FLASH FLOODS AND PLUVIAL FLOODING

ISPRA

REGIONE AUTONOMA DELLA SARDEGNA

MINISTERO DELL'AMBIENTE E DELLA TUTELA DEL TERRITORIO E DEL MARE

Working Group F Thematic Workshop

# Example of Flash Floods in Spain: Palancia River

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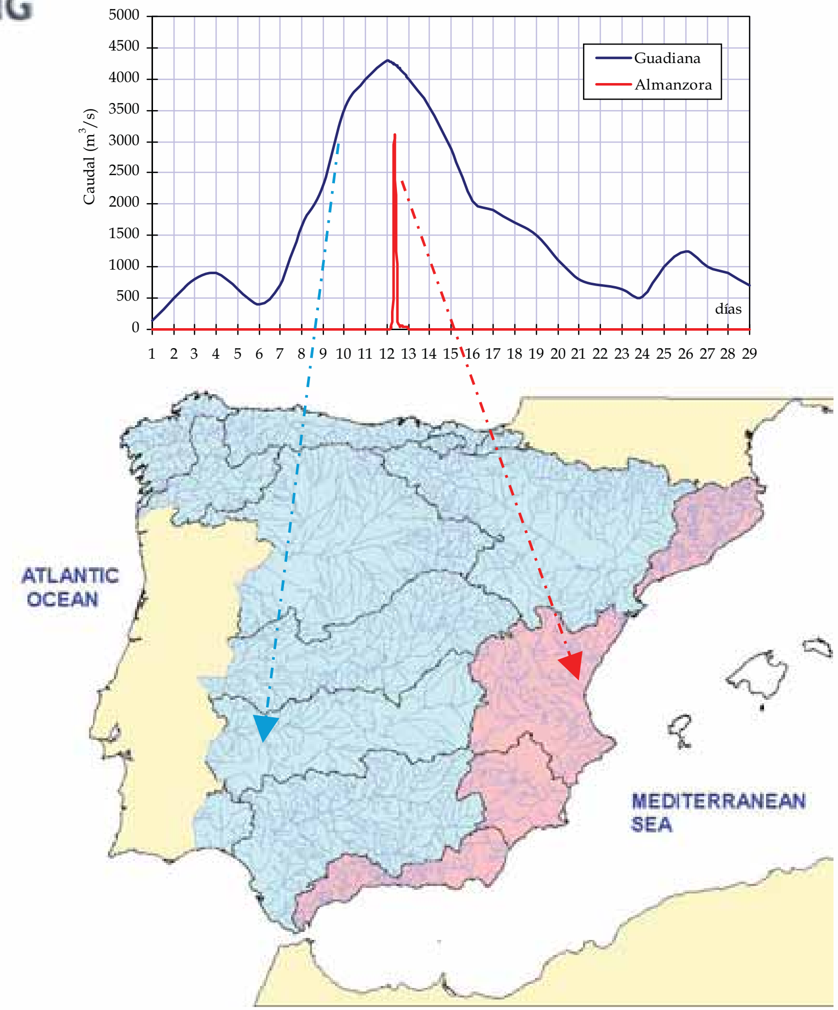
26th-28th May 2010, Cagliari, Italy

# Floods in Spain: Types

- Large and atlantic basins:
  - Large basins
  - Heavy long rains
  - Automn and winter
  - Gradual increase of flows
- Small and Mediterranean basins:
  - Small basins
  - Heavy short rains
  - October and November
  - Sudden increase of flows
  - Responsible for Flash floods

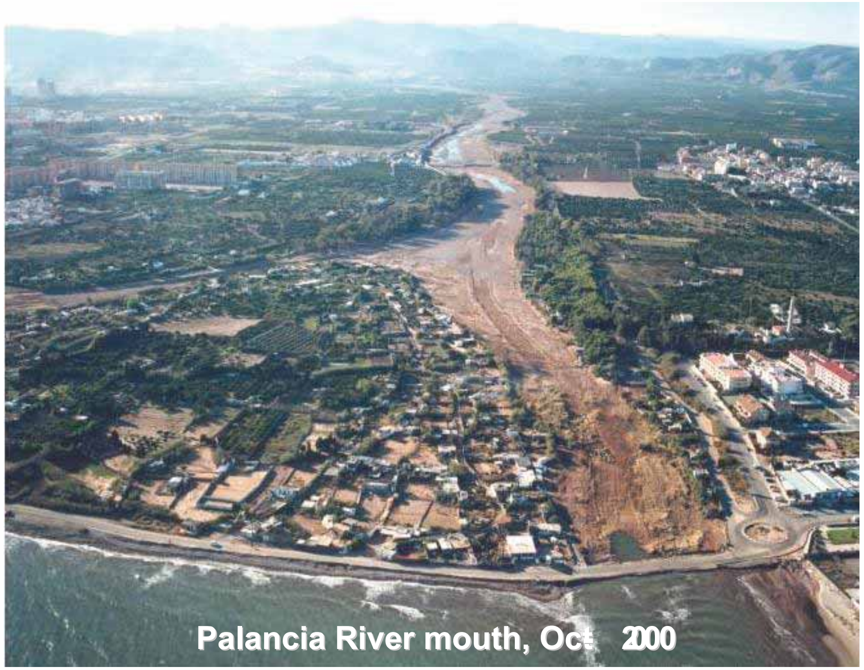


# Flash Floods in Spain: Types

- Small mountain basins
- Small scale convective rains
- Duration: 2 or 3 h.
- Season: summer

