Flood Risk estimation and the October 2024 Flash Flood in the South of Valencia (Spain)

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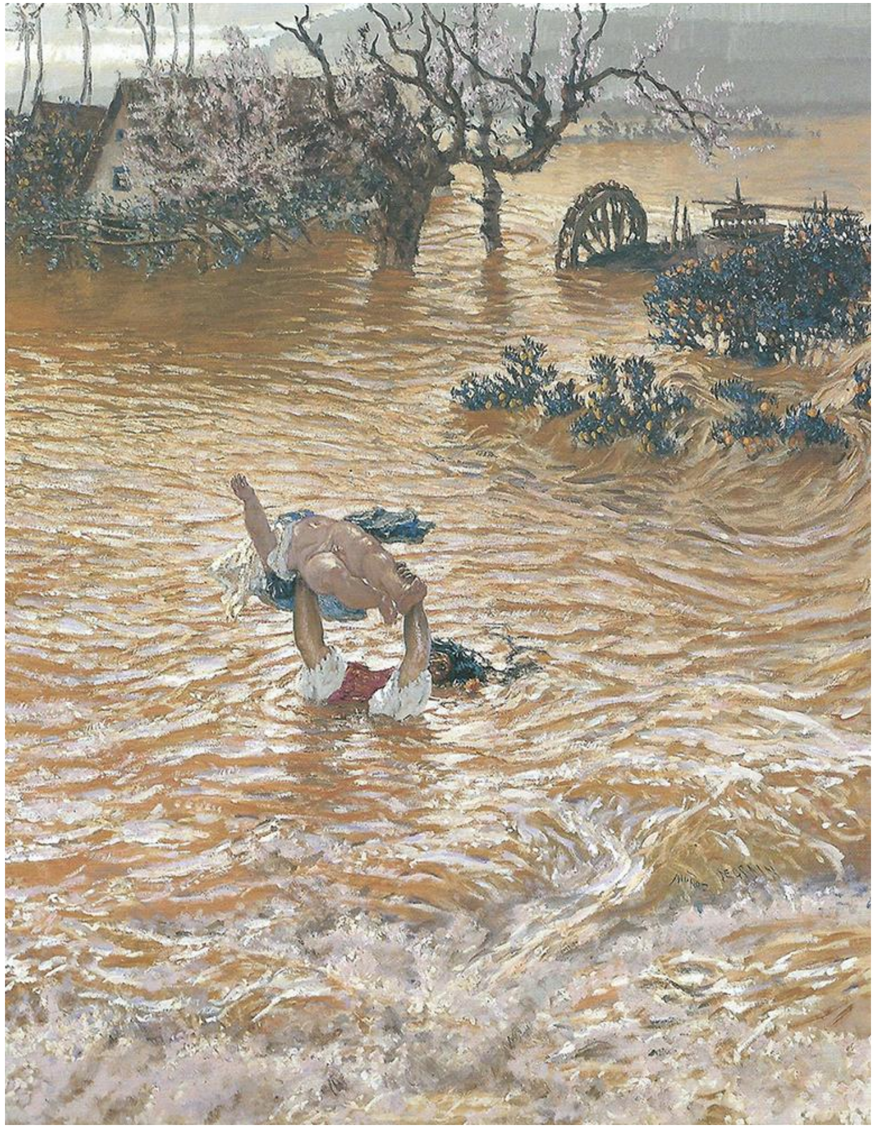
Outline of the presentation

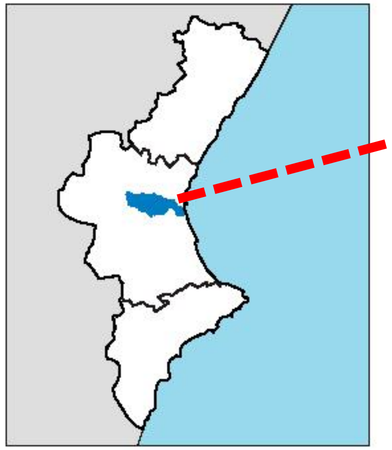


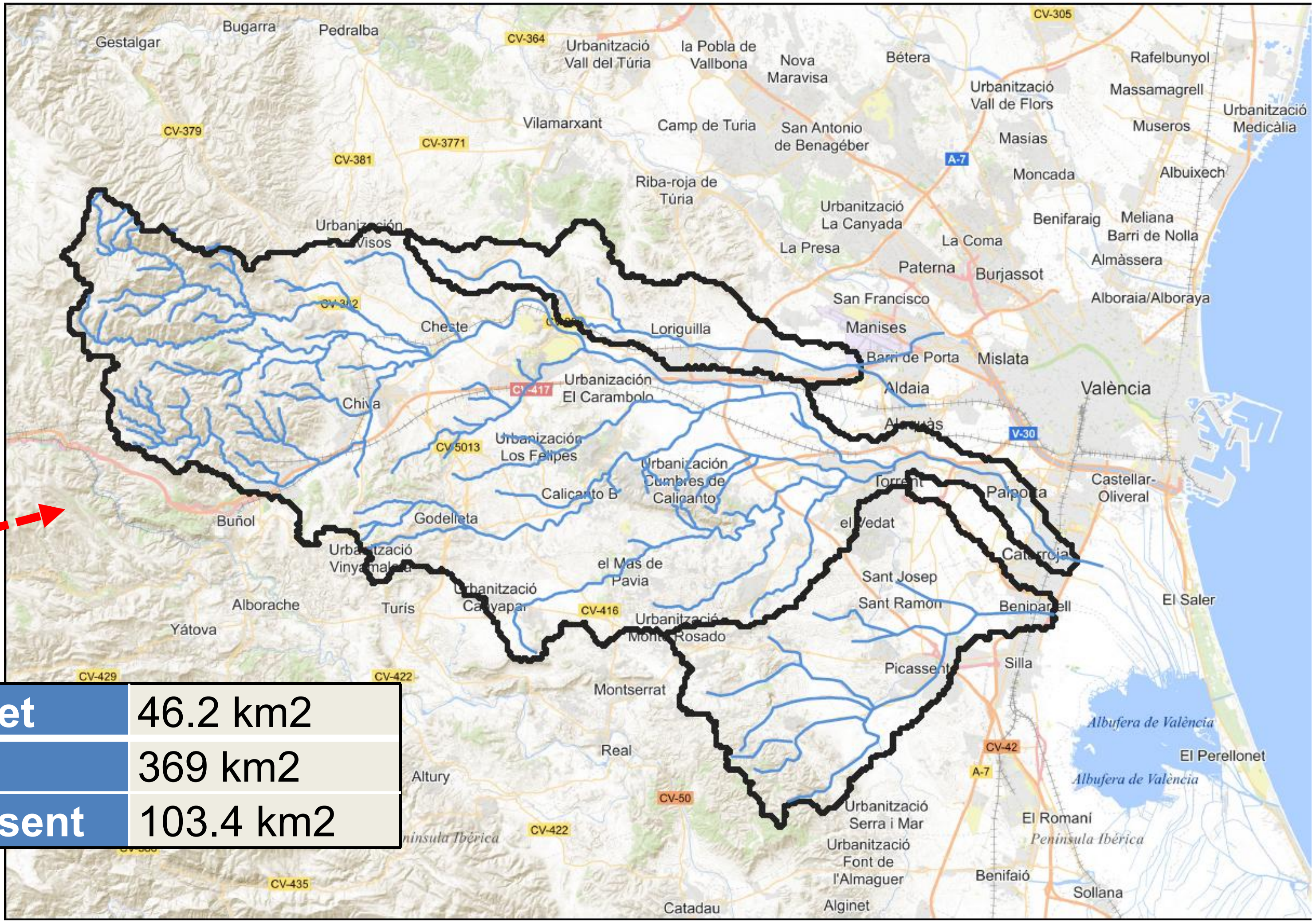
- The 2024 catastrophic event
- Flood Hazard estimation in Poyo/Pozalet
- Flood Risk estimation in Poyo/Pozalet
- Conclusions

