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Hydrological reconstruction of the October 2024 flood in southern Valencia (Spain)

Prof. Félix Francés (ffrances@upv.es)

Authors: Carles Beneyto, Jaime Cachay, José A. Aranda and Félix Francés

Research Institute of Water and Environmental Engineering (IIAMA)

Universitat Politècnica de València (UPV), Valencia, Spain



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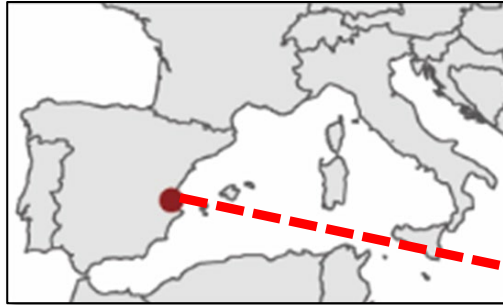
Outline of the presentation

- ❑ The case study
- ❑ The storm on October 29, 2024
- ❑ Tetis hydrological model
- ❑ The flood on October 29, 2024
- ❑ Conclusions



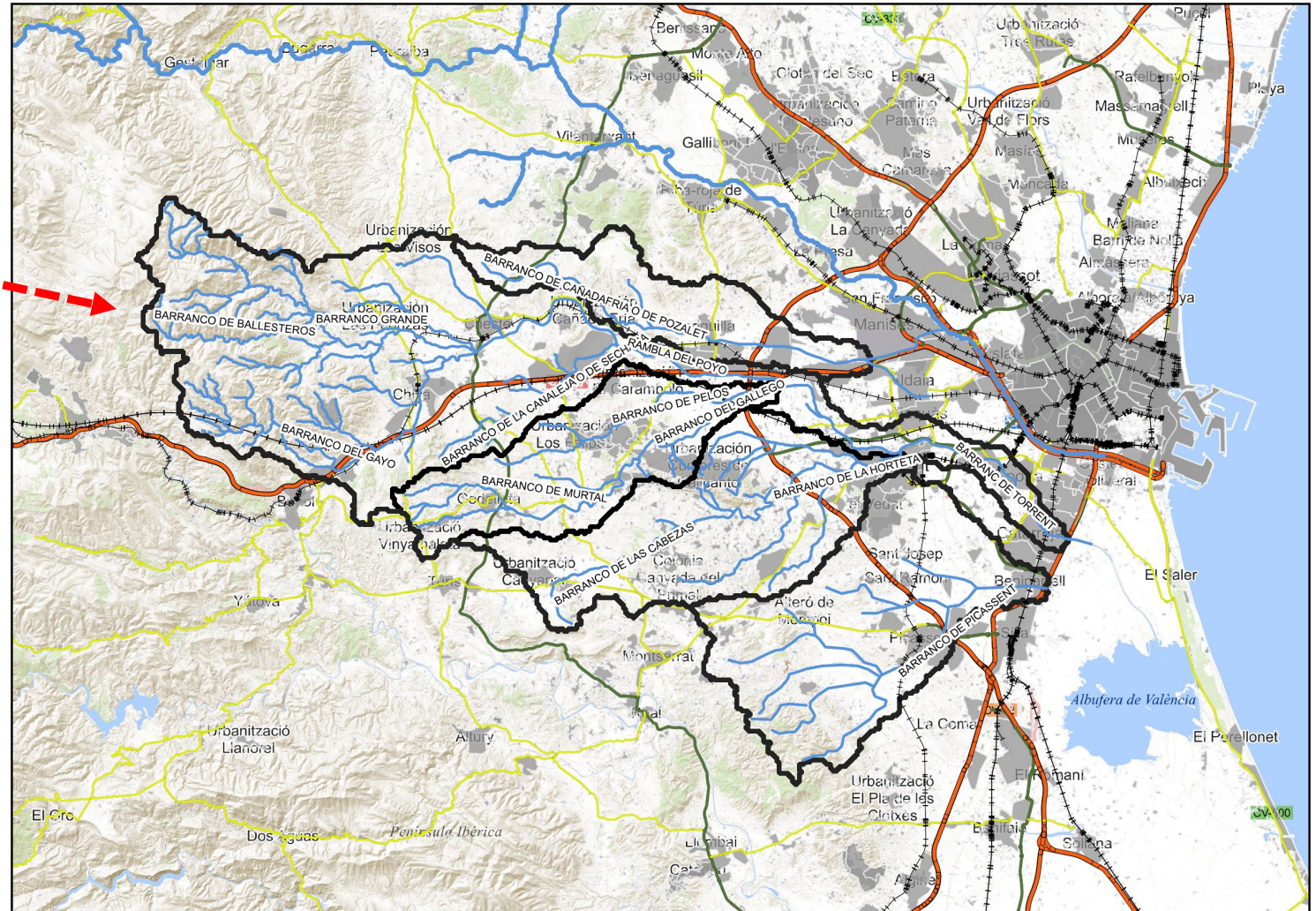
“Mother’s Love”, by Muñoz Degrain (1912),
representing a large flooding of the
orchards surrounding Valencia

Drainage area of southern Valencia



Pozalet	46.2 km²		
Poyo	369 km²		
	Horteta	91.3 km²	42.7%
	Gallego	66.2 km²	
Picassent	103.4 km²		

Flash floods!