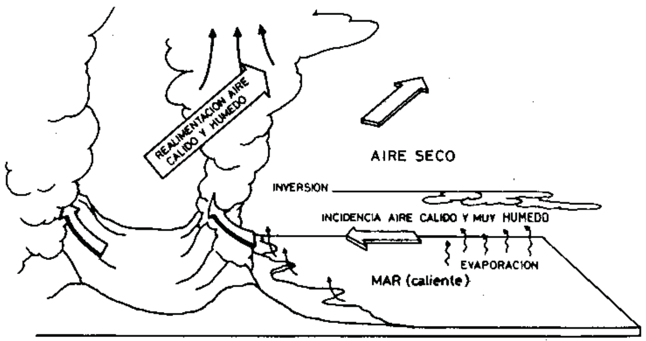
- Medium sized Mediterranean basins
- Medium or large scale convective rains
- Duration: less than 24 h.
- Season: automn


Biescas campsite, Aug 1996

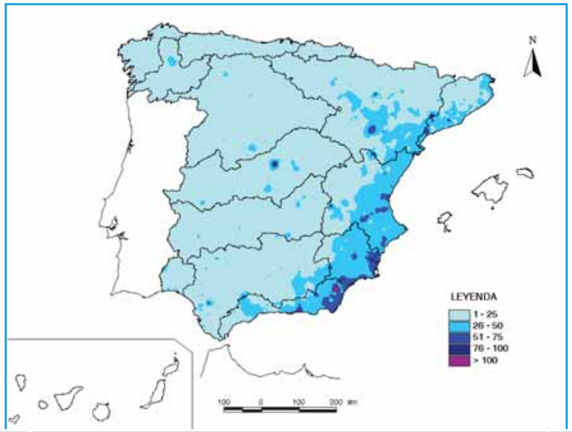

Palancia River mouth, Oct 2000

# Flash Floods characterization: Meteorologic aspects

**Convective Storm elements generation:**




**Ratio: maximum daily precipitation and average annual precipitation**




| Types | β = (precipitation > 35 mm/h)/(total precipitation) For a period | Name |
|---|---|---|
| Type 0 | $\beta = 0$ | Non Convective |
| Type 1 | $0 < \beta \leq 0.3$ | Slightly Convective |
| Type 2 | $0.3 < \beta \leq 0.8$ | Moderately Convective |
| Type 3 | $0.8 < \beta \leq 1.0$ | Strong Convective |

**Classification of convective rain in Spain(Llasat, 2001)**

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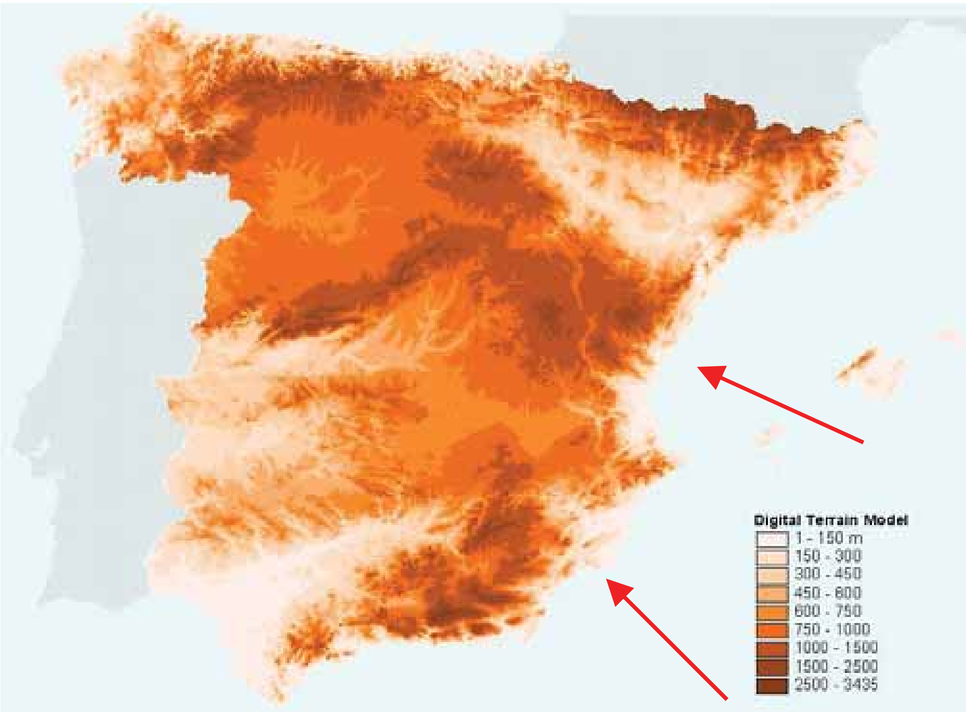
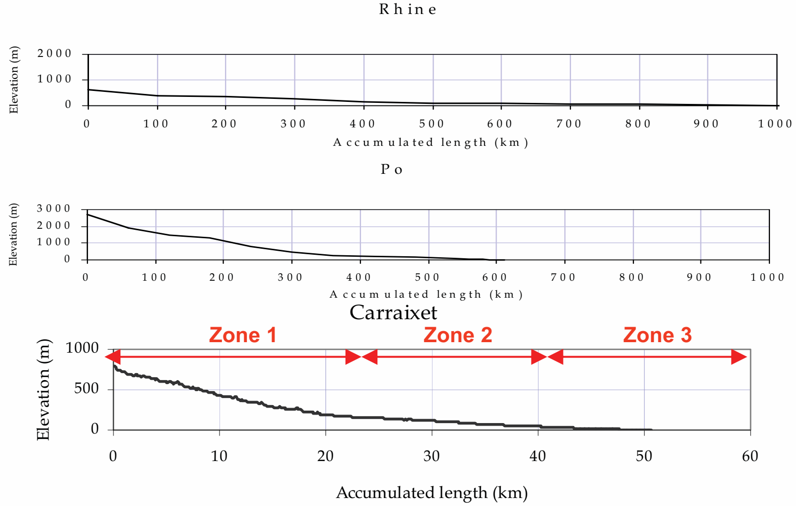
# Flash Floods characterization: Geomorphologic and Orographic aspects