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

The 2024 catastrophic event

Drainage area of southern Valencia





Pozalet	46.2 km2
Poyo	369 km2
Picassent	103.4 km2

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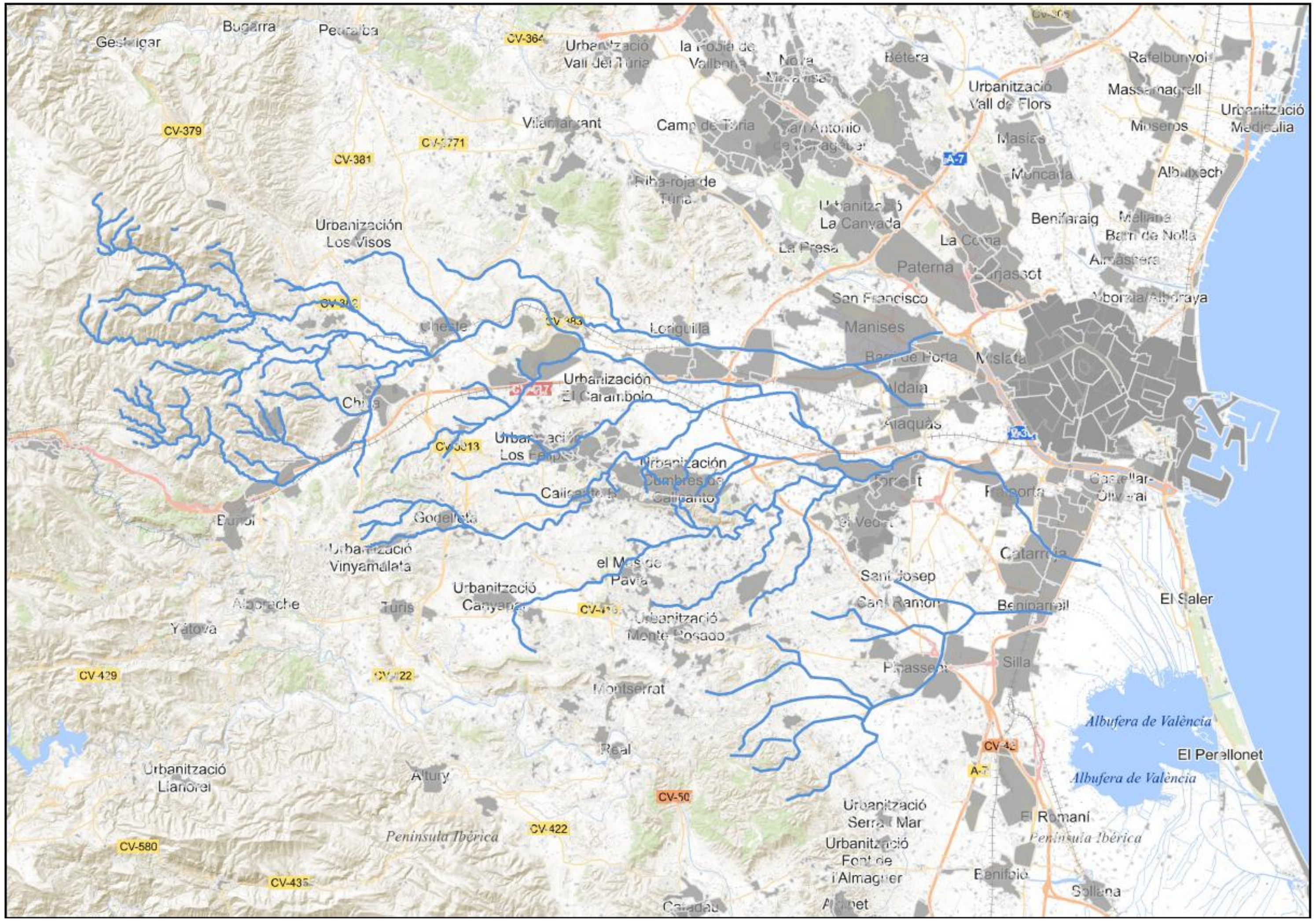
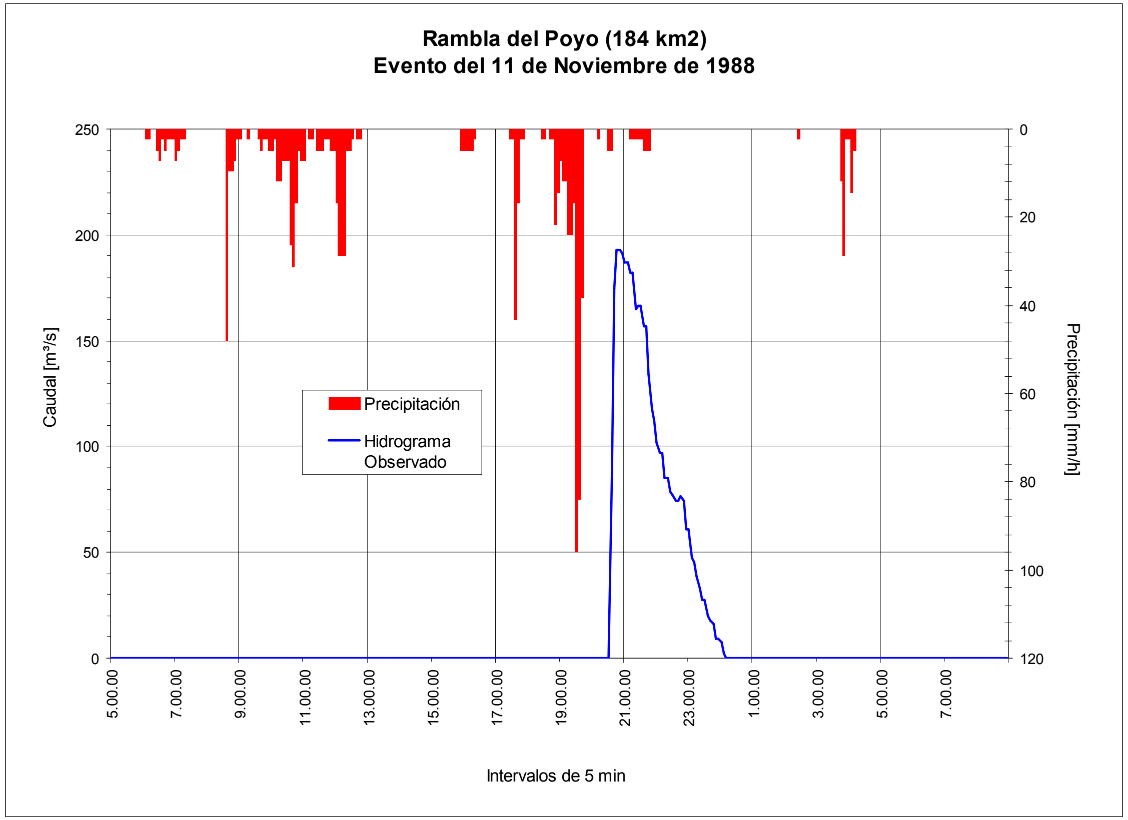
The inundation area



Flash flood catchments

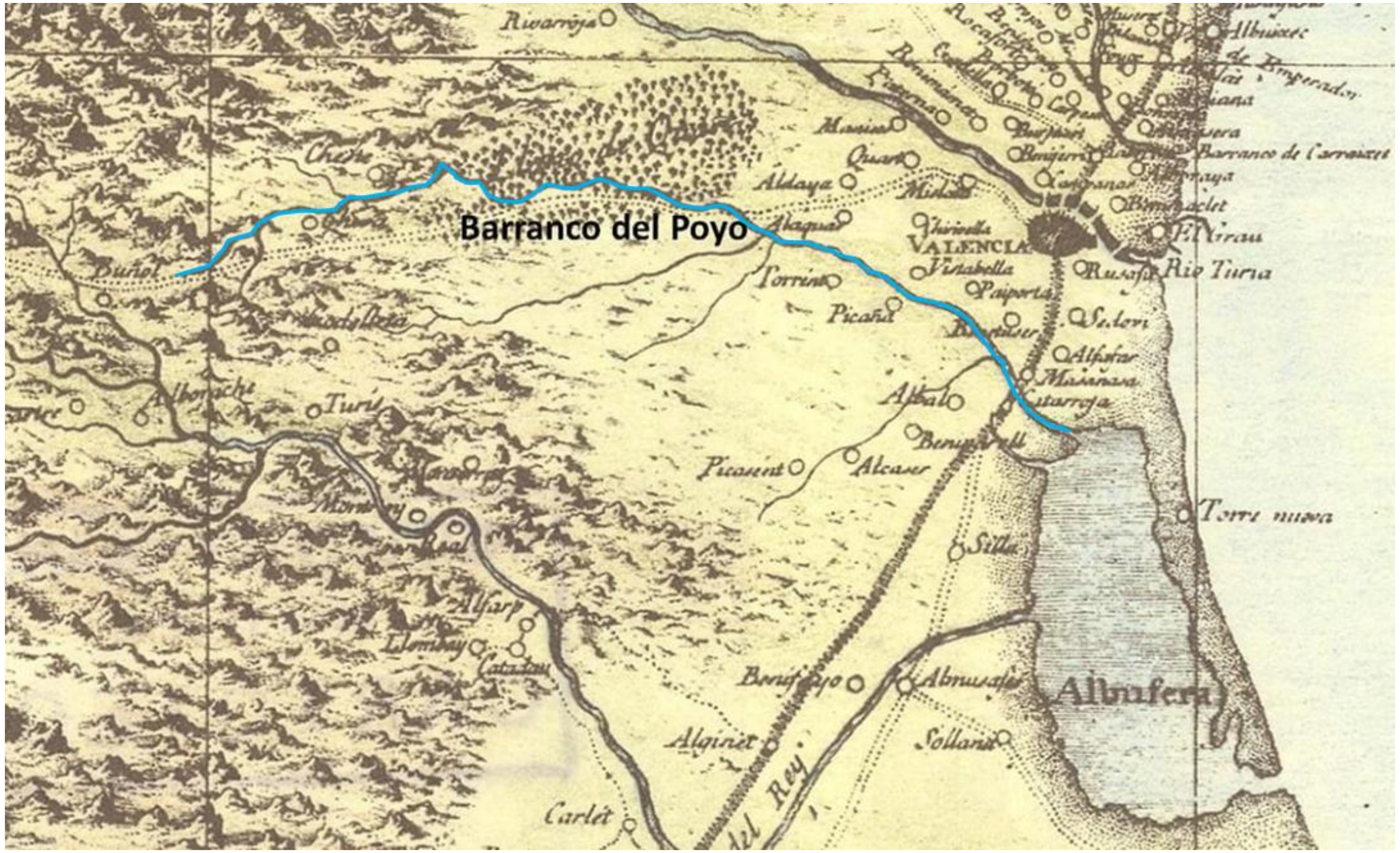
- Quick flooding:
  - Produced in small catchments in mountain areas
  - Due to torrential rain and/or snowmelting with duration Usually, time of concentration
- Usually, timescale of less than 6h => **very short reaction time**
- With **high flow velocities** (destruction) and significant transport of **sediment** and debris (cleaning costs)



An “old friend”

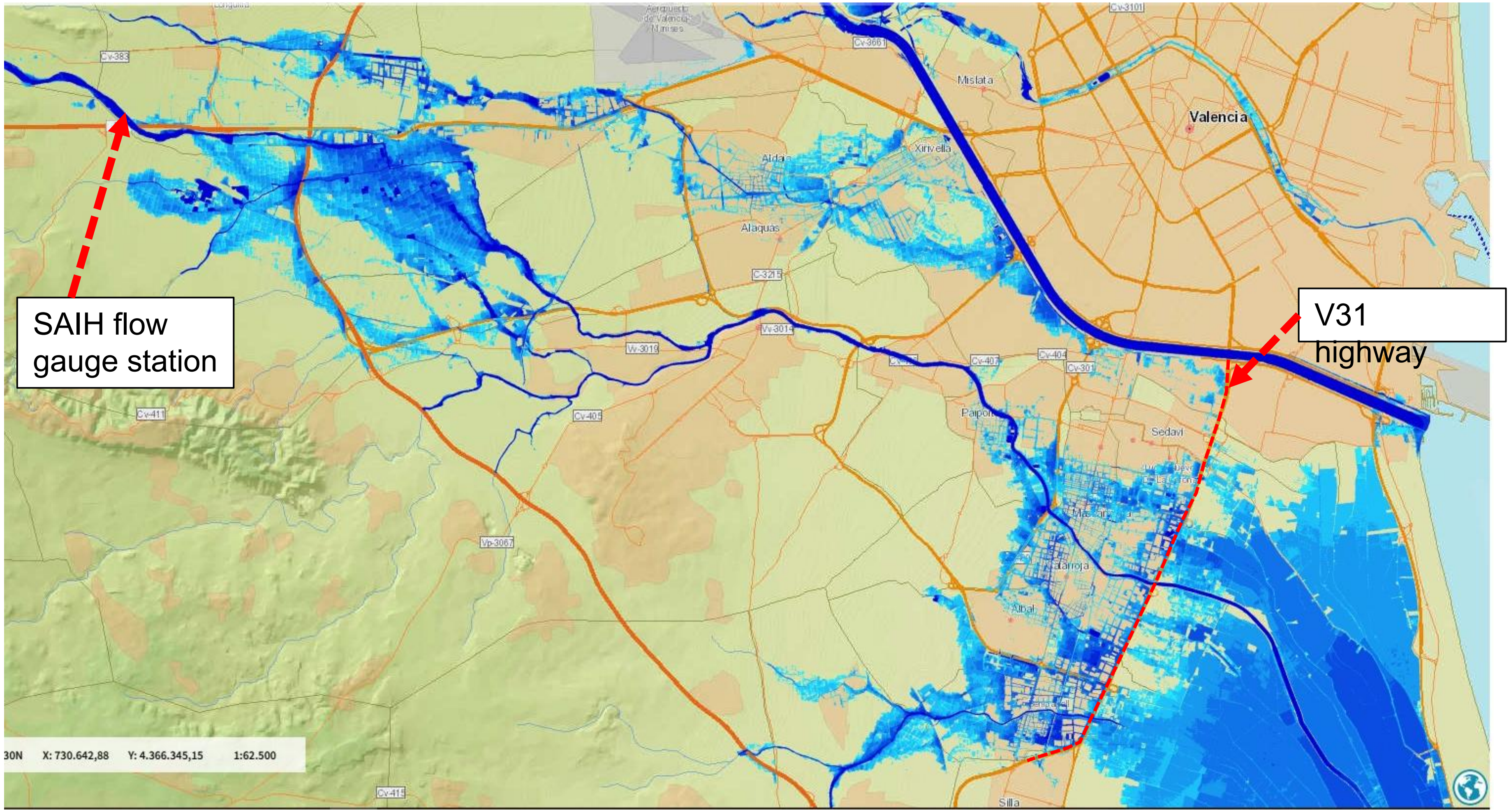
Naturalist J. A. Cavanilles **in 1795** wrote about the Poyo Creek in “Observations on the natural history, geography, agriculture, populations and fruits of the Kingdom of Valencia”:

“Siguiendo hacia el sur desde Alaquás como a un quarto de legua se atraviesa el barranco, que empieza en las montañas e Buñol con dirección a Chiva, entra en esta villa y continúa por el término de Cheste, donde recibe otro considerable: engrosado con este aeumento y con las vertiene de aquellos montes, cruza el llano de Quart junto a la venta de Poyo, pasa después por las cercanías de Torrent, que dexa a su derecha, como igualmente Catarroja, y desagua en la Albufera de Valencia. Su profundo y ancho cauce siempre está seco, salvo en las avenidas, quando recibe tantas aguas y corre tan furisoamente, que destruye quanto encuentra. En 1775 causó muchísimas esgracias en Chiva, sorprehendiendo a media noche sus vecinos; asoló un número considerable de edificios, esparciendo por mas de dos leguas los tristes despojos y los cadáveres de los pobres que no pudieron evitar la muerte. A la derecha del barranco y a muy corta distancia, bien que en un sitio elevado, está Torrent, la mayor población del reyno después de las ciudades y villas principales”



T500 flood hazard map

Application of European Directive 2007/60/EC on Flood Risk Assessment and Management



Source: SNCZI 2nd cycle

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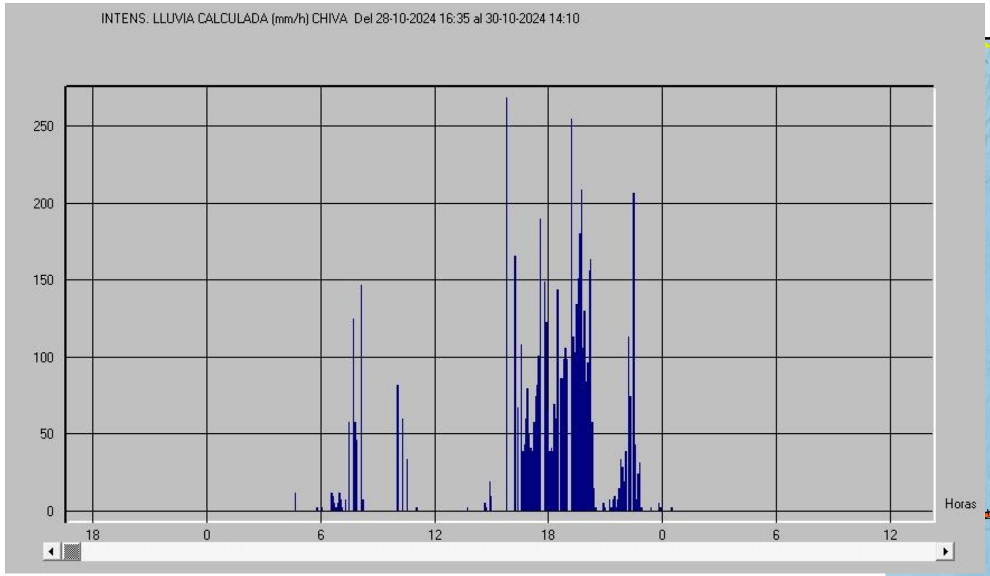
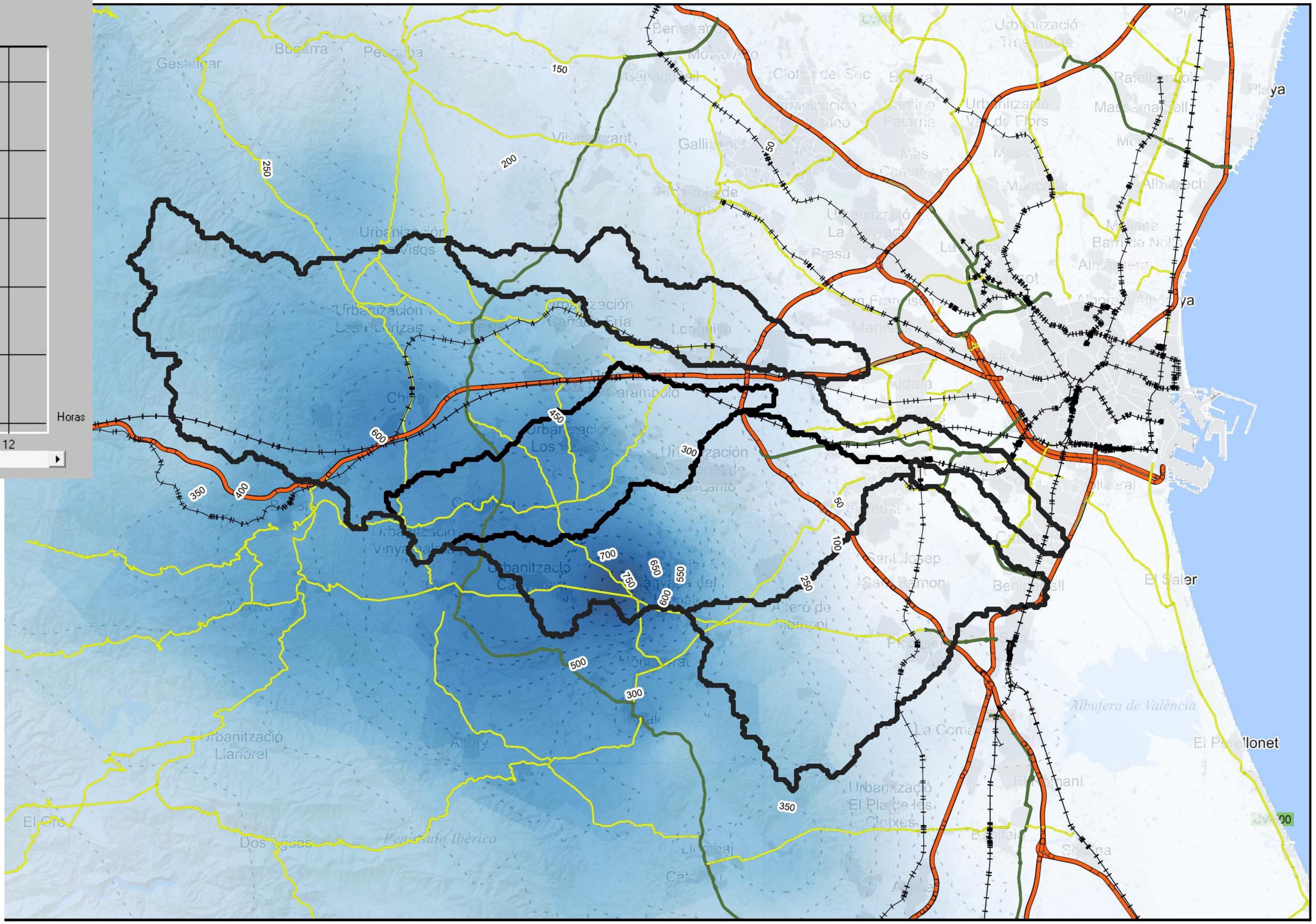
Evolution of Pozalet Ravine