T500 flood hazard map



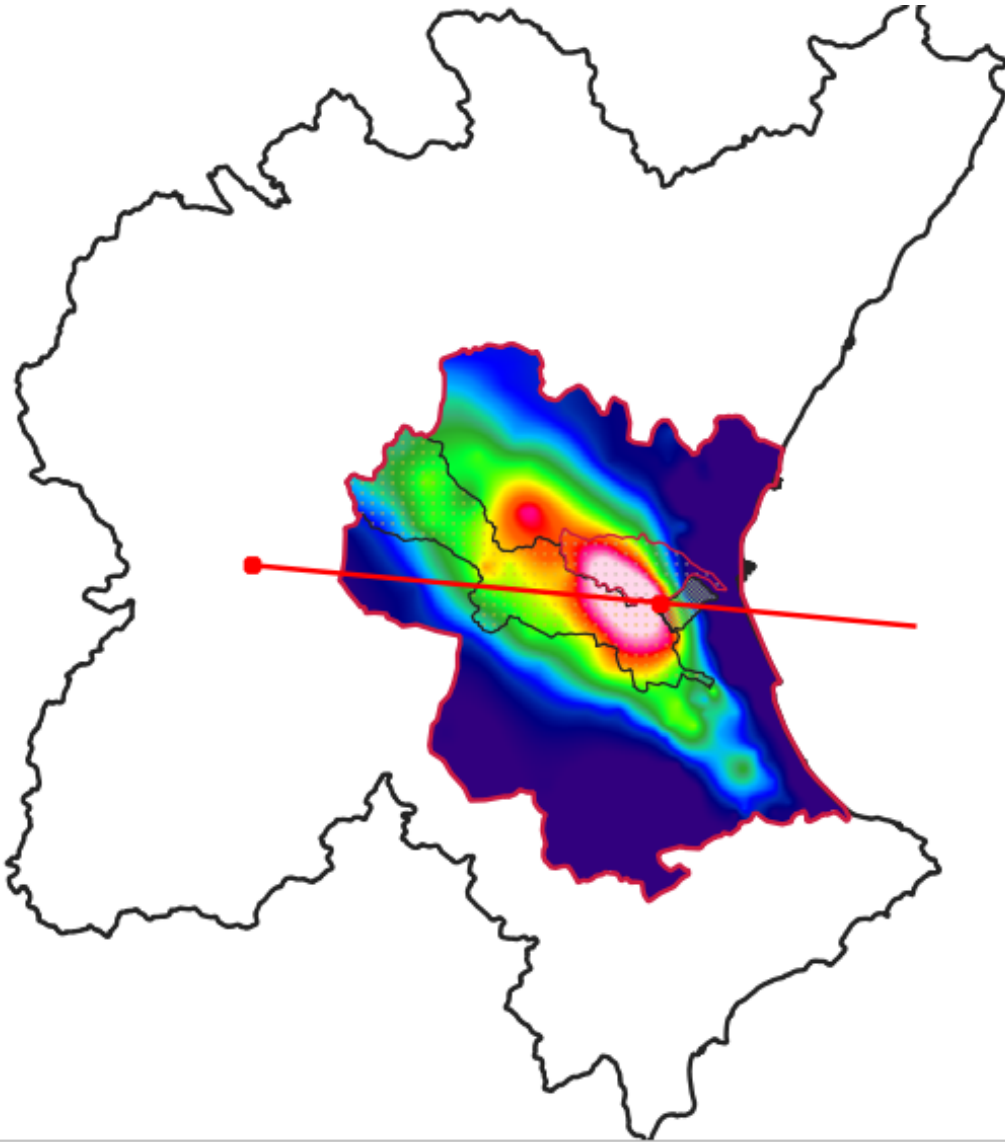
Evolution of Pozalet Creek



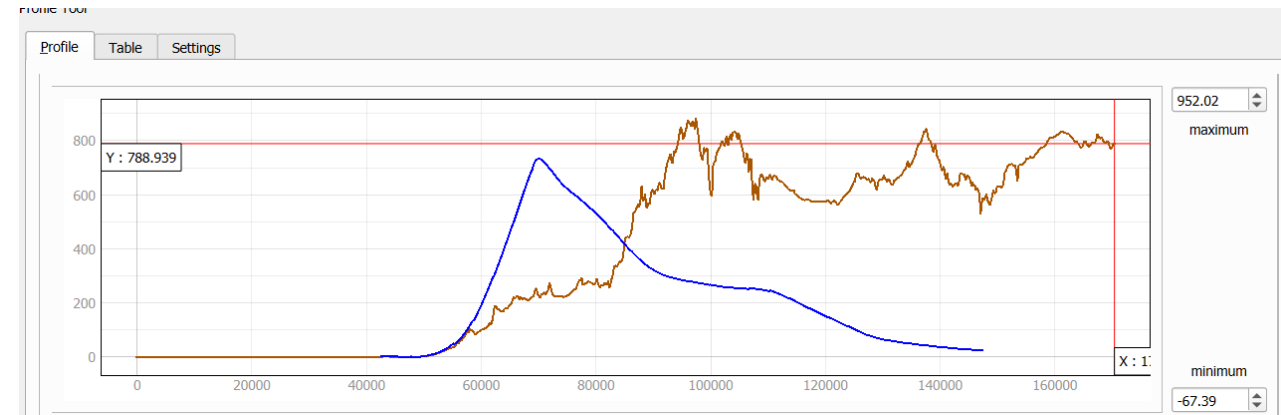
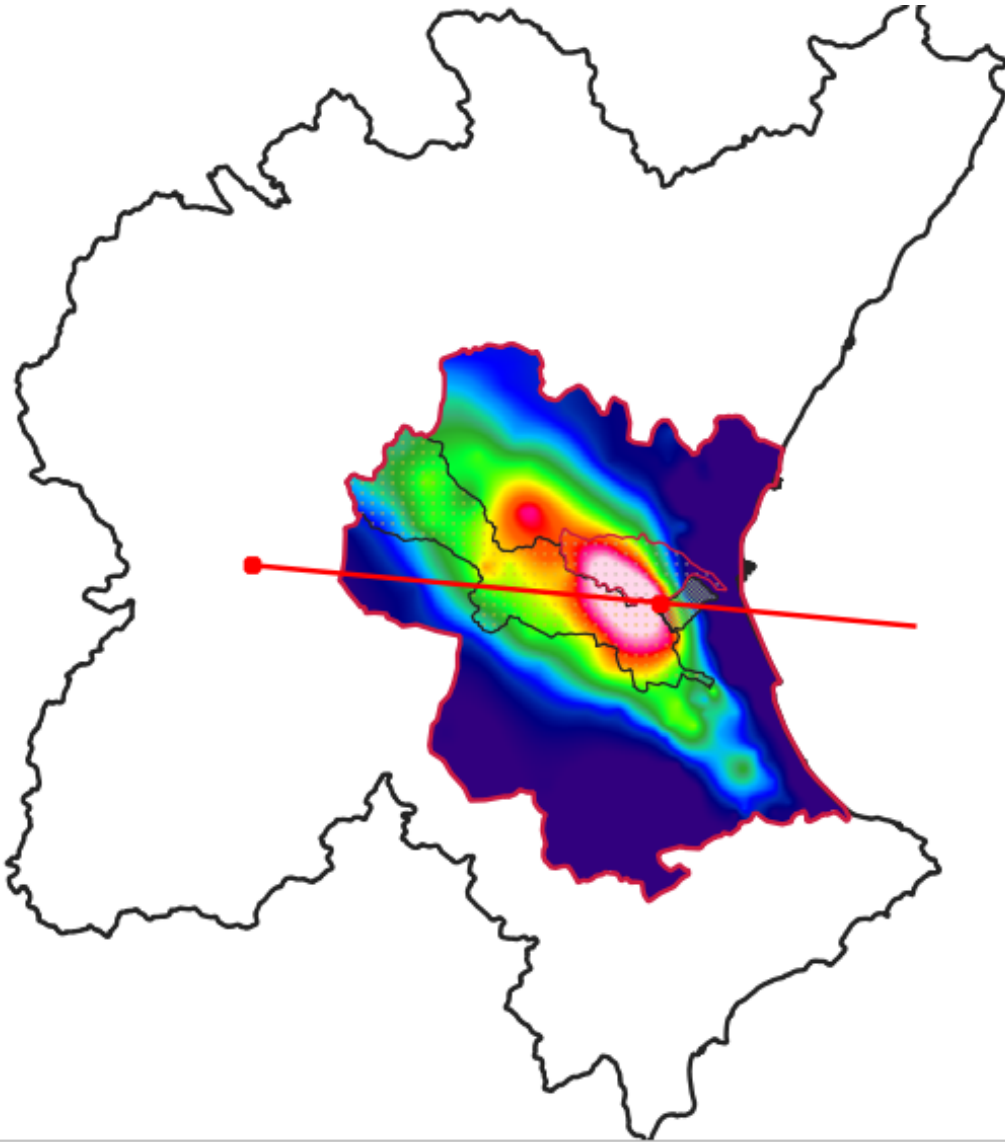
**Total: 575
rain gauges**

The storm on October 29, 2024

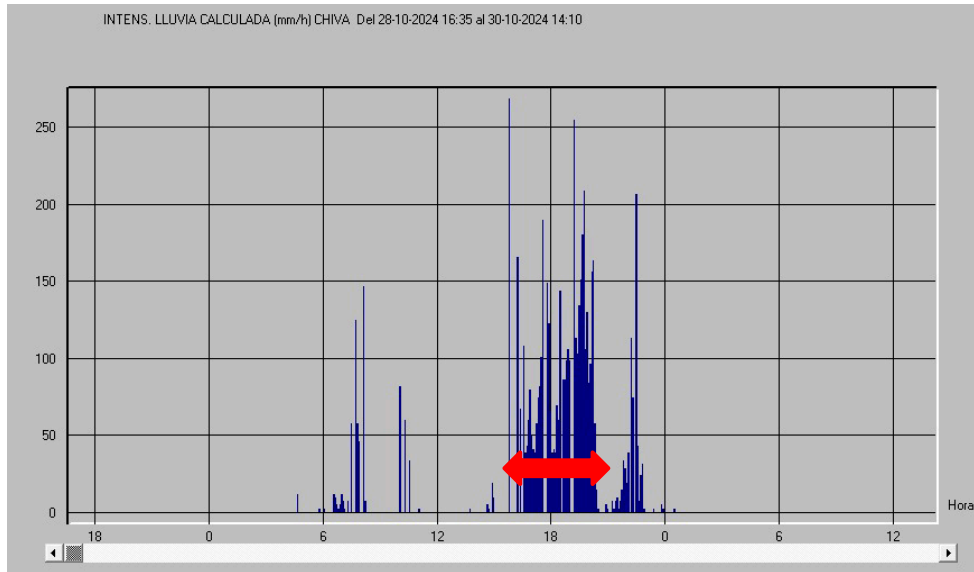
- ❑ Spatial interpolation techniques
 - Hourly and daily
 - IDW, exponent 2 and up to 10 rain gauges
 - Kriging:
 - **Exponential**
 - Gaussian
 - Spherical