## Longitudinal sections of some european rivers:




**Zone 1: Mountainous zone**
- Large gradients and scarce vegetation
- Heavy erosion process and vast sediment production

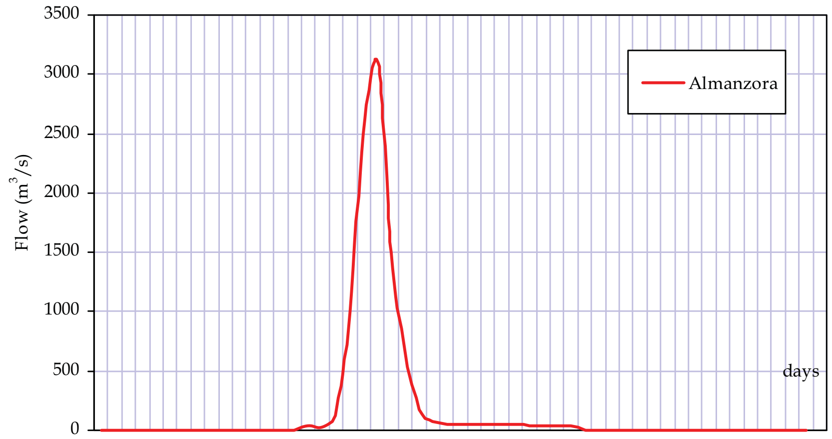
**Zone 2: Transition zone**
- Abrupt change of slope
- Alluvial fans (sediment storage areas)

**Zone 3: Floodplain**
- Braided morphology
- Received overflows during floods

# Flash Floods characterization: Hydrologic aspects

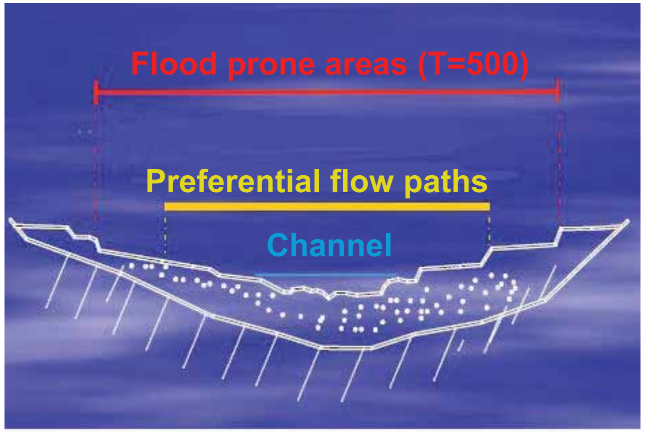
- High volumes of water fall during short-duration rains
- Infiltration capacity < rainfall intensity
- Runoff varies widely depending on soil moisture
- Rapid hydrologic response

- Hydrographs with high peak discharges and short durations
- Small Flood volumes



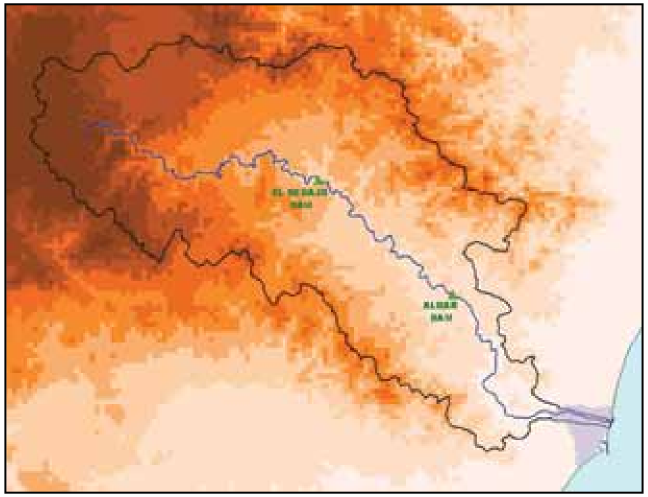
# National System for Cartography of flood prone areas

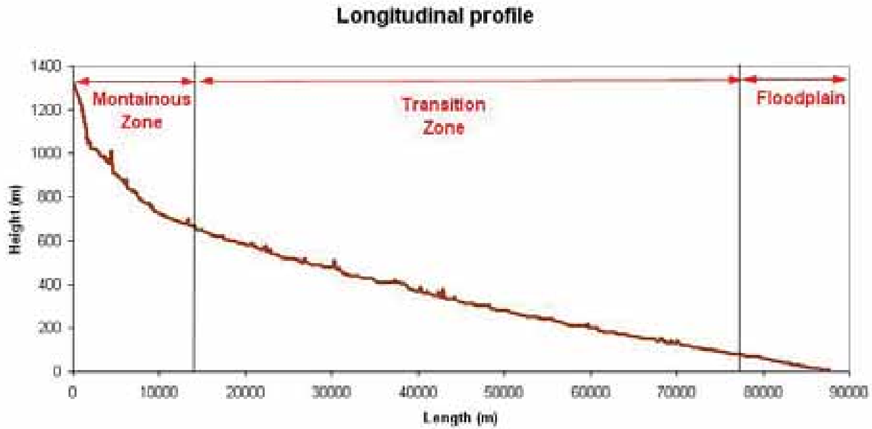
- OBJETIVES
  - Gives a framework to the existing and future flood studies (statal, regional and local studies).
  - Is a tool for policy making on land use planning.
  - Compliant with the Floods Directive on the phase of mapping the hazard.
  - Provides a map that defines the following areas (established by Water Act):
    - Geomorphologic, ecologic, hystorical criteria in addition to hidrological.