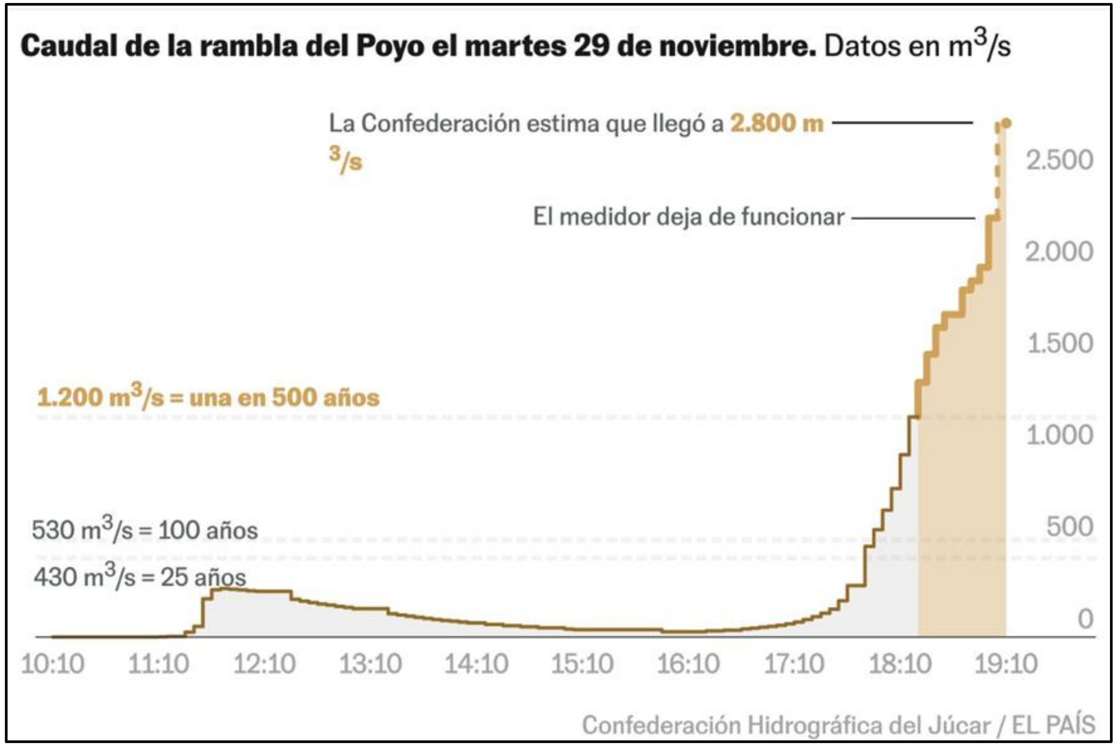
The precipitation on October 29, 2024



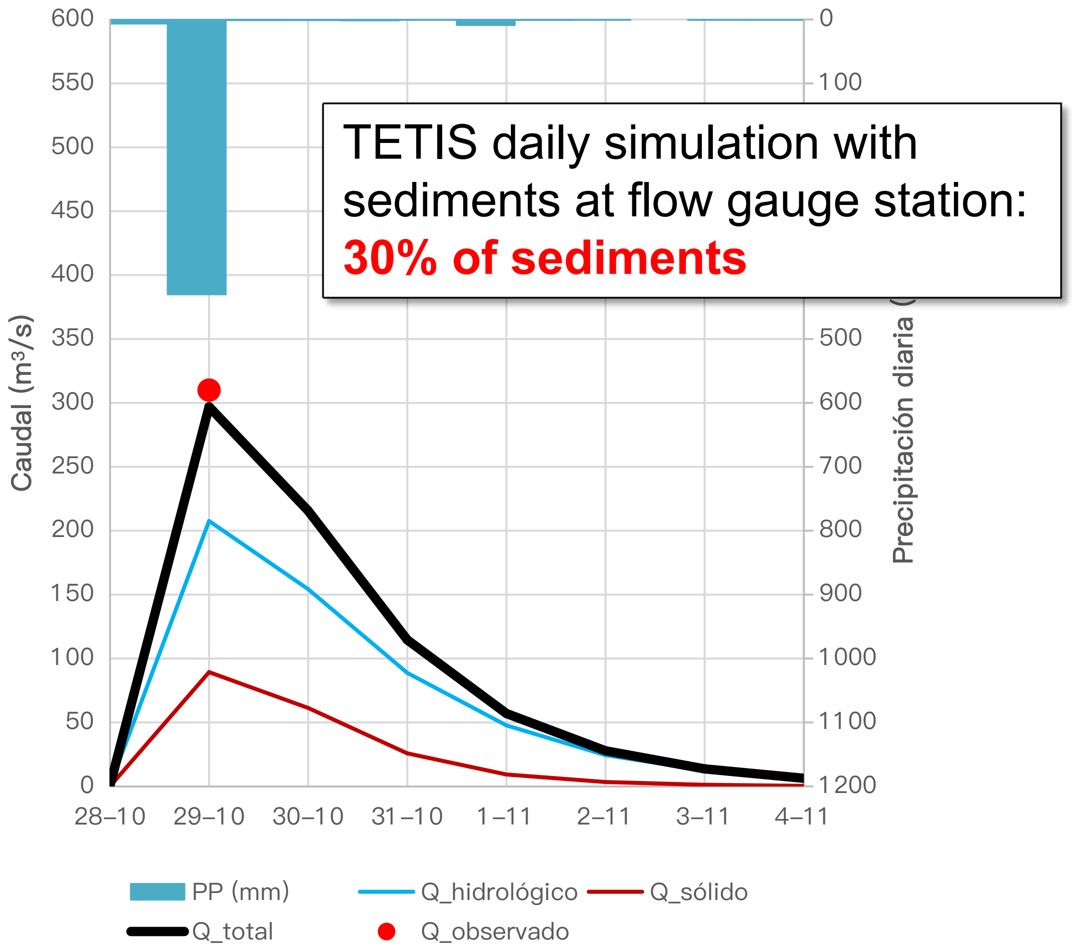


Storm duration = 5 hours
Maximum daily precipitation in Turis = 772 mm
No rain in flood prone area and no alert!

