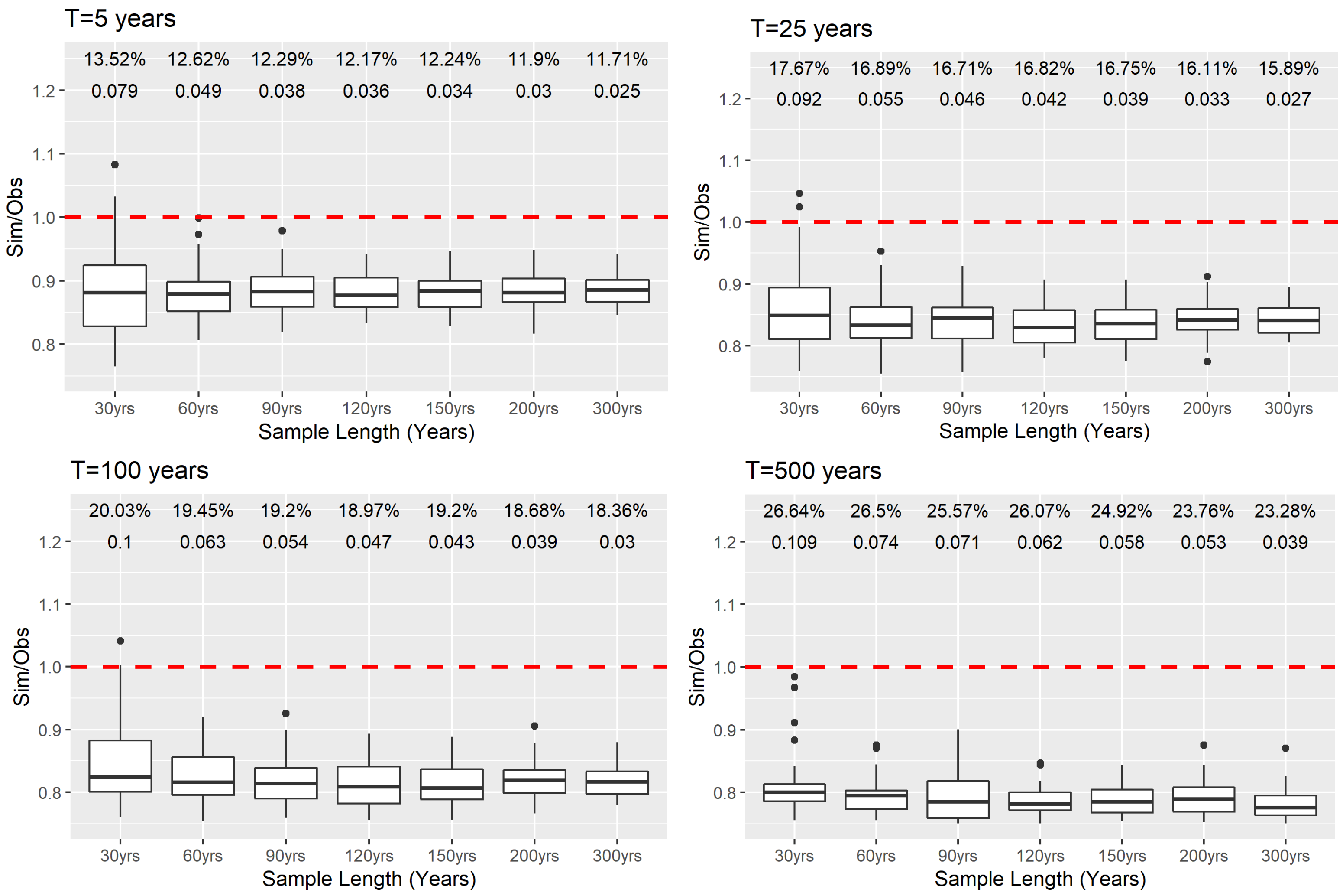
Population with ξ = 0.13



Population with ξ = 0.25

Sensitivity analysis to the sample length

Population ξ = 0.11
Scenario 0: ξ set to 0.05



Conclusions

- The incorporation of a regional study of maximum daily precipitation in the calibration of a WG clearly reduces uncertainty of higher quantile estimates
- The regional study of maximum daily precipitation, one “appropriate” quantile is more informative than the parameter ξ
  - The lower the selected quantile we use for calibrating the WG, the less informative it is
- For all information scenarios, the more extreme the climate is, the higher the uncertainty in the upper quantiles estimates
- For sample lengths plausible with the current reality (i.e. 30-90 years), larger sample sizes do not present significant improvements in the performance of the Weather Generator, from the RRMSE point of view

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

iiama Research Institute of Water and Environmental Engineering

Thanks for your attention!

Research Group of Hydrological and Environmental Modeling
lluvia.dihma.upv.es
Research Institute of Water and Environmental Engineering
Universitat Politècnica de València

This study has been supported by the Ministry of Science, Innovation and Universities of Spain through the Research Projects TETISCHANGE (RTI2018-093717-B-100).

GIMHA