- Some pilot cases have been studied to make recommendations on the zoning: **Palancia River Study**

# Palancia River Study

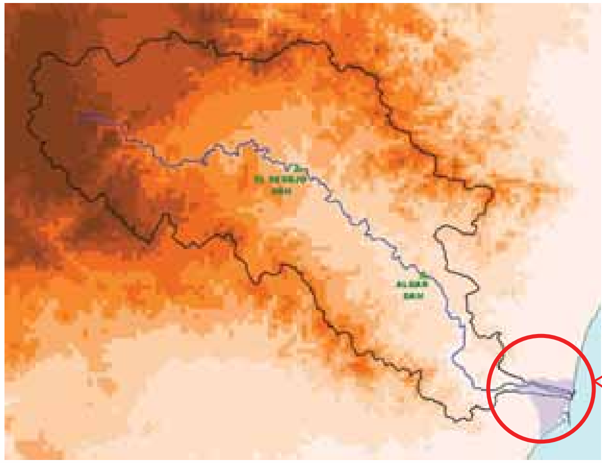






General characteristics:

- Area = 900 Km2
- Length = 85 Km
- Mediterranean climate:
  - Average annual precipitation: 500 mm
  - 20-26 Oct-2000 total precipitation: 143.3 mm
  - Highest and sudden precipitations in automn (“Gota fría”)

# Palancia River Study



**Study focuses in the mouth of the Palancia River:**

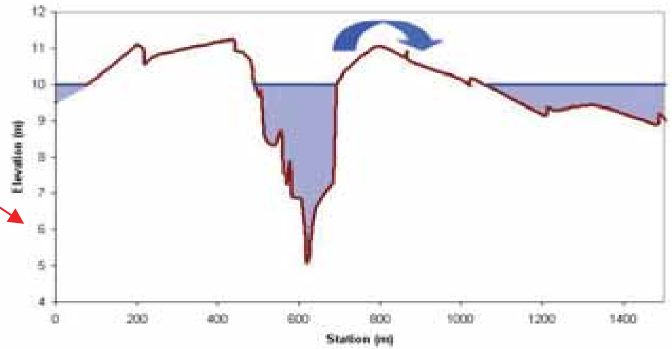
- Alluvial fan morphology
- Greatest damages on floods

## Complex Flow Regime:

- **Existence of many infrastructure and buildings**

- **Two-dimensional Flow Regime**

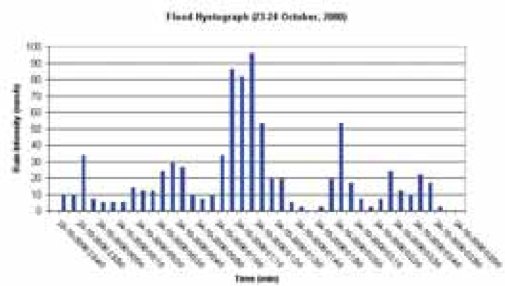
**Cross section**



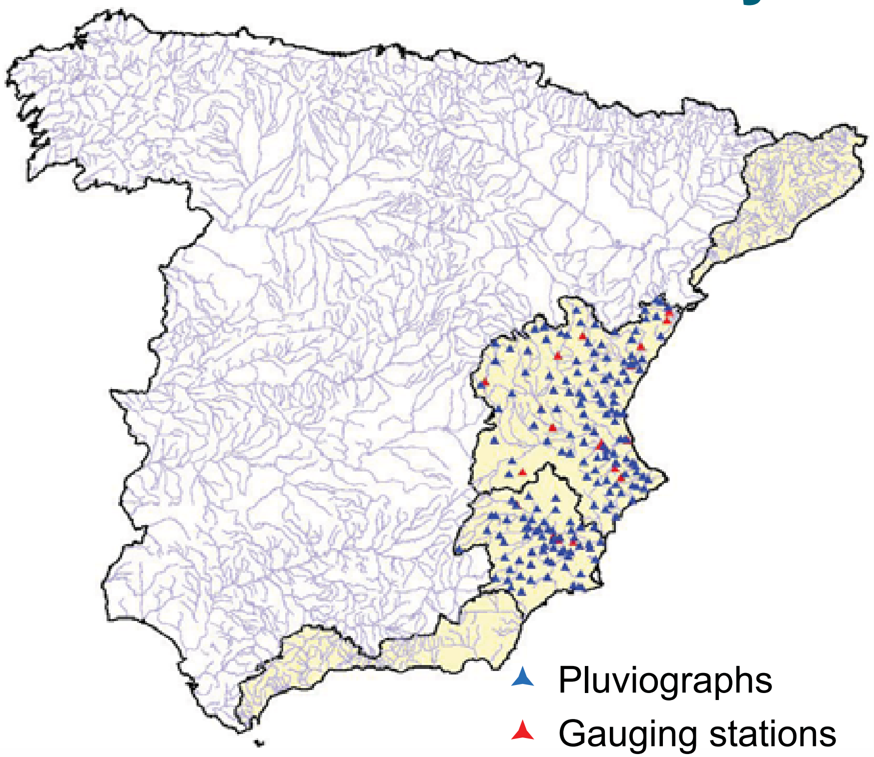
# Available information: traditional measurement network

- Pluviographs:
  - Instant and continuous records
  - Sparse and insufficient network
- Gauging stations:
  - Daily records
  - Good coverage, but mainly in large and medium sized basins.