The flood on October 29, 2024



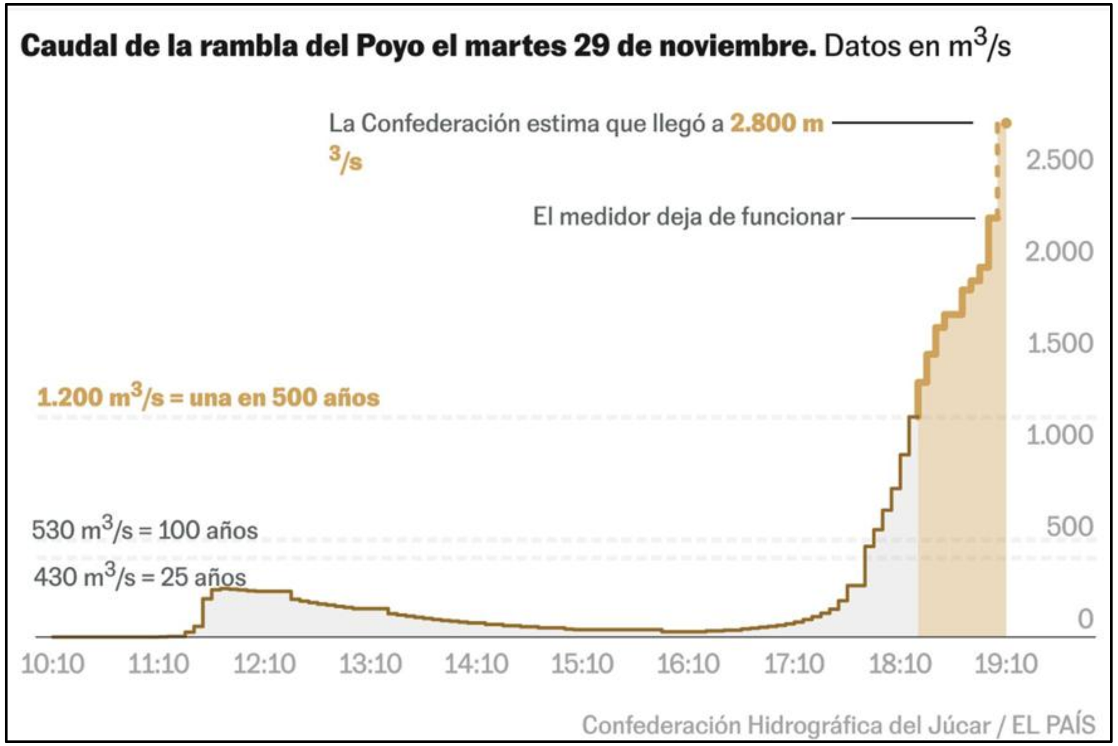
Source: CHJ SAIH and El País



Peak discharge at flow gauge station (198 km2): aprox. **2,800 m3/s**

Source: Francés et al., IIAMA , 2024

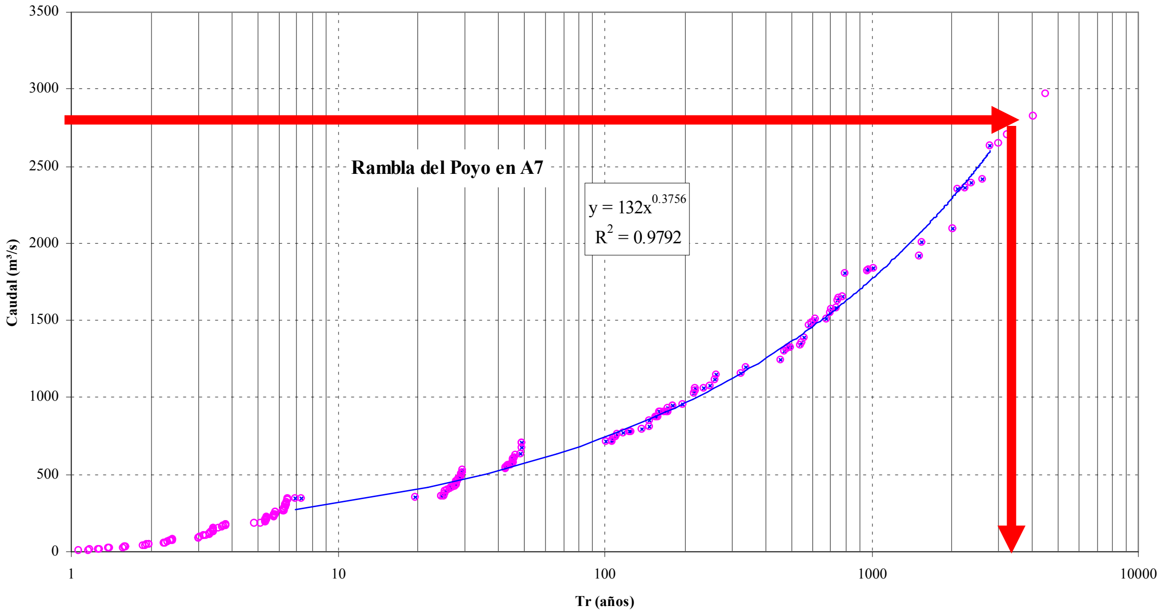
The flood on October 29, 2024



Source: CHJ SAIH and El País

Peak discharge at flow gauge station (198 km2): aprox. **2,800 m3/s**

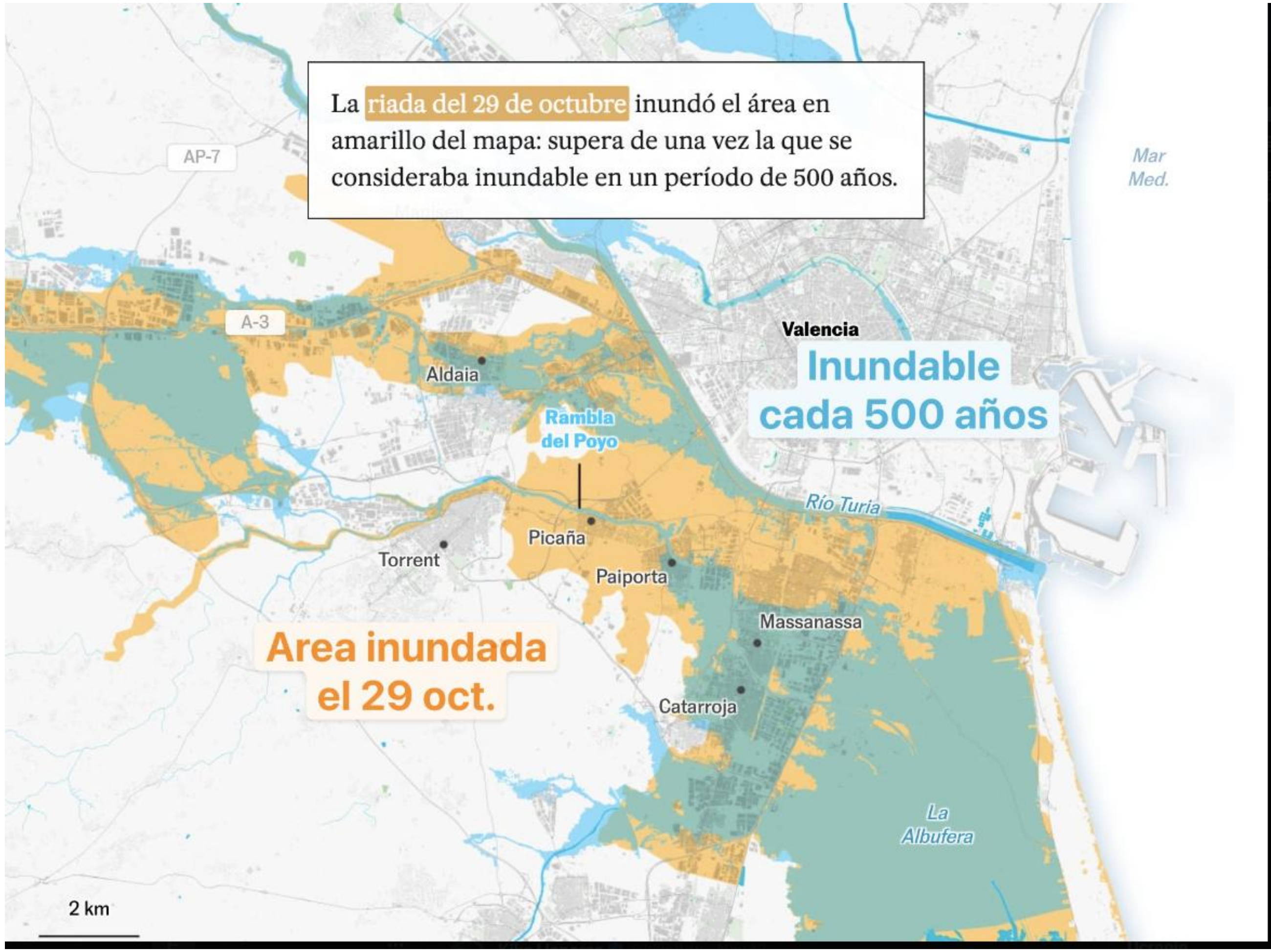
Return period between 2000 and 5000 years!



Source: Francés et al., IIAMA report, 2006

The inundation on October 29, 2024

- Inundation was larger than the estimated for T500!



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

Source: Copernicus and El País

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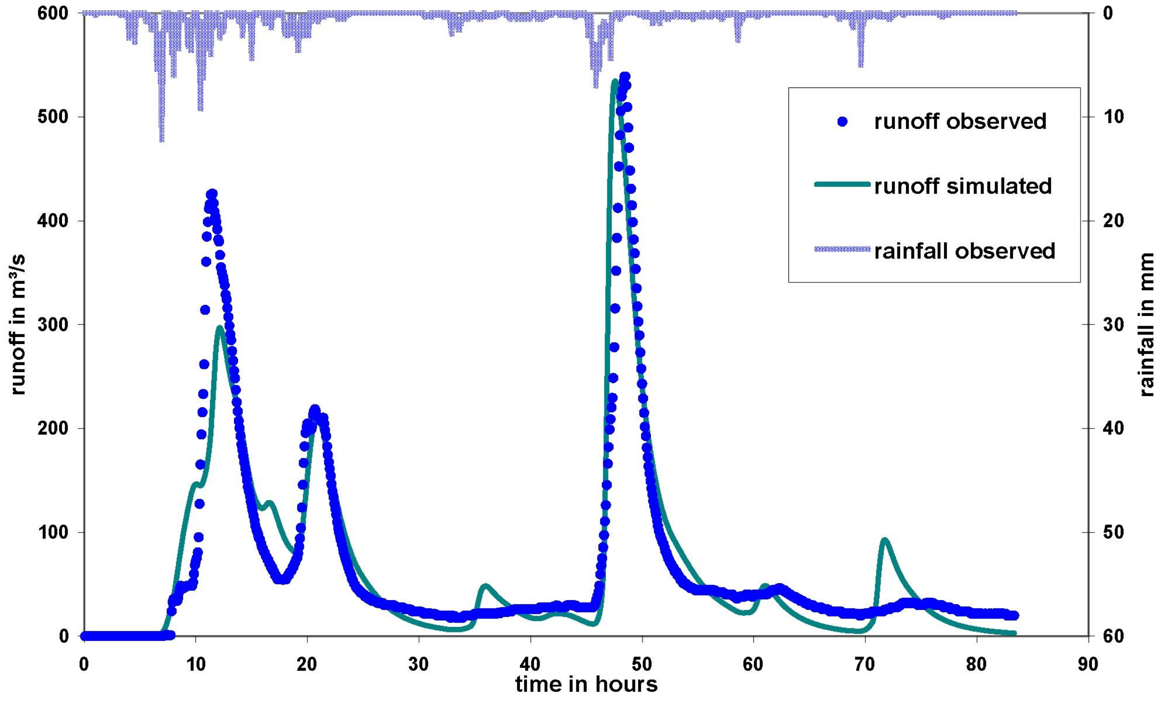
The catastrophe (provisional figures)

- **>350,000 people** affected
- **> 40,000** houses damaged, mainly in ground floors
- **Thousands** of **industries** with damages
- **20 large bridges** and kilometers of roads and railway damaged or destroyed
- **> 100,000 cars** washed away or severely damaged
- During weeks, thousands of people **cleaning the mud on streets and houses**
- Sewer system **collapsed**
- **223 victims** (trap in ground floors, cars and underground garages)
- Around **20,000 M€** only in direct damages

Flood Hazard in Poyo/Pozalet

Hydrological model calibration

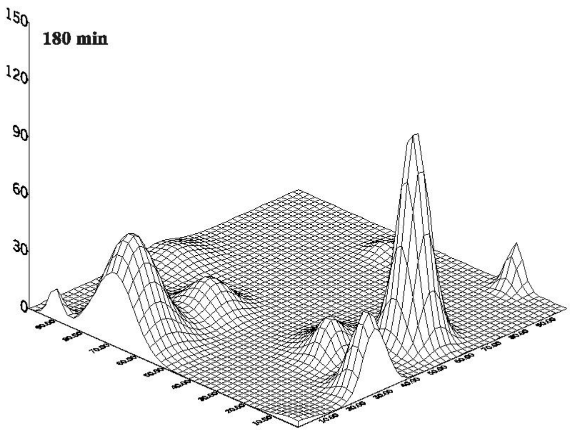
- Automatic calibration for TETIS hydrological model (Francés et al., 2007) in the Oct 2000 event at SAIH (Real Time Hydrological Information System) flow gauge station

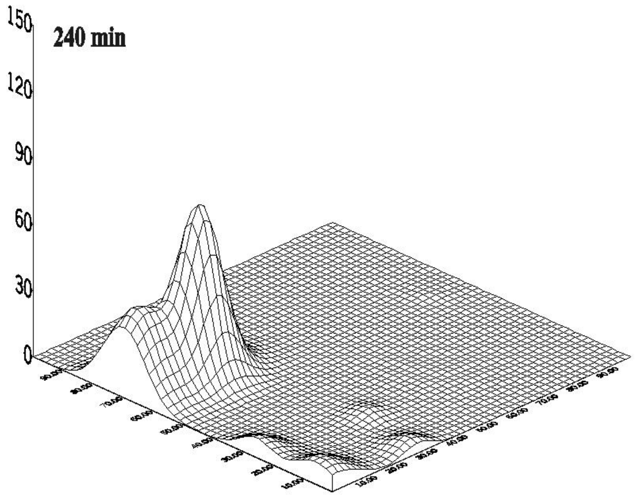


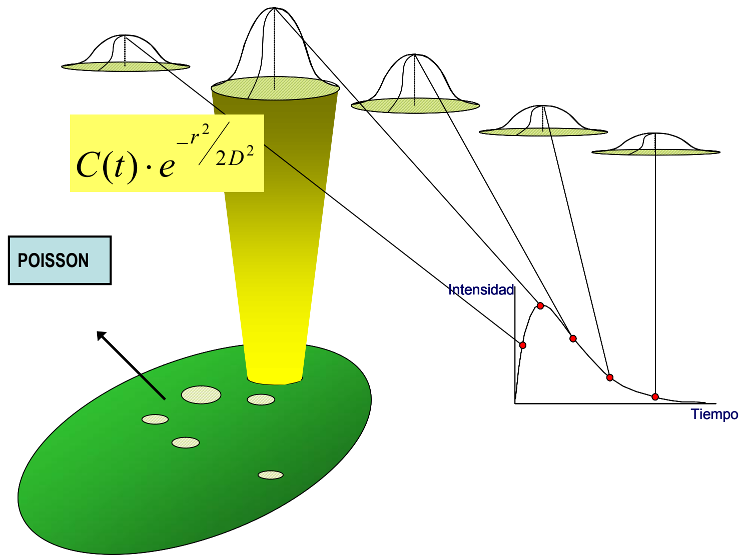
Qmax obs (m^3/s)	538.75
Qmax sim (m^3/s)	534.67
Nash & Sutclife index	0.82
Volume error %	0.20

Convective storm generator

- Model RAINGEN, based on the model of Rodriguez-Iturbe and Eagleson (1987) but improved by Salsón and García-Bartual (2003)