The storm on October 29, 2024

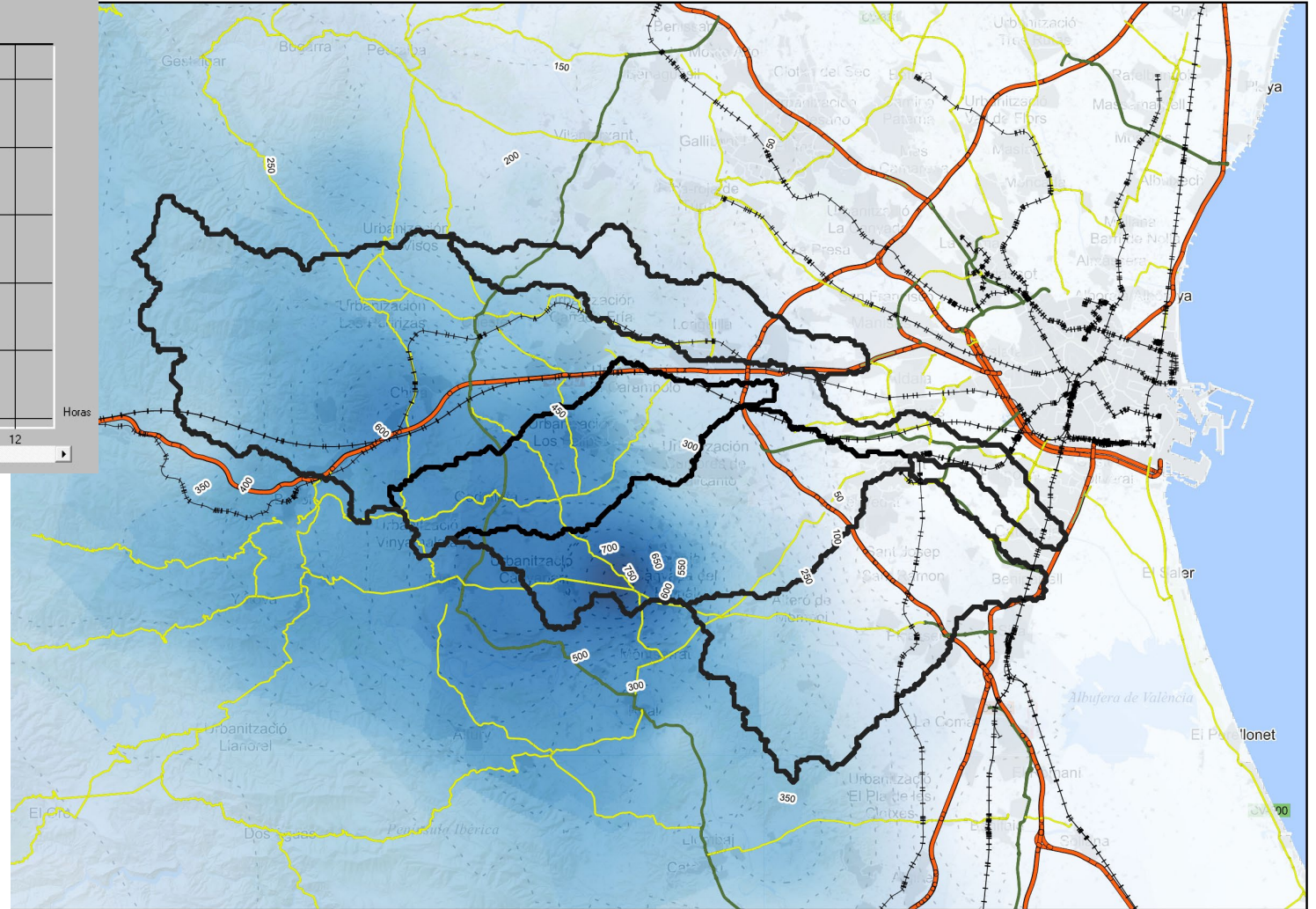


The storm on October 29, 2024



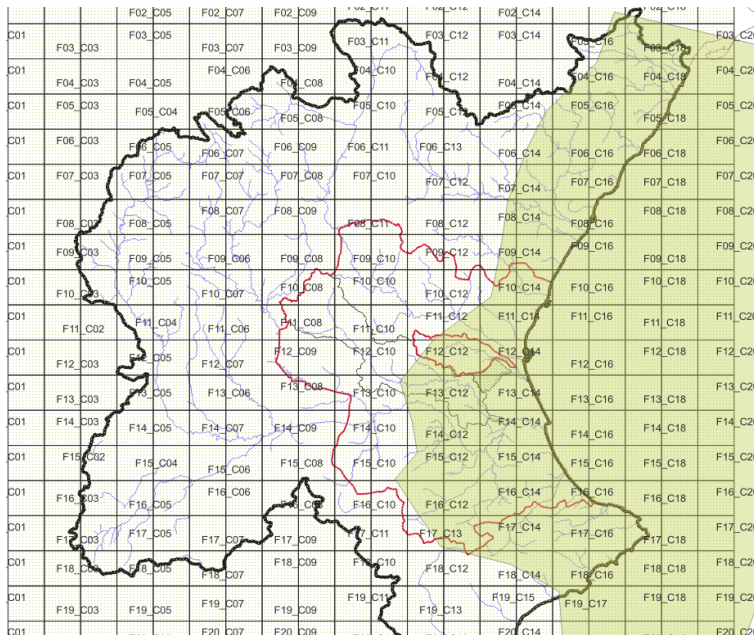
Main storm duration = 5 hours
Daily precipitation in Turis = 772 mm
Max hourly intensity: 185 mm/h

No rain in the IA and no alert!

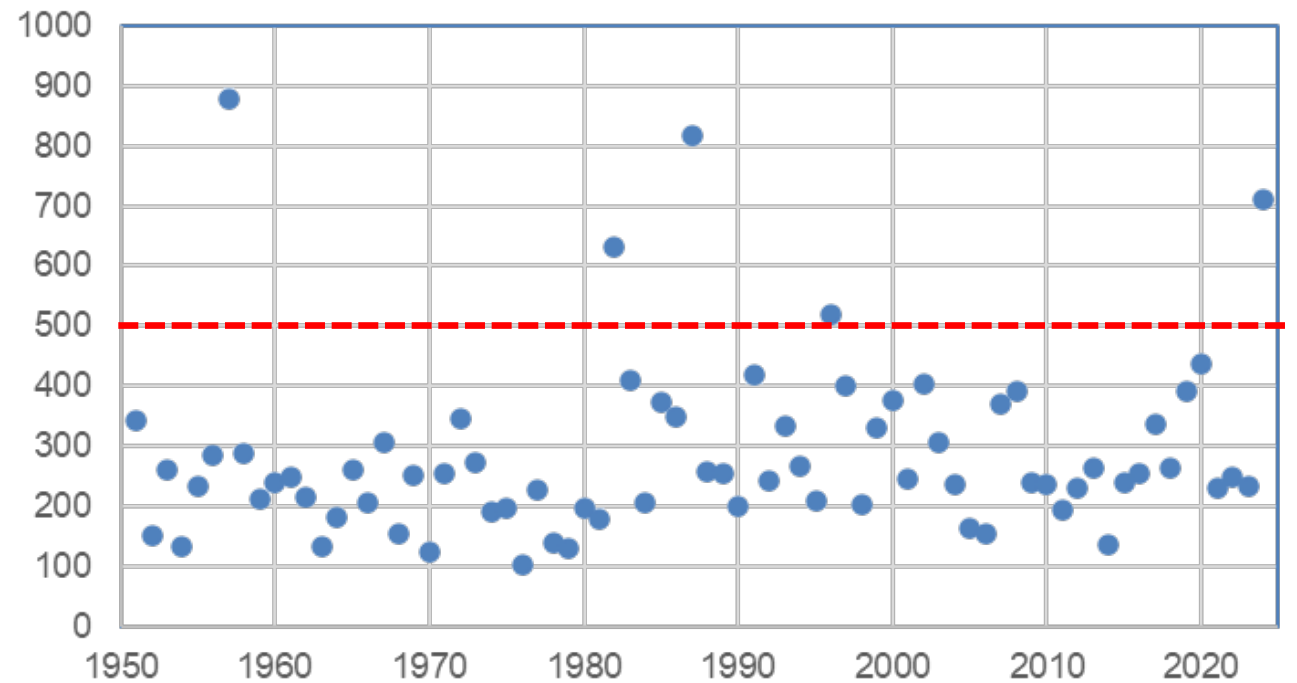


Storm frequency in the Region of Valencia

- Every year since 1951 until 2024 (74 years) P_{dmax} is larger than 100 mm
- P_{dmax} 500 mm has a $T=15$ years

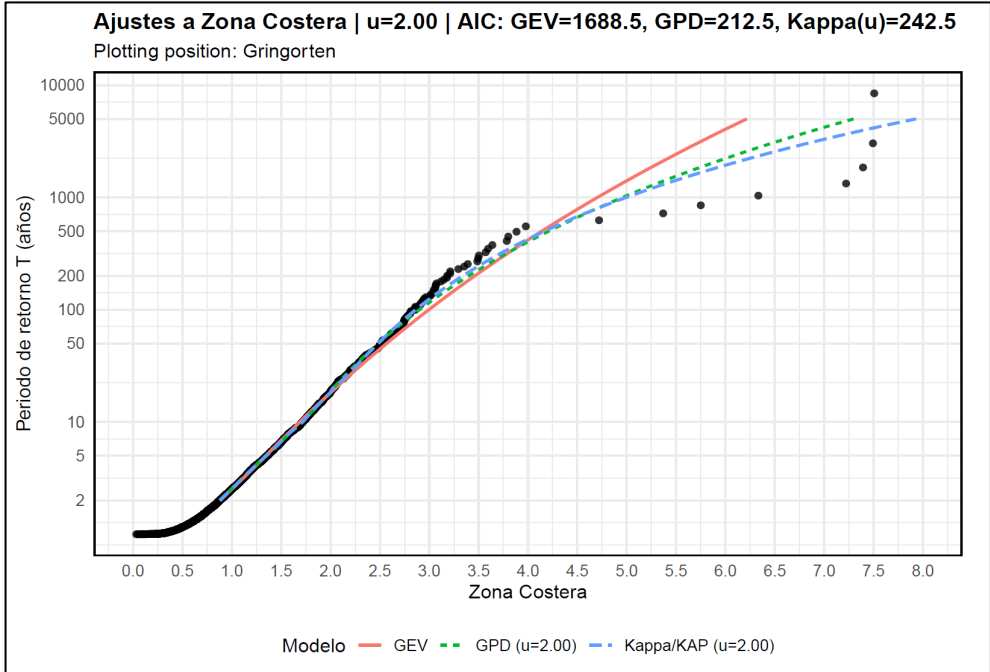
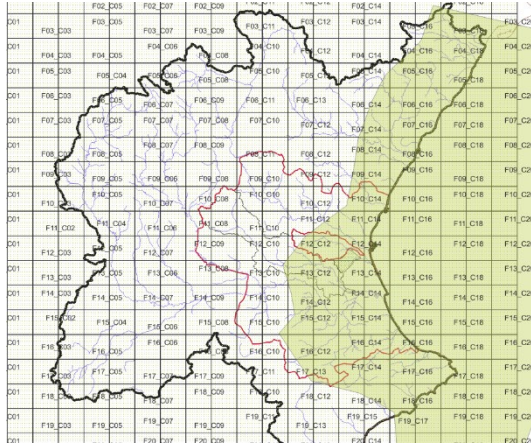


Annual maximum daily precipitation (P_{dmax}): coastal area





Storm frequency in the Poyo Creek



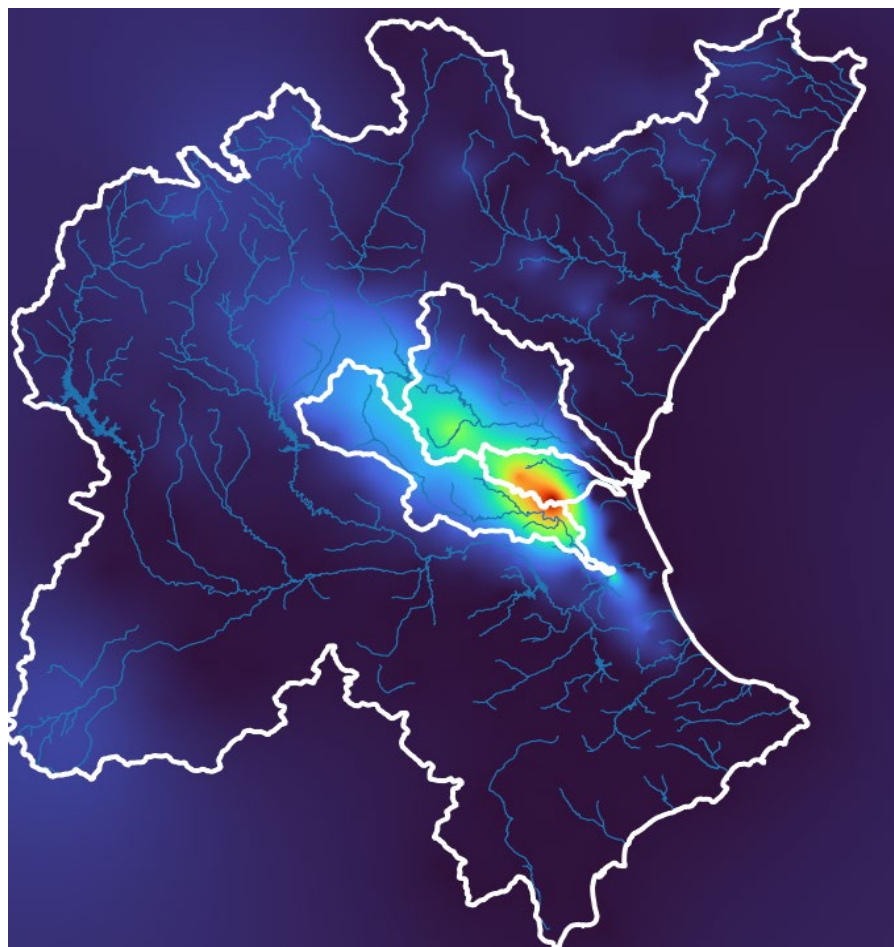
	CELDAS	F12_C12	F12_C13	F12_C14
	Media	82.07	94.69	92.6
PERÍODO DE RETORNO	2	103.4	119.3	116.7
	5	124.7	143.9	140.8
	50	203.5	234.8	229.6
	100	238.0	274.6	268.5
	500	345.5	398.6	389.8
	1000	407.1	469.7	459.3
	5000	599.1	691.2	676.0