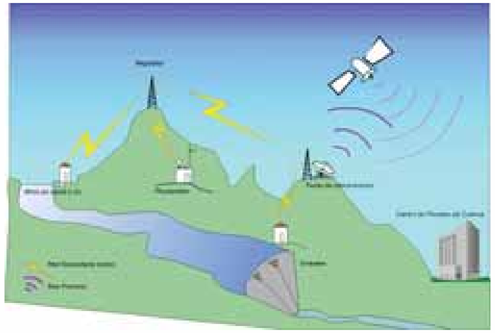
Examples of a Hyetograph and Hydrograph of a Flash Flood (Oct-2000, Palancia River)




# Available information: Automatic Hydrological Information System network (AHIS)



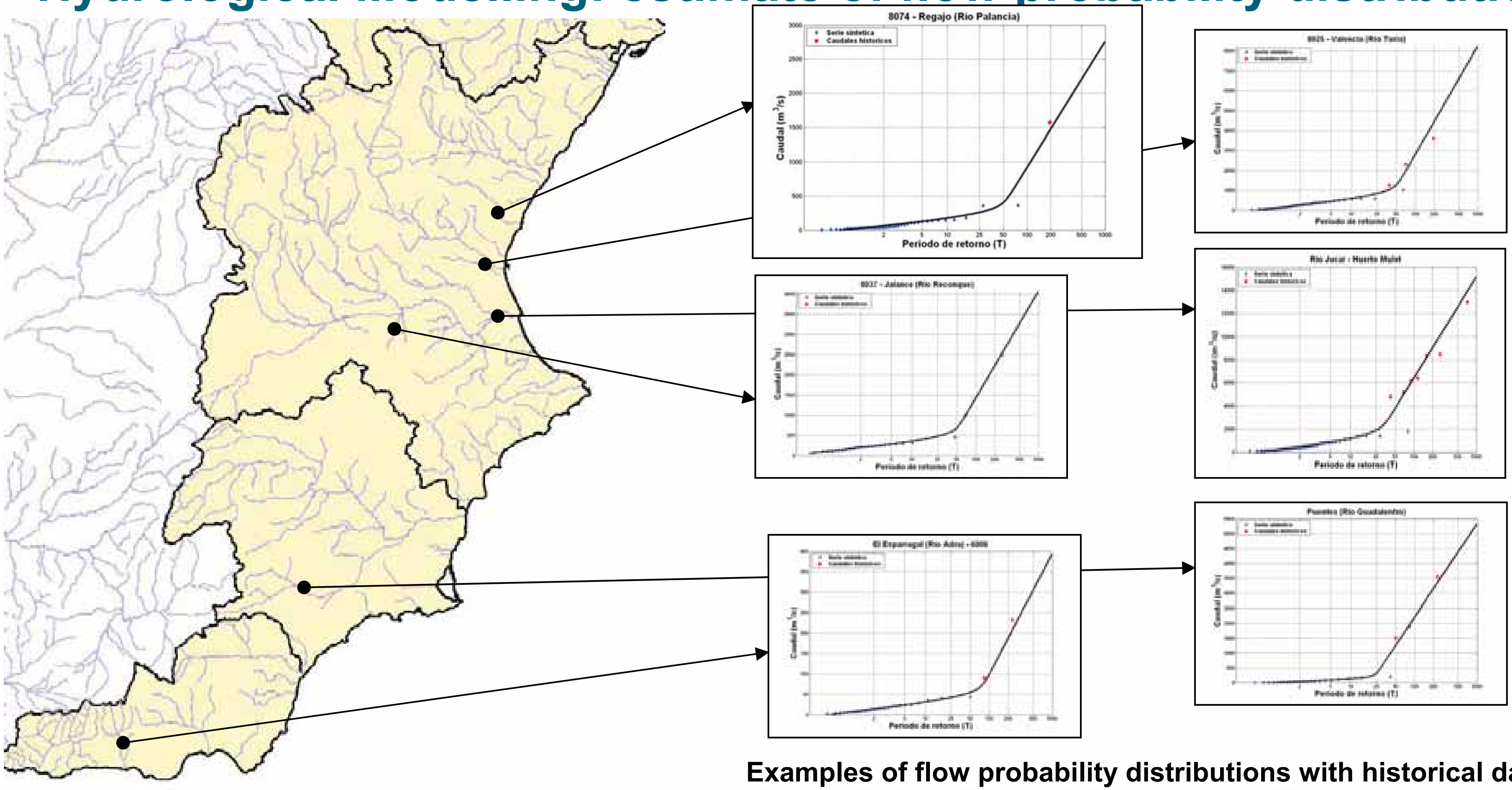

- First AHIS network built in 1988 in Júcar river District (less than 20 years records).
- Instant real time data:



**AHIS System communication scheme**

- 5-minutal information is available.
- Good coverage but still insufficient due to the local nature of the convective rainfall events.