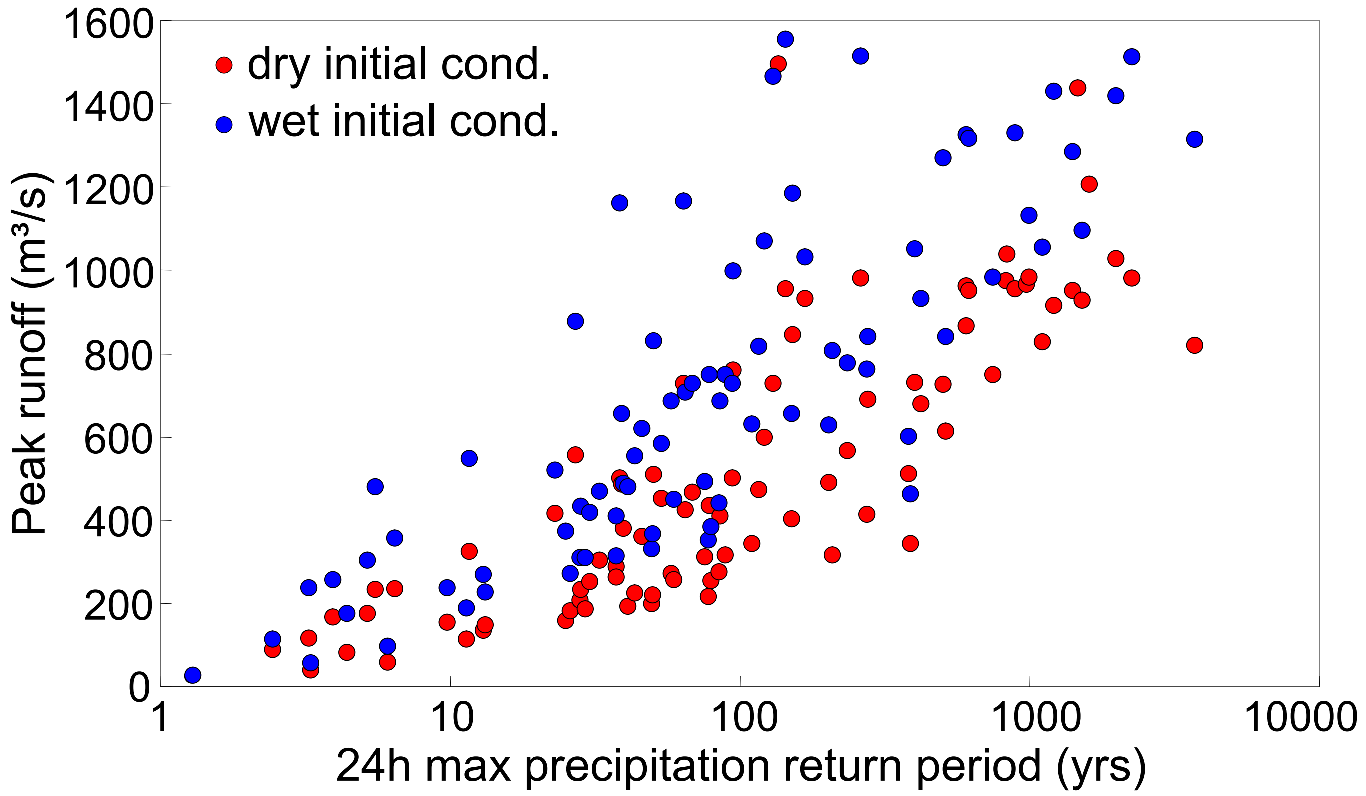






Hydrological results at Poyo flow gauge station

- Peak runoff (and hydrograph) depends highly on:
  - Precipitation spatial and temporal variability
  - Initial soil moisture



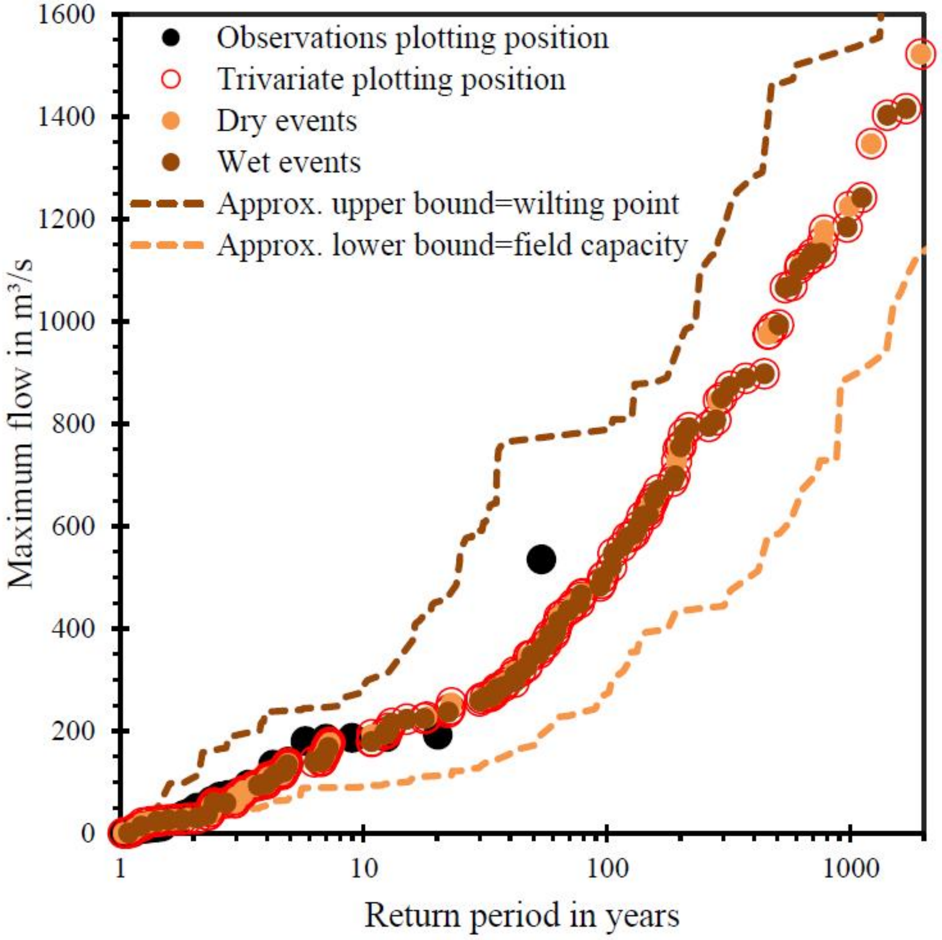
200 event simulations using
100 synthetic storms and two initial conditions

Flood frequency

- Assuming a trivariate statistical model (Salazar et al., 2021):
  - R = maximum areal 24 h precipitation
  - X = peak runoff
  - M = initial soil moisture with two states (dry and wet) and independent of R

- Finally, it can be obtained the plotting positions for the marginal distribution of X:

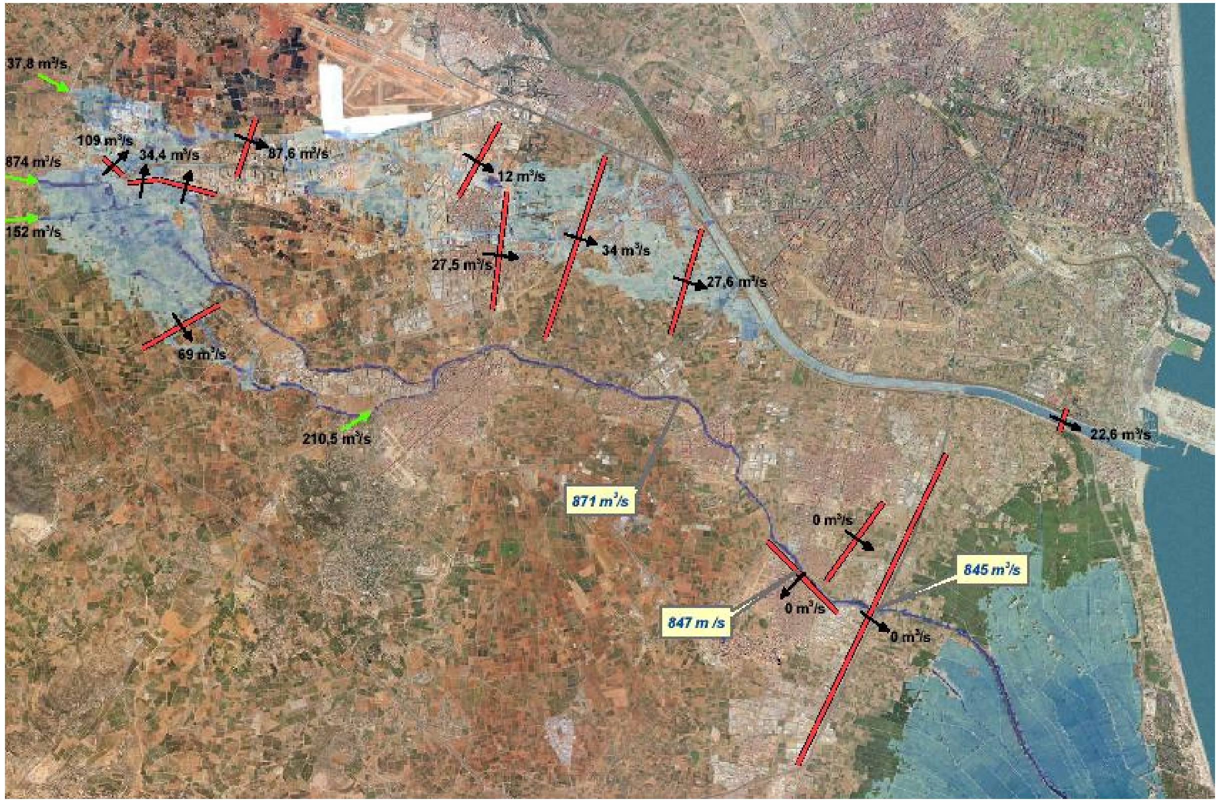
$$F_X(a) \approx P[M = dry]\sum_{i=0}^{\infty}\frac{n_i(a)}{N_i}\left[F_{dry}(R_{i+1}) - F_{dry}(R_i)\right] + \\ + P[M = wet]\sum_{j=0}^{\infty}\frac{n_j(a)}{N_j}\left[F_{wet}(R_{j+1}) - F_{wet}(R_j)\right]$$