AEMET predictions: from 13 to 24h 29/10/2024

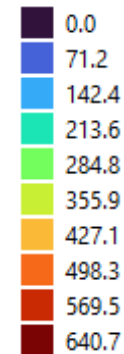
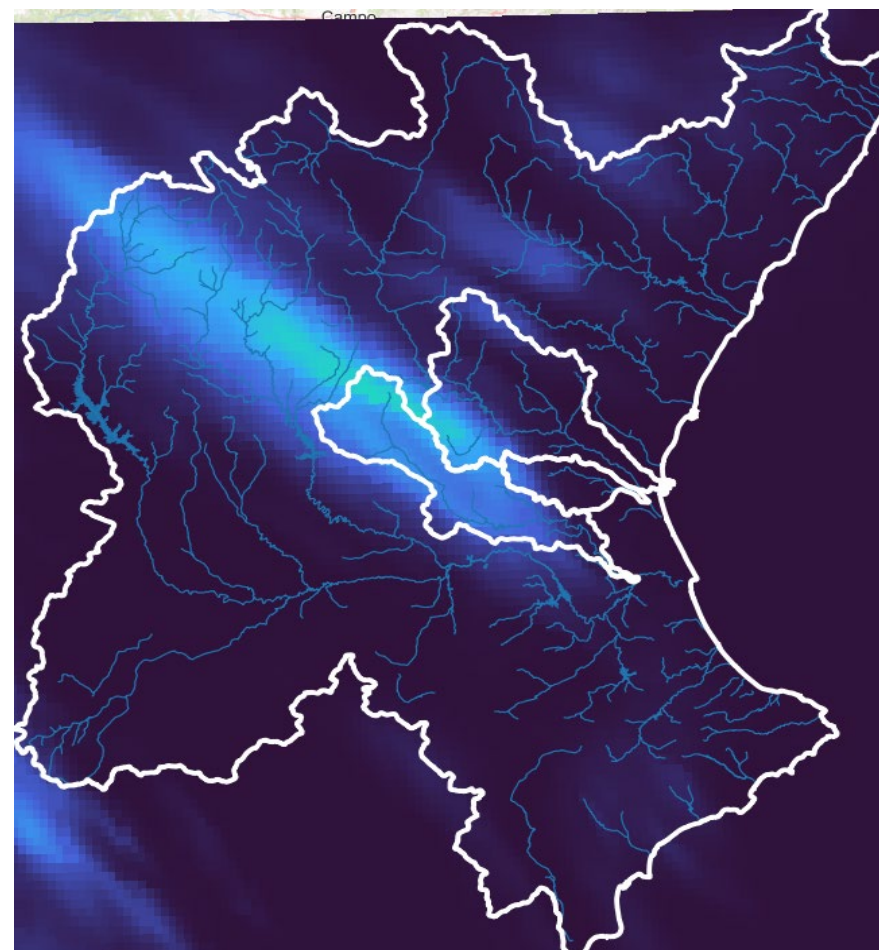
OBSERVED

Pmax = 641 mm



HARMONIE 6hUTC (7h local)

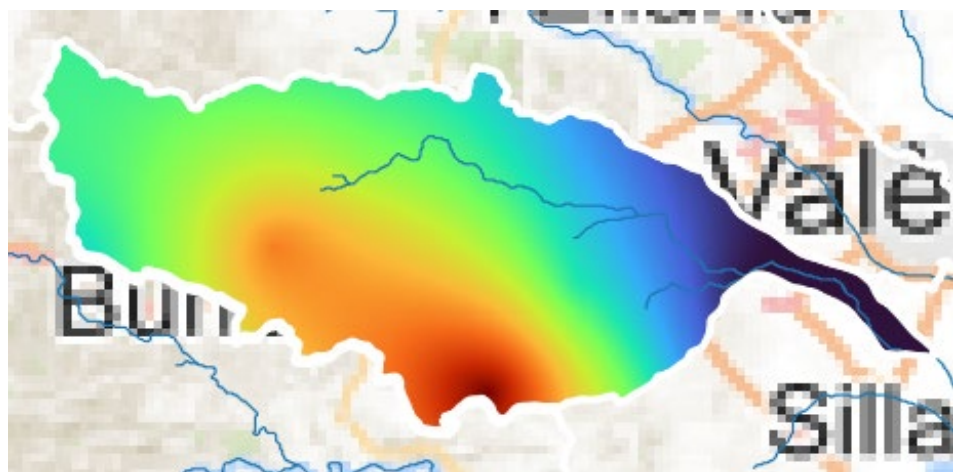
Pmax = 197 mm





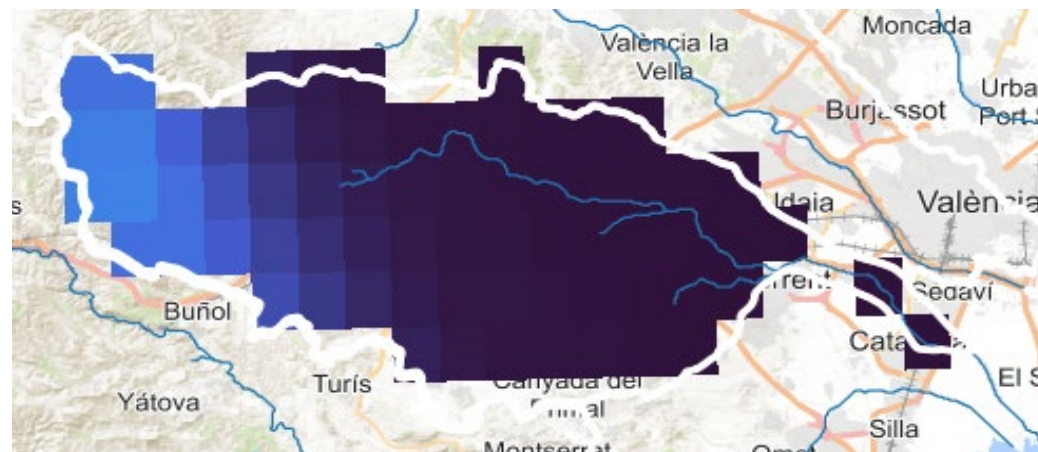
AEMET predictions: from 13 to 24h 29/10/2024

OBSERVED

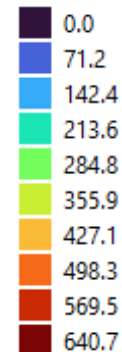


P areal = 289 mm
Pmax = 641 mm

HARMONIE 12hUTC (13h local)

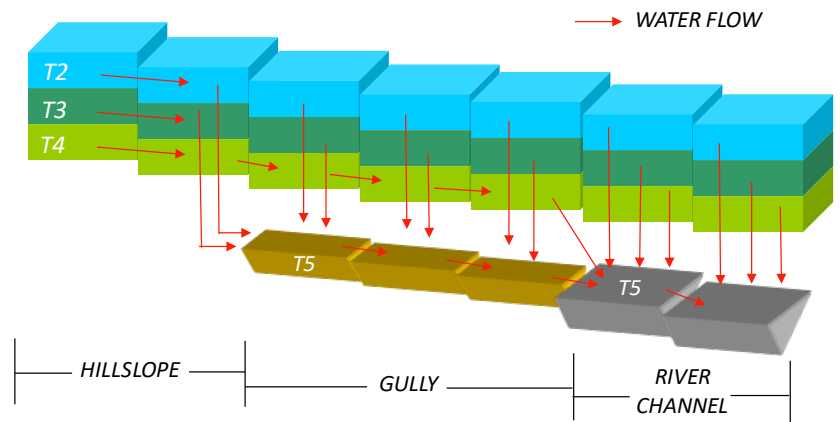
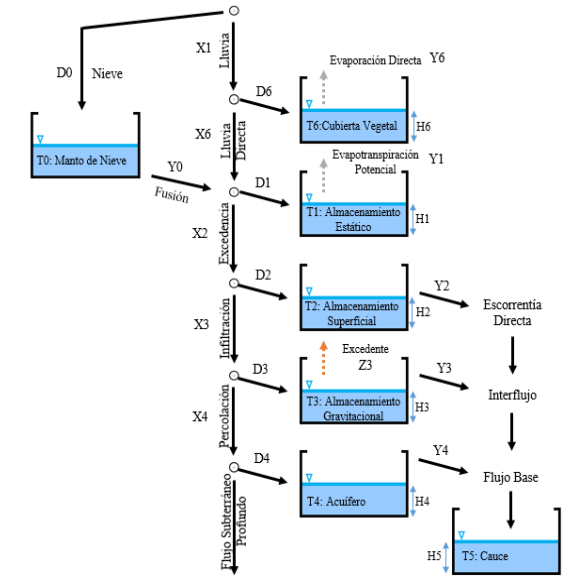