# Hydrological Modelling: estimate of flow probability distribution




Examples of flow probability distributions with historical data

# Flow Probability Distribution: Two Components Extreme Value (TCEV)

- Two Components Extreme Value (TCEV):

$$F(x) = e^{\left[-\alpha_1 e^{-\frac{x}{\theta_1}} - \alpha_2 e^{-\frac{x}{\theta_2}}\right]}$$

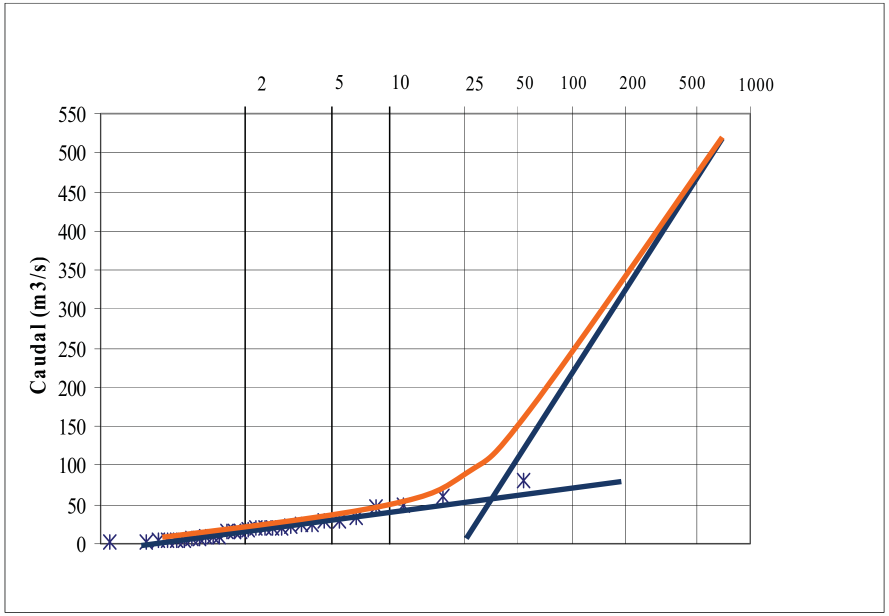
Parameters: $\alpha_1$, $\alpha_2$, $\theta_1$, $\theta_2$

- Fitting method proposed for TCEV:
  - **<u>If there is enough historical information</u>** <u>available</u>: local fitting using maximum likelihood method.
  - **<u>If not</u>**:
    - Local fitting of a Gumbel Distribution for the low part of the distribution.
    - Local fitting of a Gumbel Distribution for the high part of the distribution using regional information:

$$(L - C_V)_2 = -0.24$$

$$M_2 = -10^{2.6039} \cdot M_1^{0.5659} \cdot (L - C_V)_1^{0.6861}$$

    - TCEV distribution will be the product of both two Gumbel distributions.



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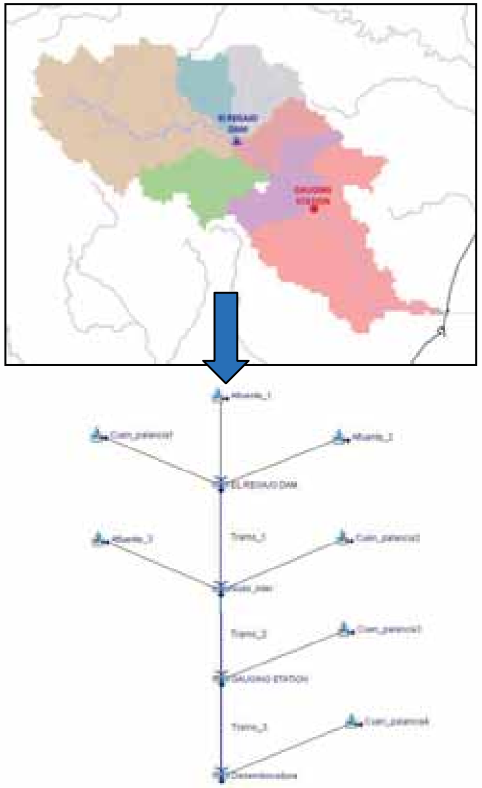
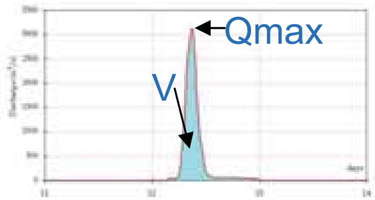
# Calibrating Hydrological Modelling: Probability distributions of flows and volumes

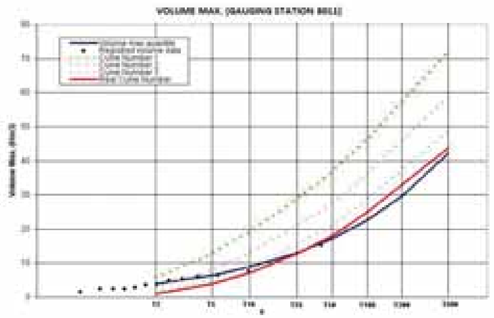


Quasi-distributed basin model:
HEC-HMS (US. Army Corps of Engeneers)

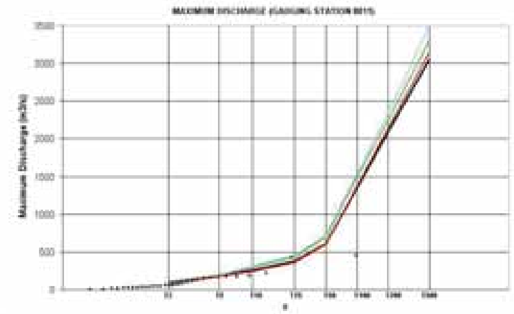
- **CALIBRATION**: of both peak flows and volumes associated (Qmax>>>; Vmax<<<)