Synthetic inundation maps

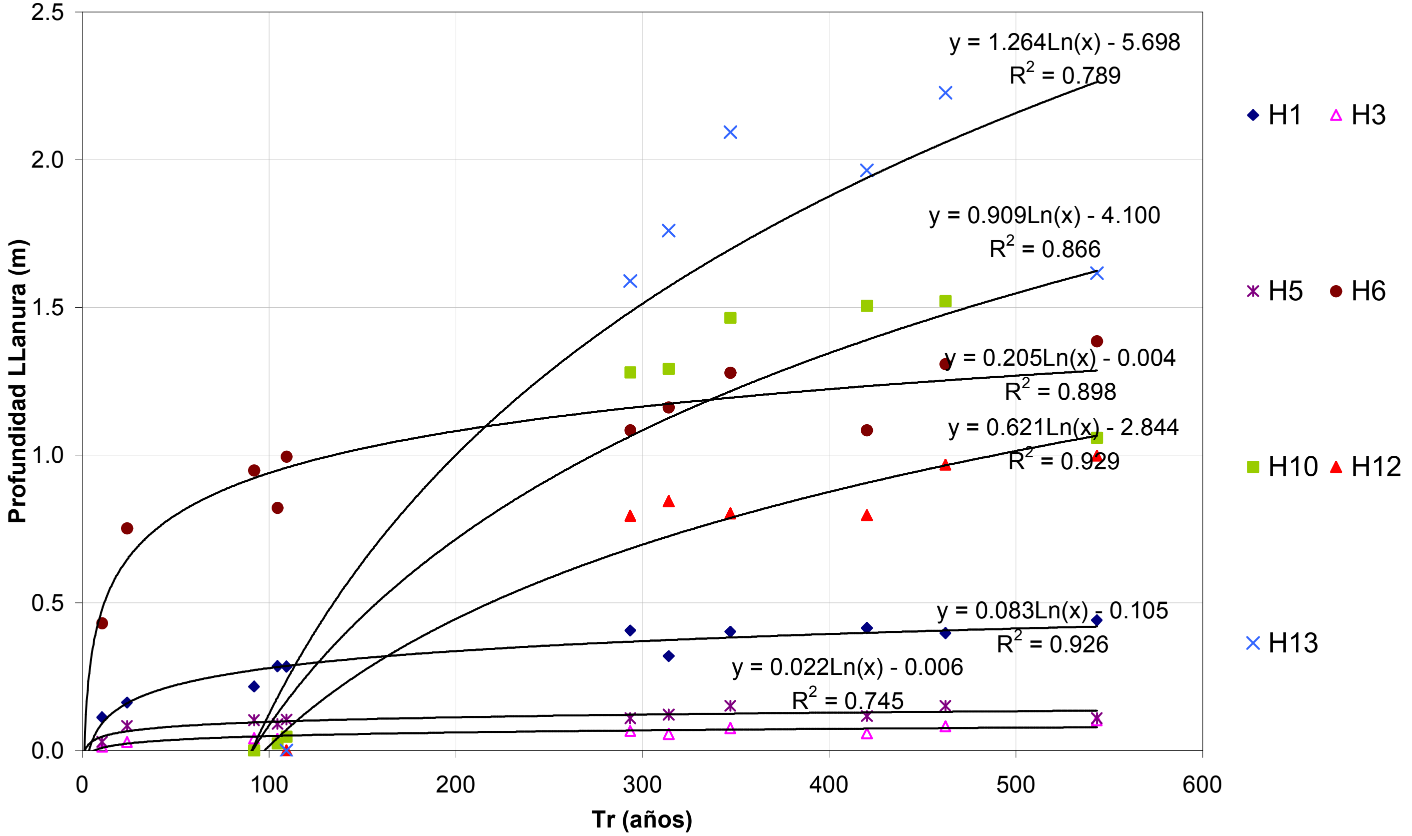
- Software (in 2005): Sobek 1D2D
- Unfortunately, a few number of events for each scenario: 20 events for each scenario

Event 160, wet, present



Hazard mapping

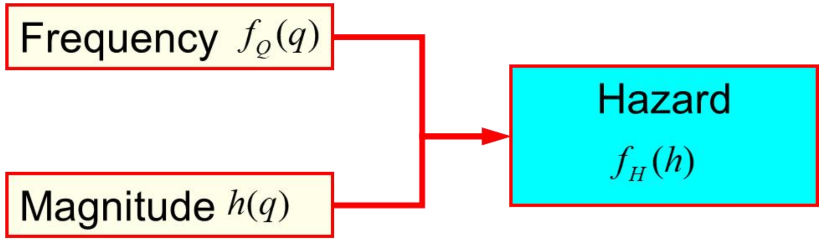
- For each cell within the inundation area, semilog linear regression for depth interpolation:

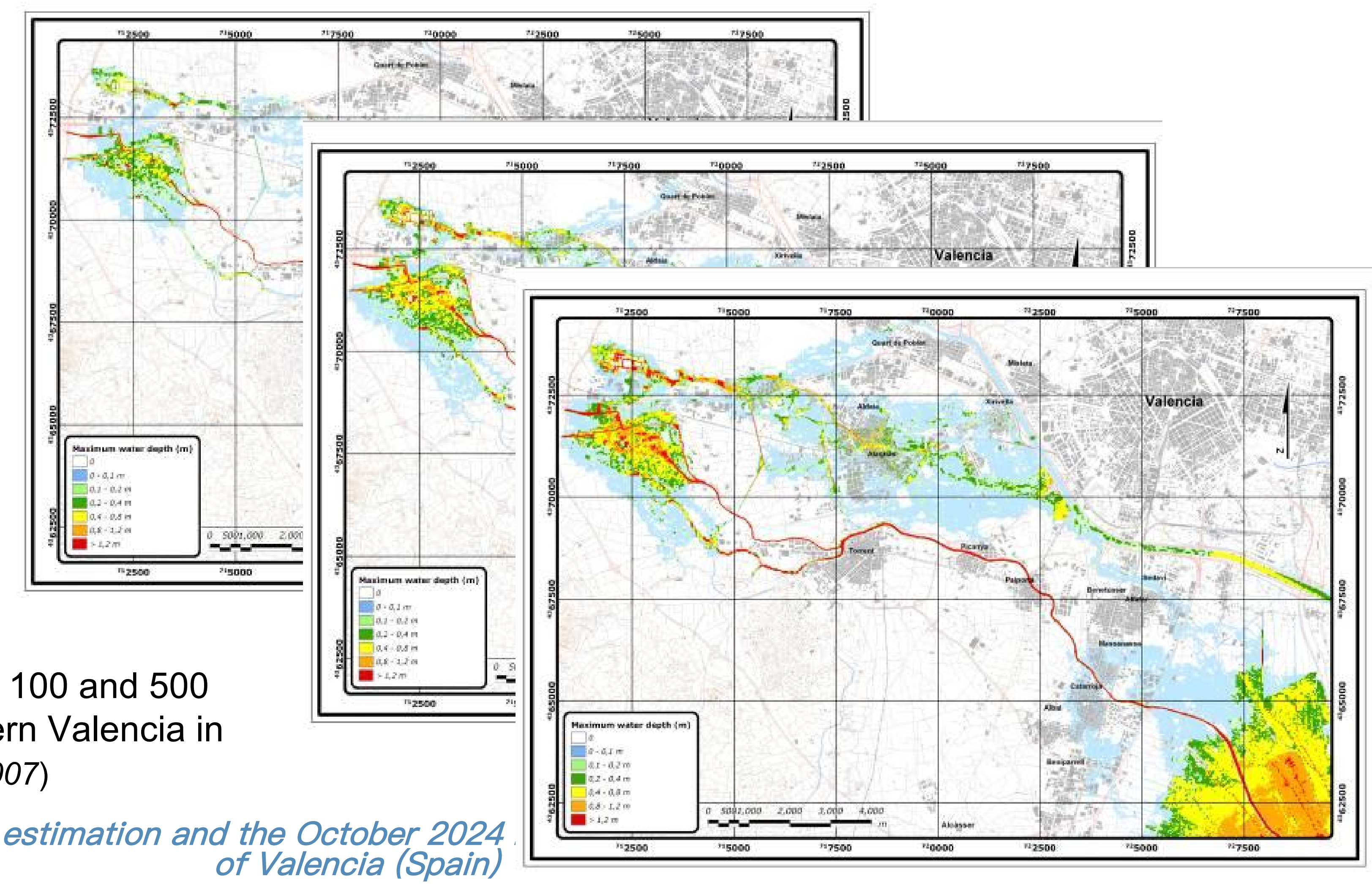


Hazard mapping

$\boxed{f_H(h)}$

- Usually, one map of magnitudes for each return period T





Maximum water depths for T= 10, 100 and 500 years in Rambla del Poyo, Southern Valencia in Spain (Francés et al, IIAMA report, *2007*)

Flood Risk in Poyo/Pozalet

Flood damages

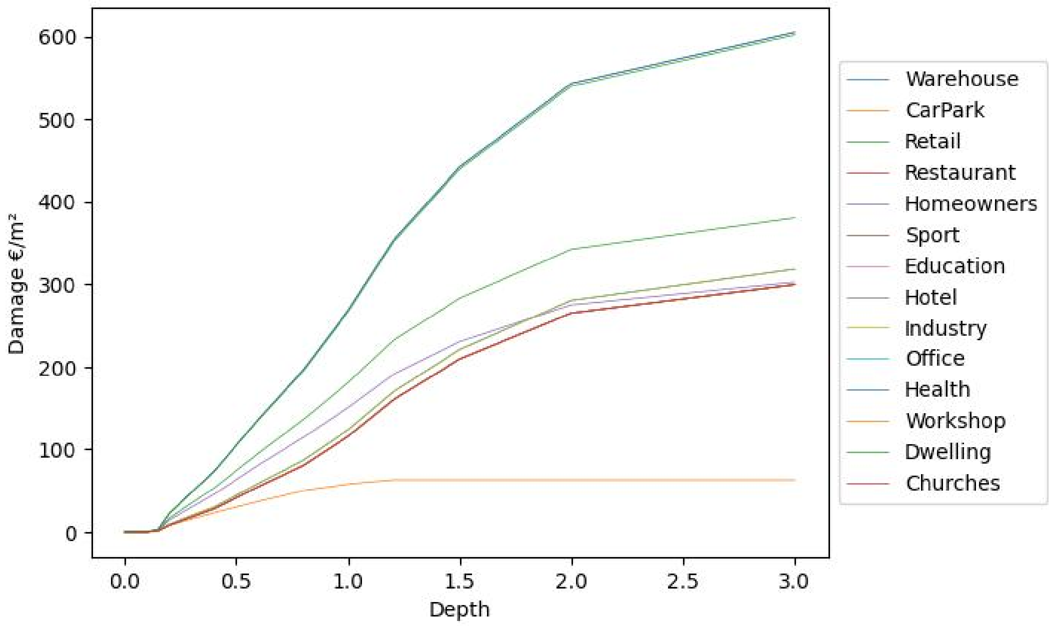
- Tangibles: can be measured in monetary terms
  - Directs
  - Indirects: difficult to estimate