P areal = 22 mm
Pmax = 104 mm



The eco-hydrological model TETIS

- ❑ Conceptual model with **physically based parameters**, developed as a *living-lab* by UPV-IIAMA since 1994 (v9 on the web)
- ❑ **Distributed in space**, so it can:
 - => Reproduce the spatial variability
 - => Reduce spatial scale effect
 - => Exploit all available environmental information
 - => Obtain results at any point of the basin

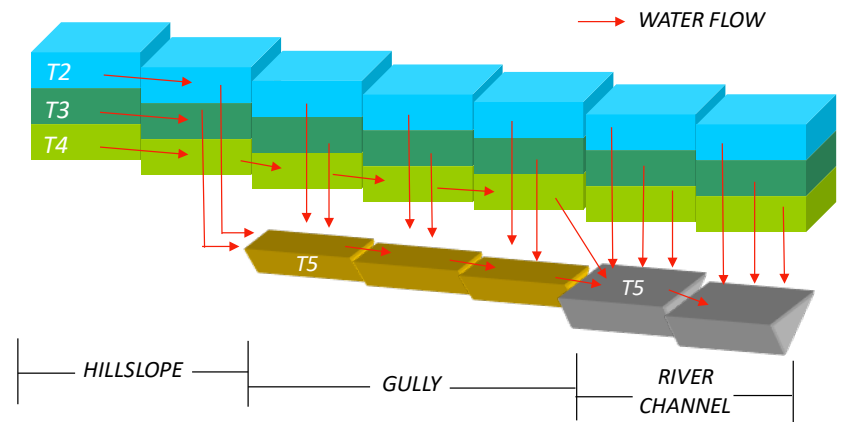


(Francés et al., 2007; Vélez et al., 2009)

The eco-hydrological model TETIS

- ❑ Conceptual model with **physically based parameters**
- ❑ **Distributed in space**
- ❑ **Integral model:** water resources (continuous simulation), **floods, erosion and sediments cycle**, dynamic vegetation, N cycle, agricultural production, irrigation, reservoirs and **check dams, transmission losses** and water abstraction y river channels, snow, ...
 - => Same model for different problems
 - => Can consider actual interactions between processes

(Francés et al., 2007; Vélez et al., 2009)

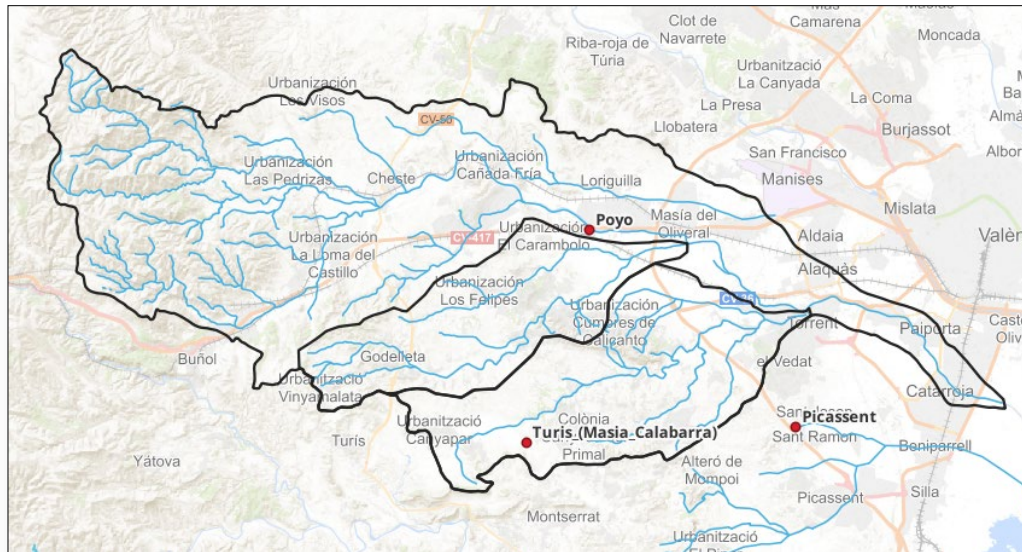


Hydrological modeling: 2 models implemented

- Daily
- 100x100m cells
- 3 rain gauges (1996-2024)
- Sediments and check dams
- From 1990 to 28/10/2024: Hu_{final}



- Δt 10 min
- 100x100m cells
- Reconstructed storm
- Sediments and check dams
- Only for the 29/10/2024
- Input $Hu_{initial}$
- 5 recirculations for sediments $H_{sed}_{initial}$