- **Volumes:**
Calibration of the infiltration model (SCS: Curve Number)

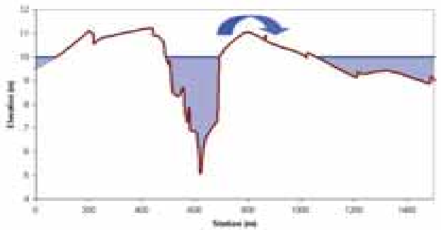


- **Peak flows:**
Calibration of the transform model (ModClark: Storage Coefficient)

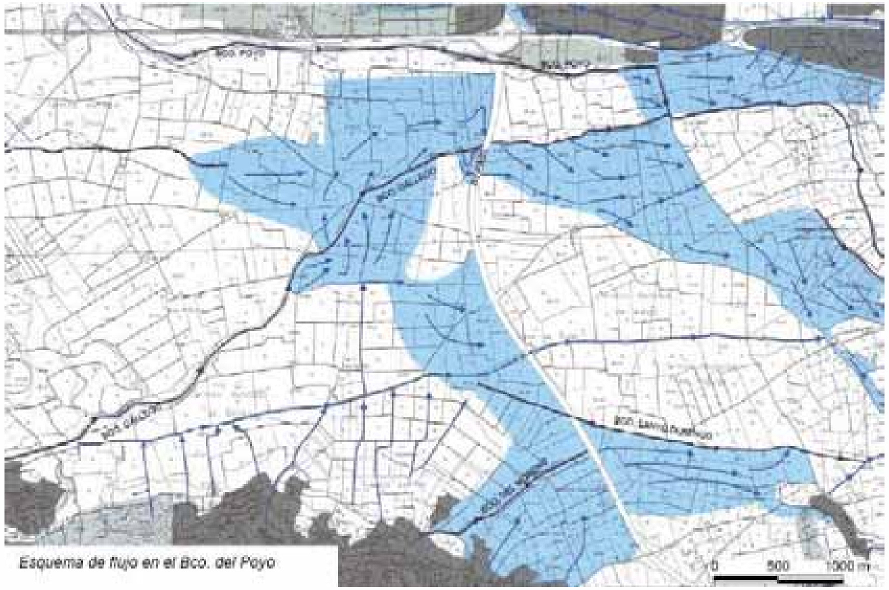


# Hydraulic Modelling: complex and bidimentional problem

- **PROBLEMS**:
  - Large extend of floodings:
    convex section channels, flat terrain,...



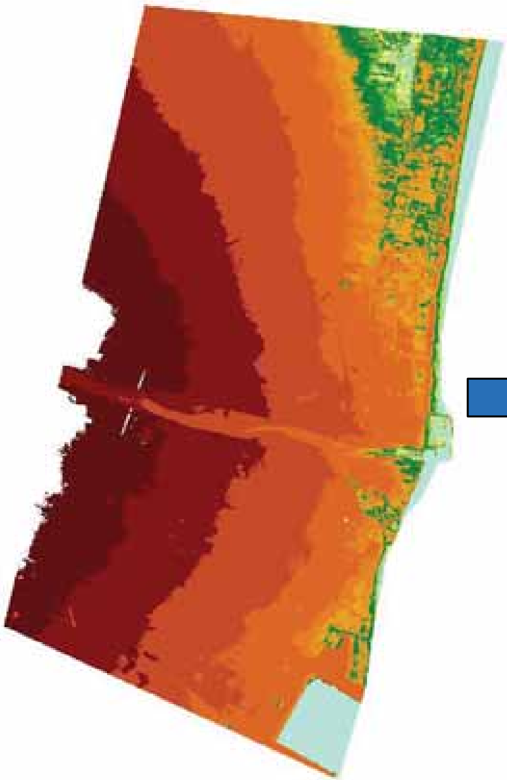
  - Erratic and complex flows:
    shallow drafts, great amount of barriers
    (infraestuctures, buildings,...).