- Intangibles

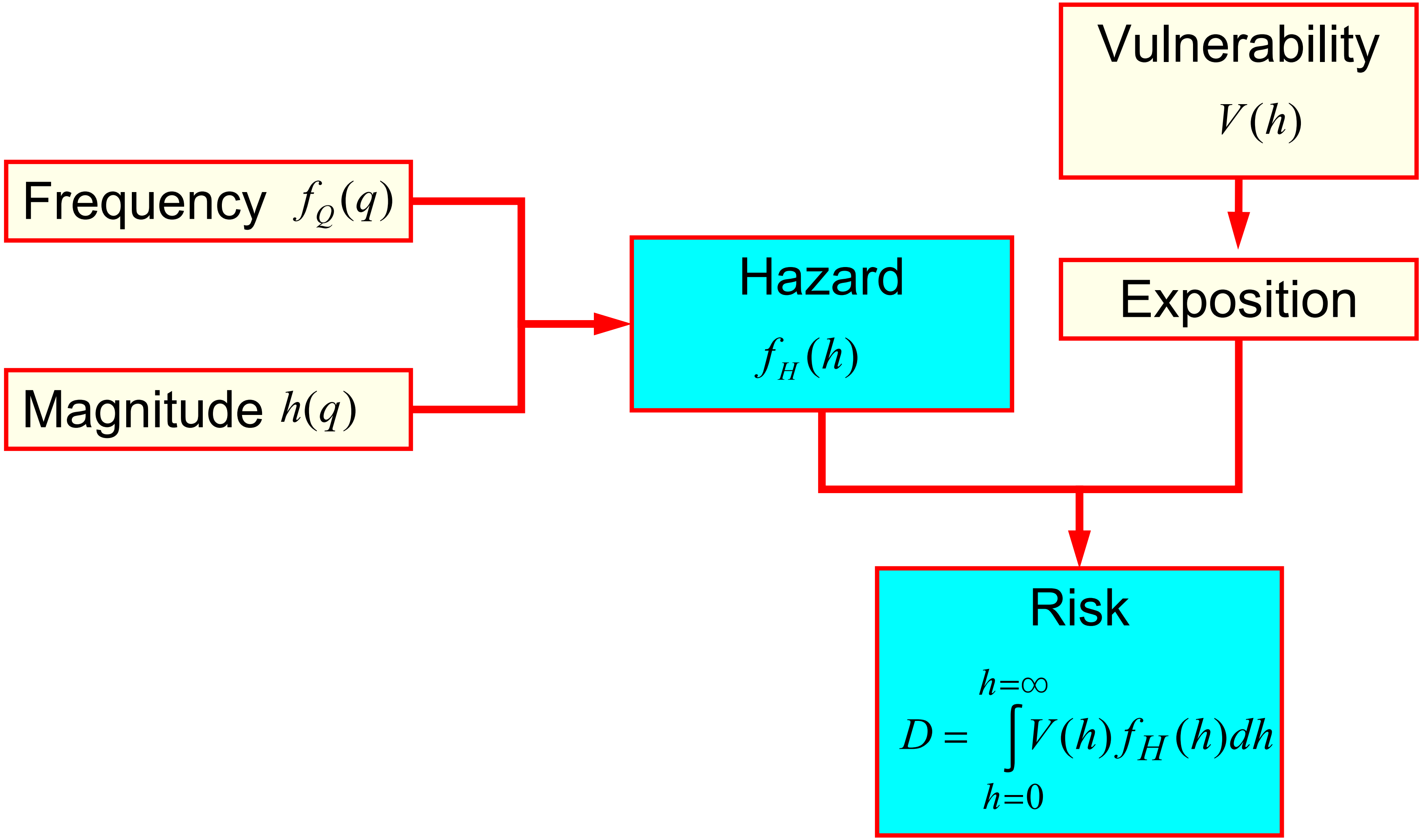
Vulnerability

$V(h)$

- Damages can potentially be produced in a point of the territory
- Depends on:
  - Land use (present and planned)
  - Time of the year
  - Magnitude: mainly maximum water depth
  - **Most** of the total damage in **urban areas**
- Depth-damage curves
  - Case study dependent **=> Validate with historical data**



Risk definition



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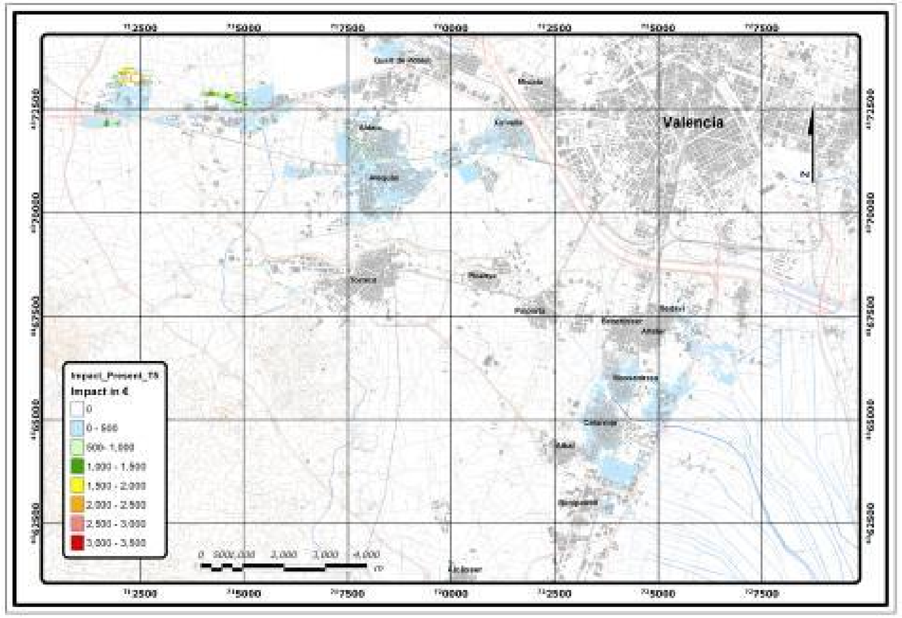
Risk mapping

- Risk density integral: $$D = \int_{F=0}^{F=1} V(h)\,dF_H = \int_{h=0}^{h=\infty} V(h)\,f_H(h)\,dh$$ that can be approximated by:

$$D \sim \frac{V_{10}}{2}\left(\frac{1}{T_{min}} - \frac{1}{10}\right) + \frac{V_{10}+V_{50}}{2}\left(\frac{1}{10} - \frac{1}{50}\right) + \frac{V_{50}+V_{100}}{2}\left(\frac{1}{50} - \frac{1}{100}\right) + \frac{V_{100}+V_{500}}{2}\left(\frac{1}{100} - \frac{1}{500}\right) + V_{500}\frac{1}{500}$$

  - Units: €/year/m^2 or affected people /year/m^2, or …

Total risk in Poyo/Pozalet = 15 M€/year (in 2006, excluding cars, cleaning and infrastructure direct costs and indirect costs)



Risk map in flood prone area of the Rambla del Poyo at present scenario (urban and industrial land use with Tmin = 5 years). Francés et al., IIAMA report, 2007

Car dragging risk map

- It is defined at a given point of the territory (pixel) and is measured as the **mean number of vehicles washed away per year per unit area**
- It can be estimated as:

$$r = \sum_{i=1}^{K} d\, g_i \int_0^1 D(s_i)\, dF_{S_i} = \sum_{i=1}^{K} d\, g_i \int_0^\infty D(s_i)\, f_{S_i}(s)\, ds$$

where:

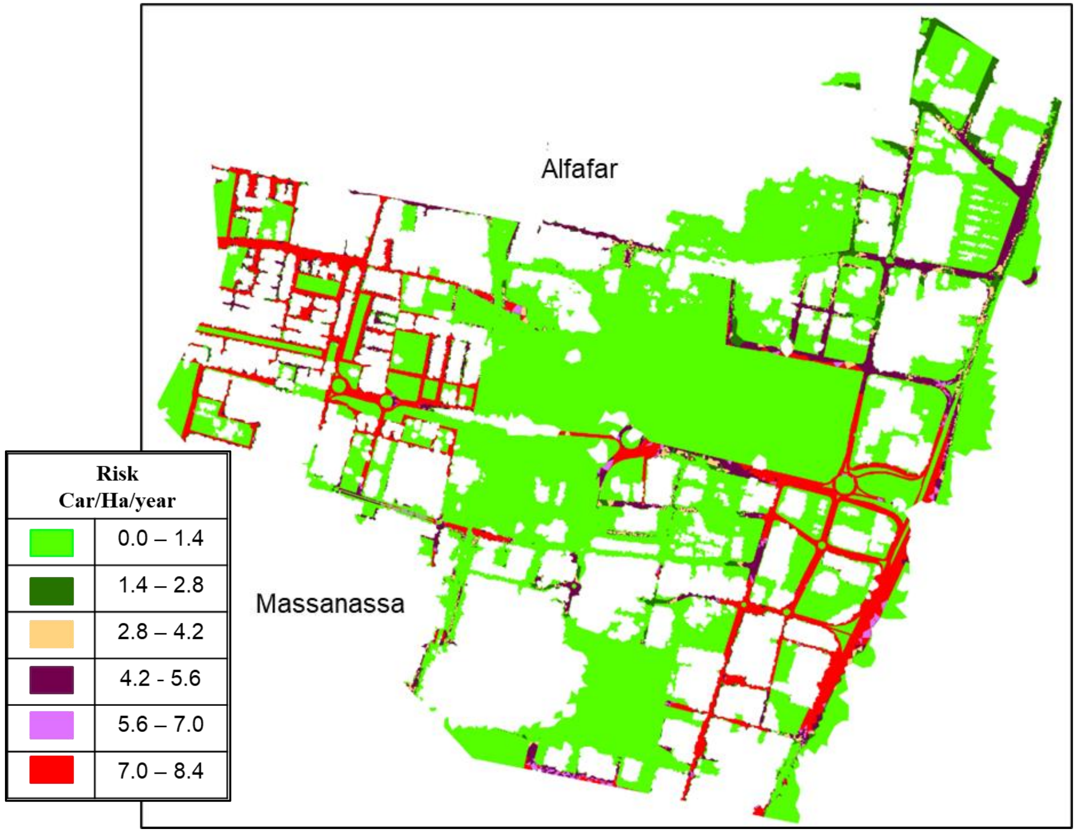
$D(s_i)$ = damage function for car type i, i= 1, …, K

s_i= stability index for car type i

d = density of vehicles in this pixel

g_i = proportion of car type i

(Bocanegra and Francés, 2021)



Conclusions

- The objective is the **risk reduction** in the Inundation Area (European Directive 2007/60/EC)
- The economical and social implications of flooding force **maximum accuracy** in the methodology to be used
- In developed countries majority of victims are **related with cars or flash floods**
  - In Poyo event both + no rainfall in inundation area

- Importance of considering in the future:
  - Hazard mapping of the **catastrophic event** (T2000?)
  - **Sediments** in flash floods
  - **Cars** risk and their influence in the inundation dynamics

Thanks for your attention

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Solidarity Bridge
(01/11/2024)