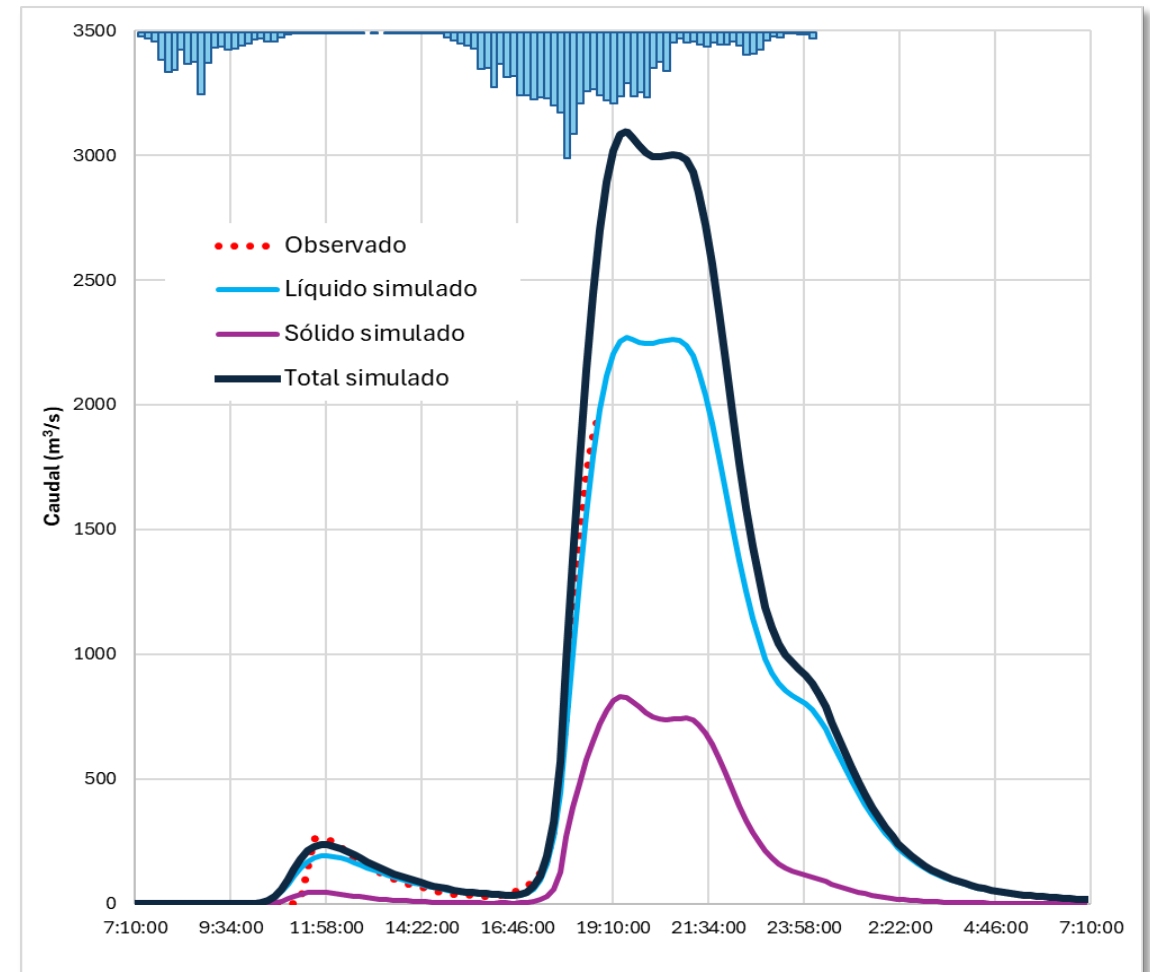


Calibration and validation at Poyo flow gauge station

The flood on October 29, 2024

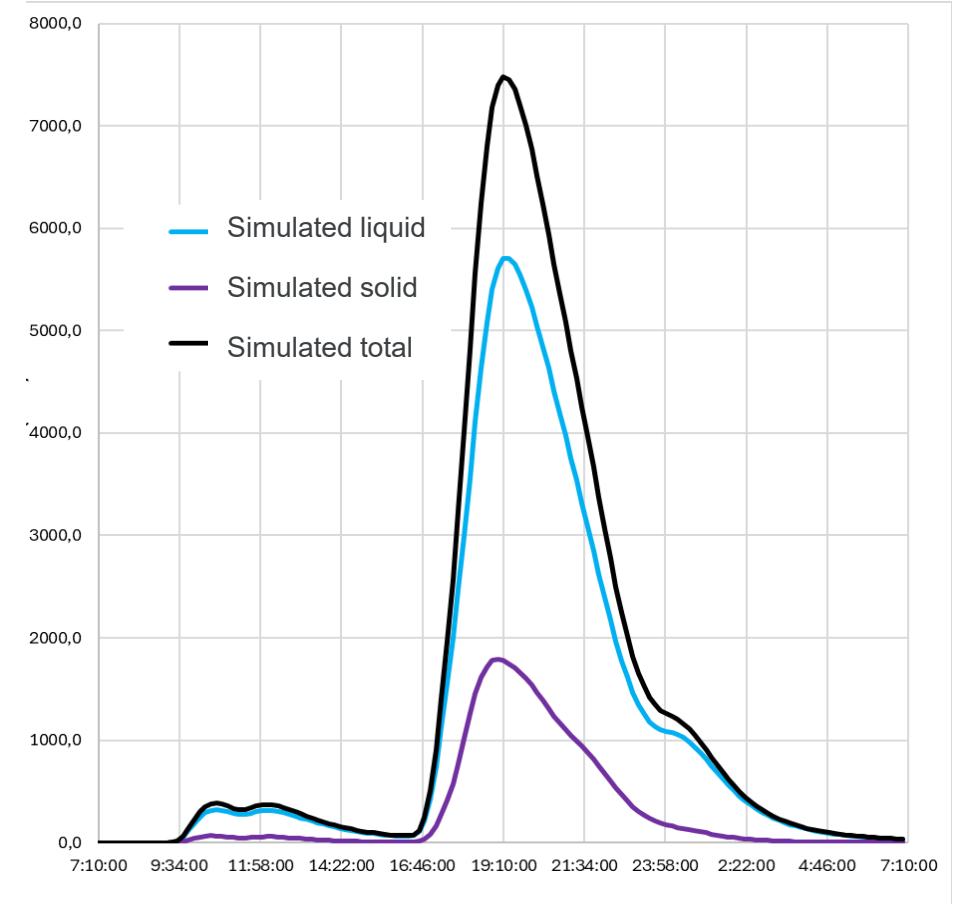
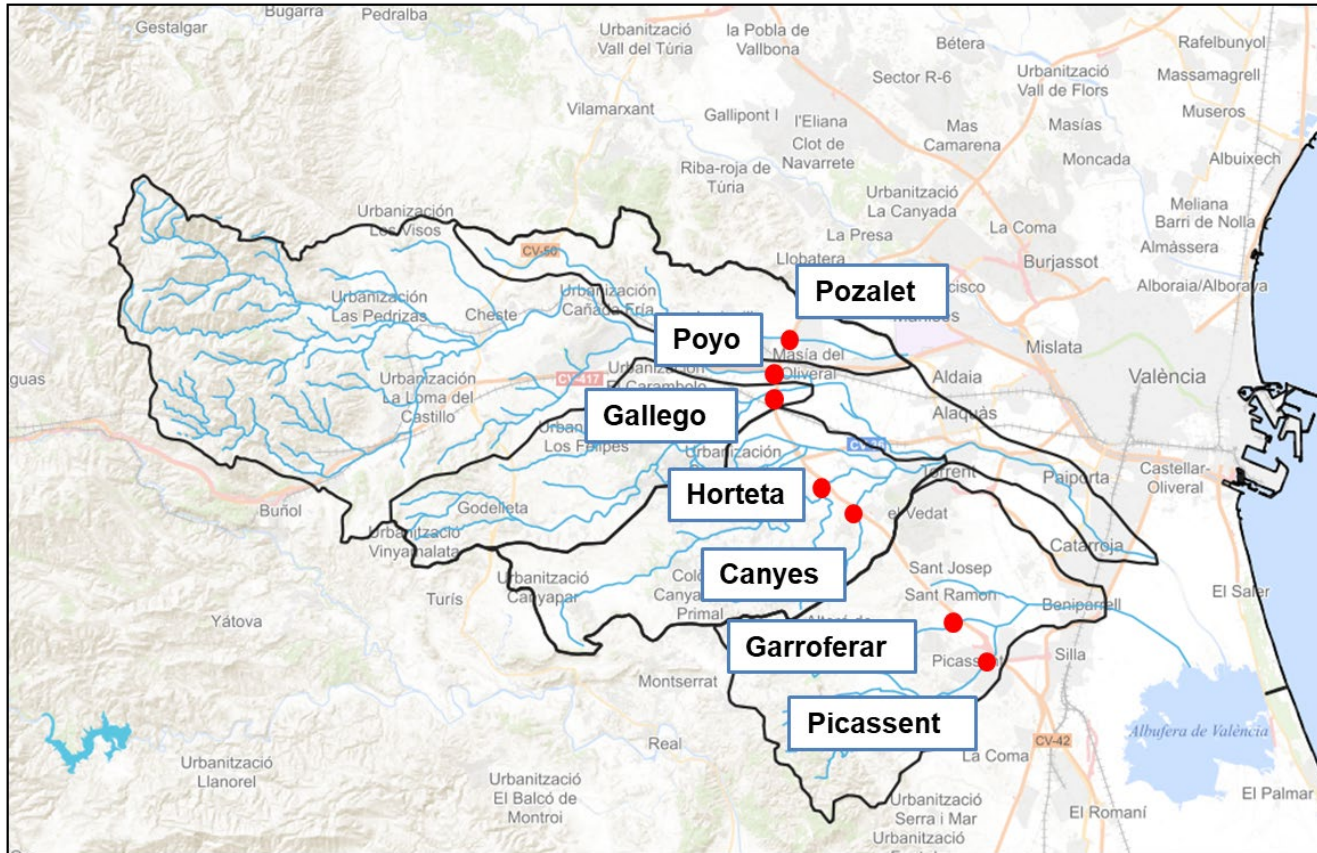
□ At flow gauge station (184 km²):

- $Q_p = 3,100 \text{ m}^3/\text{s}$
- **22% sediments in total volume**
(26% in peak flow)



The flood on October 29, 2024

- With a distributed model, we can have results at any point: inputs to the IA



-
- The map displays the Segura river basin, a major water body in the Eastern Iberian Peninsula. The river network is shown in blue, with the main river and its tributaries clearly visible. Urban areas are indicated by grey shading and labels, including Valencia, Alicante, Murcia, and various smaller towns. The Poyo (SENSOR) station is marked with a red star and labeled 'Poyo (SENSOR)'. The map also shows the location of the Poyo station relative to other urban areas and the river network. The map is titled 'Mapa de la Cuenca del Segura' and includes a scale bar and a north arrow.



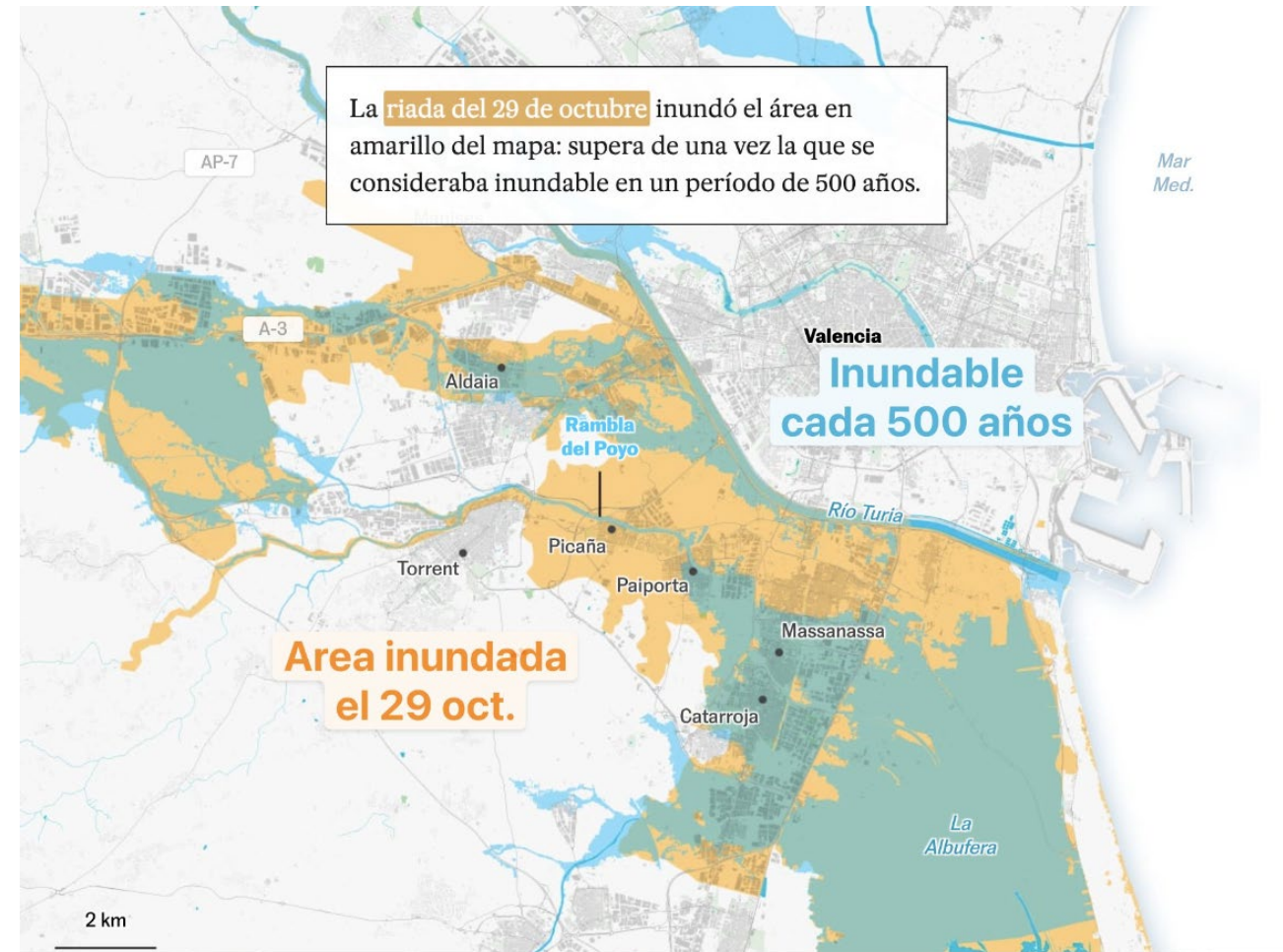
The inundation on October 29, 2024

- Inundation was larger than the estimated for T500!