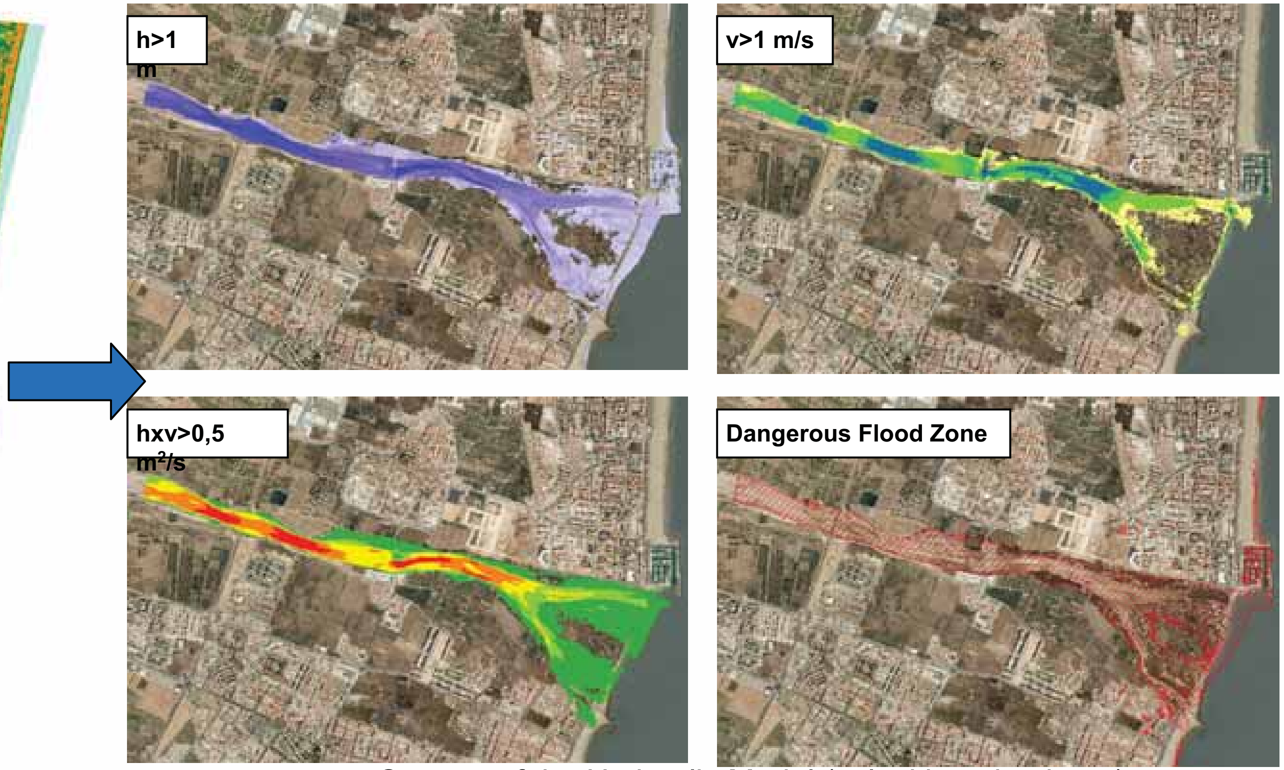

  - Lack or scarcity of records of the extend and behaviour of water in flood

# Hydraulic Modelling:

- **SOLUTIONS:**
  - Use of two-dimensional hydraulic models based on a detailed cartography:

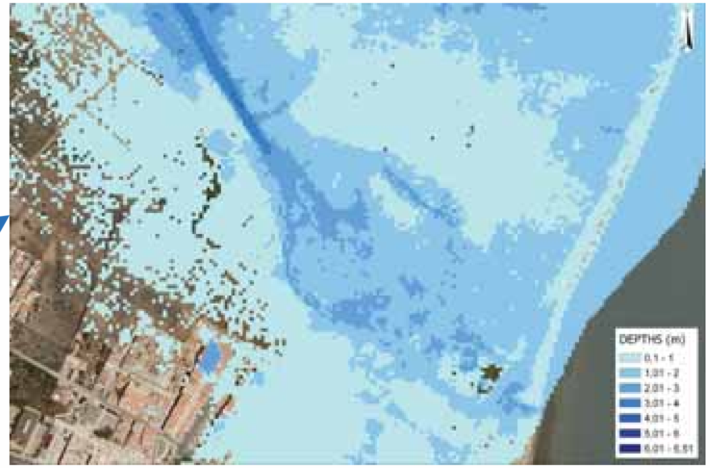


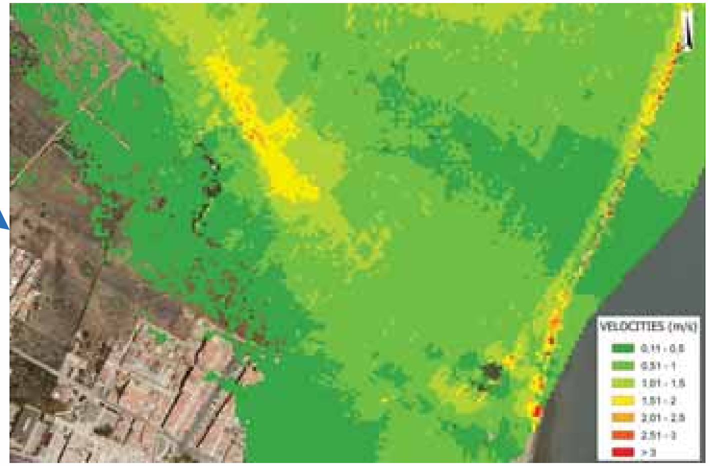
Digital Terrain Model (1x1 m)




Outputs of the Hydraulic Model (velocities, depths,...)

# Mapping the results:

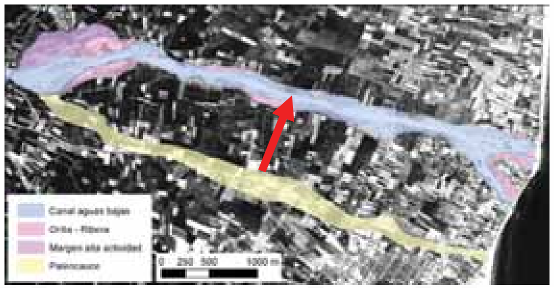


# Hydraulic Modelling:

- **SOLUTIONS:**
  - **Use of historical and geomorphological evidences for:**
    - **Calibration of hydraulic models**
    **(extent, levels and velocities reached on flooding)**
    - **Flood zoning**


- **Predict and detect changes in the channel morphology due to these floods**




# Conclusions:

- Delineation of the flooded areas based on:
  - Results from the hydraulic studies
  - Geomorphologic and historical references:
    - Possible channel movements
    - Areas that remain longer flooded due to coastal barrier or other obstacles.
- Required information:
  - To calibrate the Hydrologic model:
    - Peak flows and volumes associated: temporary scale as short as possible
    - Historical information to estimate high return period flows
  - Hydraulic model:
    - Based on a detail cartography
    - Information from geomorphologic studies
- Mapping the results:
  - Velocities, depths, the product of both v and h

# Thank you for your attention

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