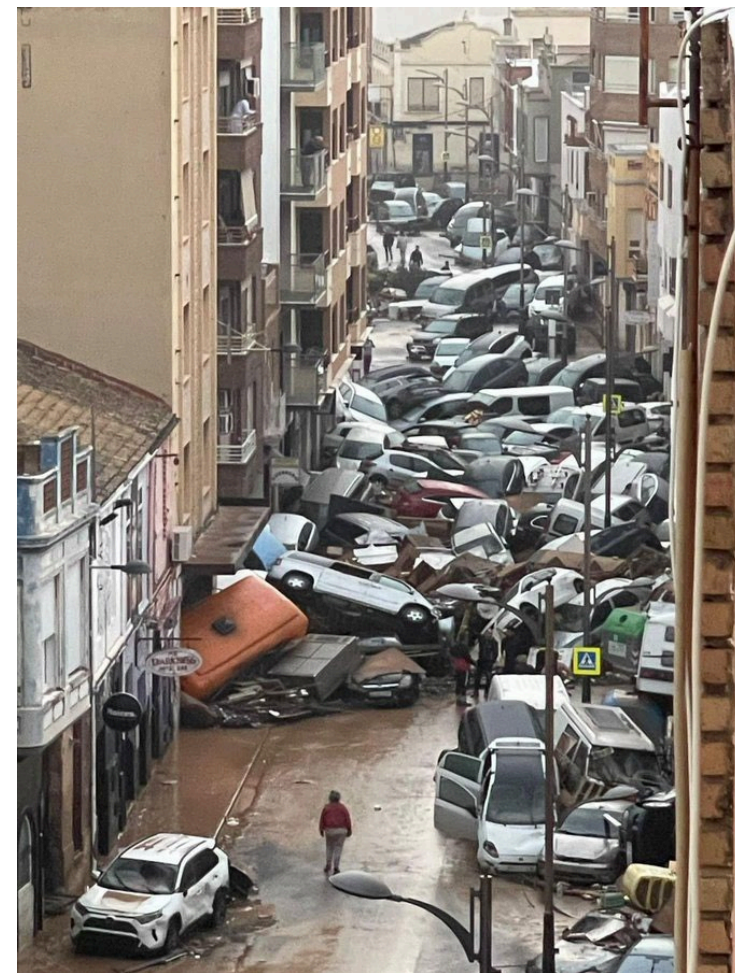
Peak total discharge crossing the V31 highway:
aprox. **4,000 - 5,000 m³/s**

Source: Copernicus and El País



The catastrophe (official data)

- ❑ **306,000 people** affected
- ❑ **11,242 houses** damaged, mainly in ground floors
- ❑ Aprox. **10,000 elevators** out of service
- ❑ **2,823 industries** with damages
- ❑ **20 large bridges** and kilometers of roads and railway damaged or destroyed
- ❑ **141,000 cars** washed away or severely damaged
- ❑ During weeks thousands of people **cleaning the mud on streets and houses**
- ❑ Sewer system **collapsed**
- ❑ **229 victims** (mostly trap in ground floors and cars)
- ❑ **17,800 M€** only in direct damages



- ❑ The flooding in southern Valencia was **extraordinary**, but not unusual
- ❑ **Distributed** modeling has allowed us to establish:
 - The **chronology** of the flood through the channel network is a key factor to determining the magnitude of the inundation
 - The inputs to the hydraulic model
- ❑ The **daily** model was used for the **initial conditions** in the subdaily model
- ❑ It is estimated that the peak flow in the IA could have been $>7,000 \text{ m}^3/\text{s}$ if we sum the hydrographs of all the ravines and **including sediments**

- ❑ Lessons learned for the future:
 - Hazard mapping of the **catastrophic event** (T2000?)
 - **Sediments** in flash floods
 - **Influence of cars** in the inundation dynamics
 - **Uncertainty** in the results, mainly from weather forecasts

Thanks for your attention

Prof. Félix Francés (ffrances@upv.es)

Research Group of Hydrological and Environmental
Modelling (GIMHA)

<https://gimha.upv.es/>



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Asociación Valenciana de Meteorología (AVAMET)
Agencia Estatal de Meteorología (AEMET)



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Solidarity Bridge
(01/11/2024)



Impact of Climate Change

□ 12 EUROCORDEX models RCP 8.5

- Control Period: (1971-2000)
- Mid-term projection: (2035-2064)
- Long-term projection: (2065-2094)

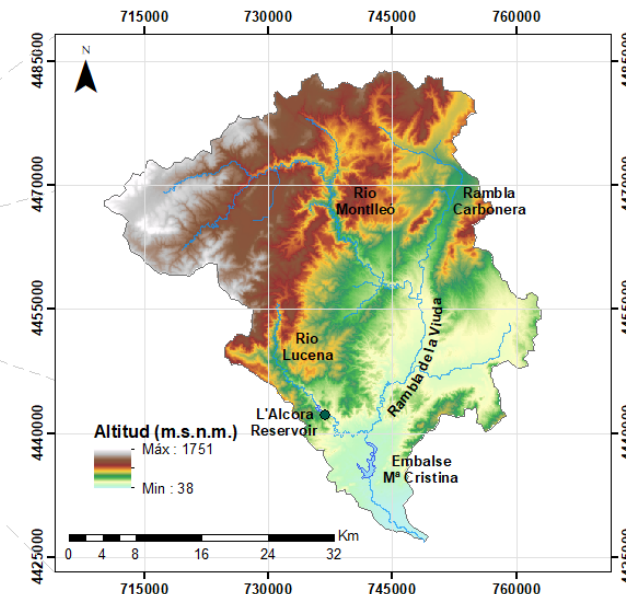
□ Rambla de la Viuda (Castellón)

- Ephemeral river
- 1,500 km²
- Semi-arid Mediterranean climate
- High spatio-temporal variability of precipitation

(Beneyto et al., 2023)

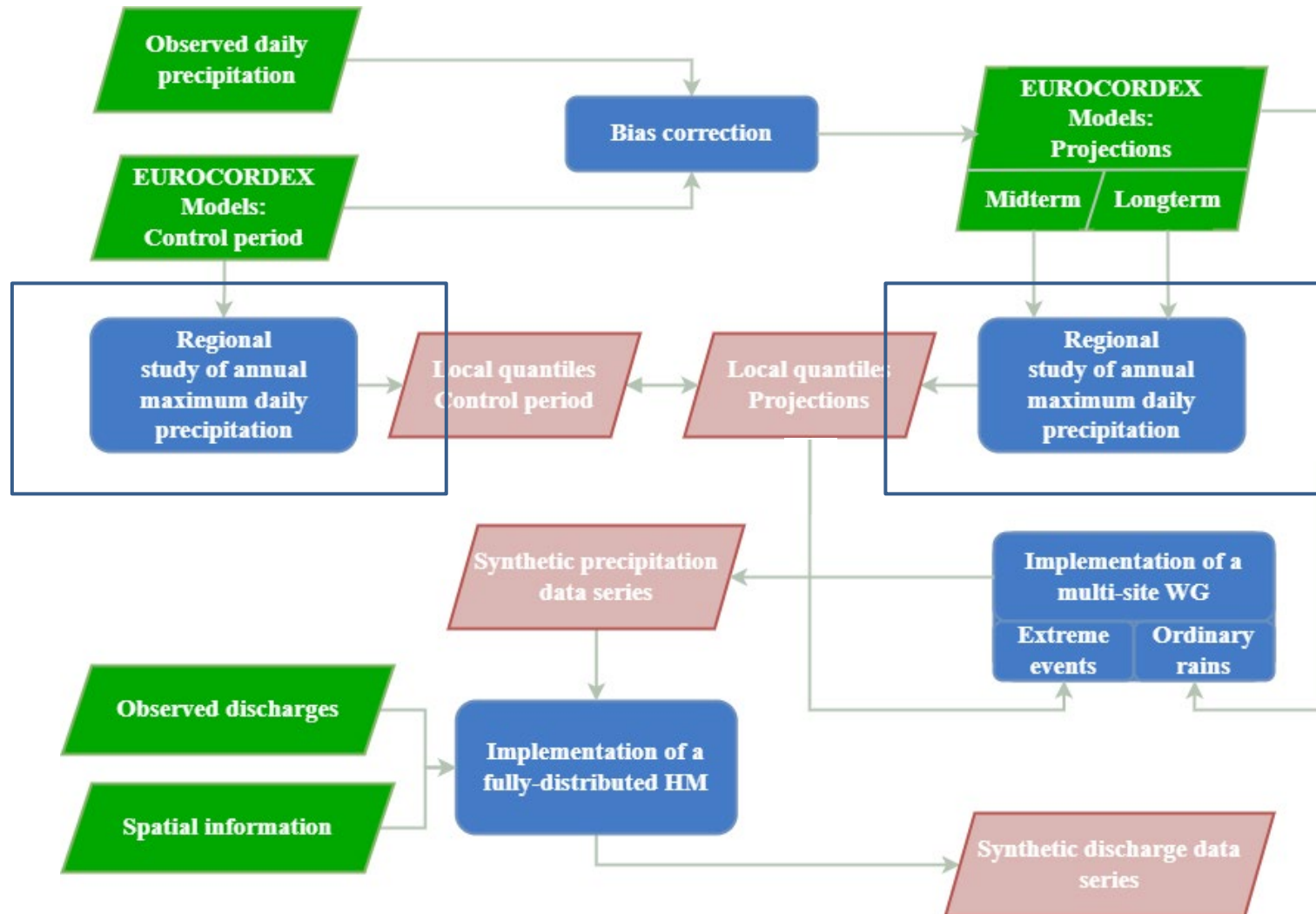


Case study



Methodology with Weather Generators

Beneyto et al, (2024)



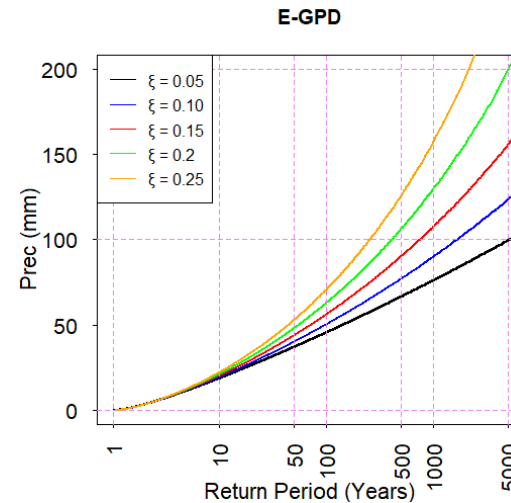
- Developed by Evin et al. (2018)
- Extended Generalized Pareto Distribution (E-GPD)
=> heavy-tailed

$$F(x; \lambda) = \left[1 - \left(1 + \frac{\xi x}{\sigma} \right)_+^{-1/\xi} \right]^k, x > 0$$

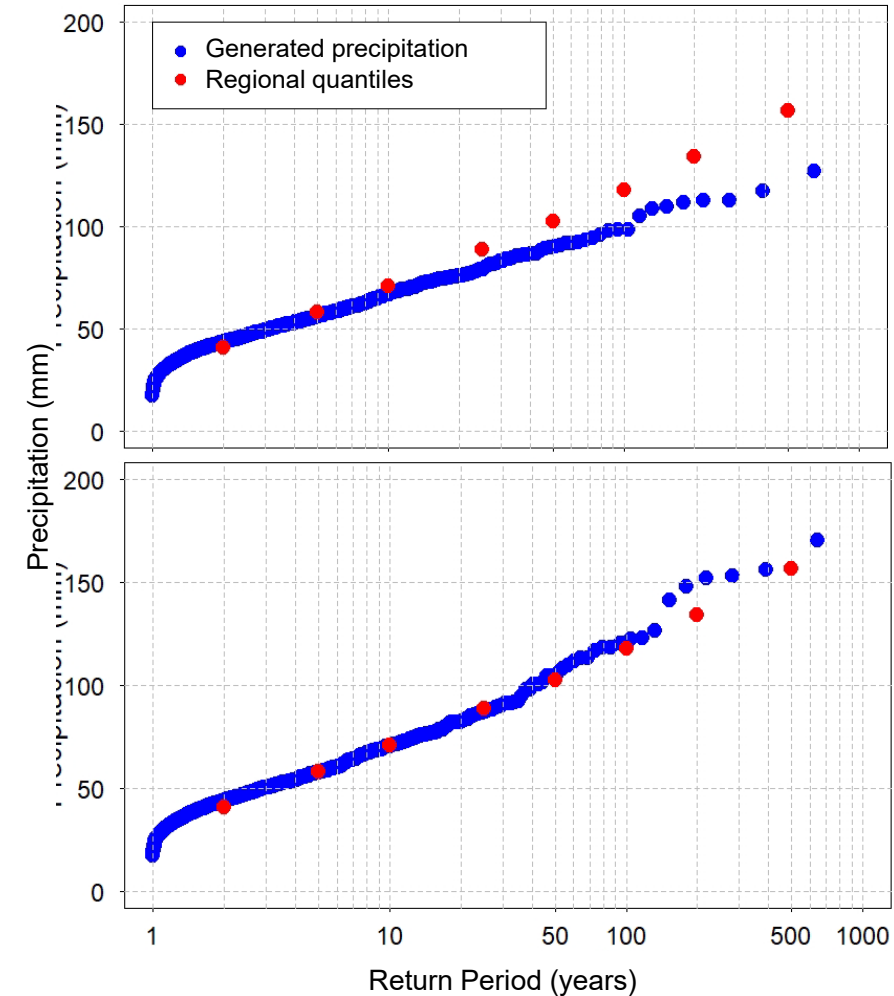
- Parameter estimation

σ
 κ } From observations
 ξ From more robust studies

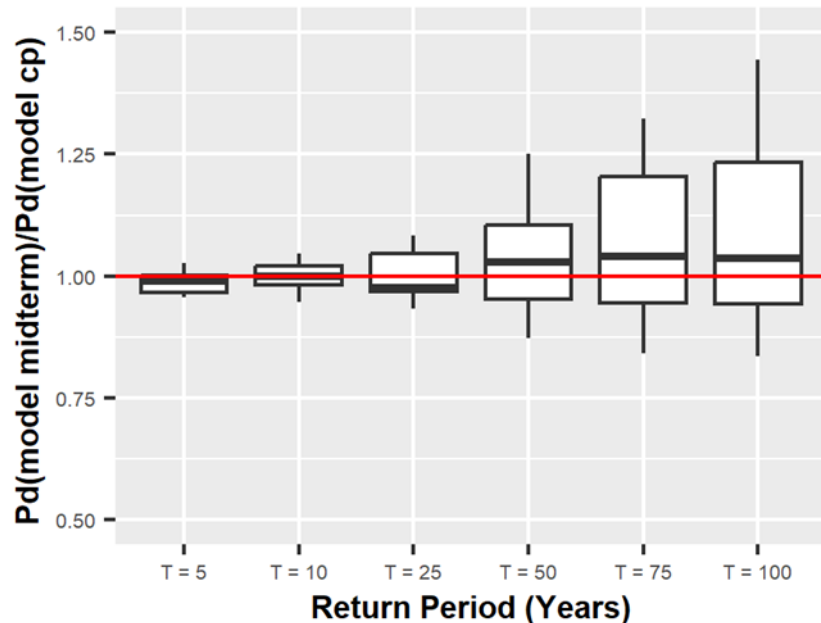
- 3-day aggregation



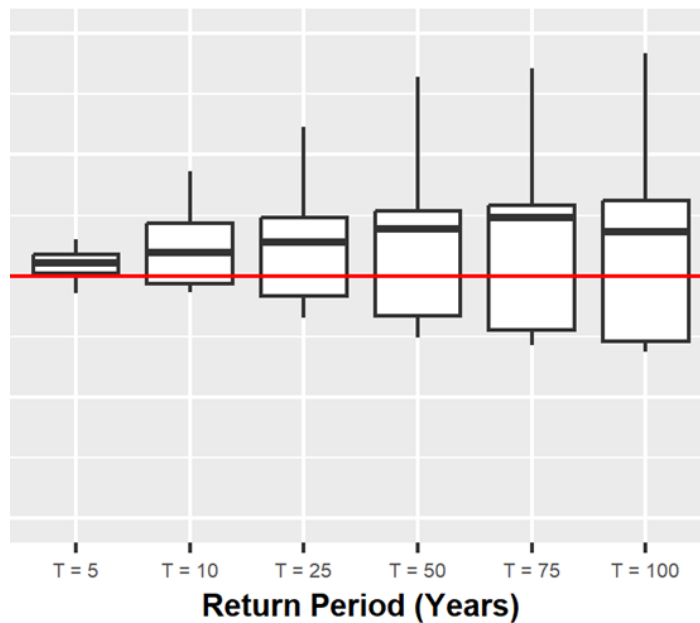
Beneyto et al, (2020)
Beneyto et al, (2023a)
Beneyto et al, (2023b)



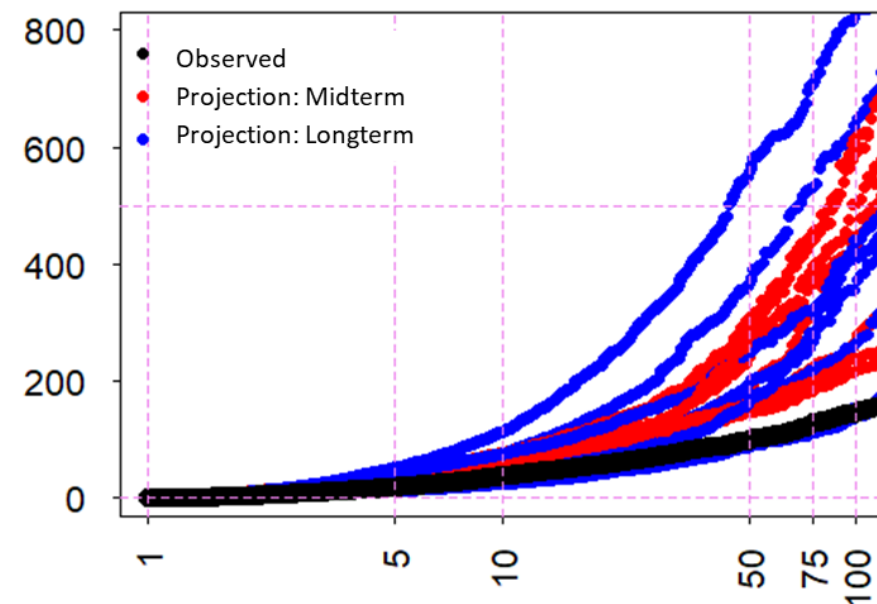
Projection - MIDTERM: grid03759



Projection - LONGTERM: grid03759



Rambla de la Viuda en Maria Cristina



T (años)	Observados (mm)	Proyección a medio plazo*		Proyección a largo plazo*	
	X_T	$\Delta\%$	X_T	$\Delta\%$	X_T
5	80	4.3%	83	12.8%	90
10	99	6.0%	105	16.7%	116
25	125	8.4%	136	18.6%	148
50	145	11.5%	162	19.3%	173
75	158	13.5%	179	19.7%	189
100	167	14.4%	191	19.4%	199

T (años)	Observados (m3/s)	Proyección a medio plazo*		Proyección a largo plazo*	
	X_T	$\Delta\%$	X_T	$\Delta\%$	X_T
5	20	12%	22	8%	21
10	38	12%	43	16%	44
25	68	22%	83	33%	91
50	101	38%	140	54%	155
75	130	48%	192	56%	202
100	147	53%	225	58%	232