EMS Annual Meeting
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| 4–8 September 2017 | Dublin, Ireland

October 25, 1907. The Ebro overflowed in Tortosa.

Synoptic aspects of large floods in the south of Catalonia (Spain)

J.C. Peña, D. Pino, C. Balasch, **J. Mazón**, M. Prohom, M. Barriendos, J.L. Ruiz-Bellet, J. Tuset

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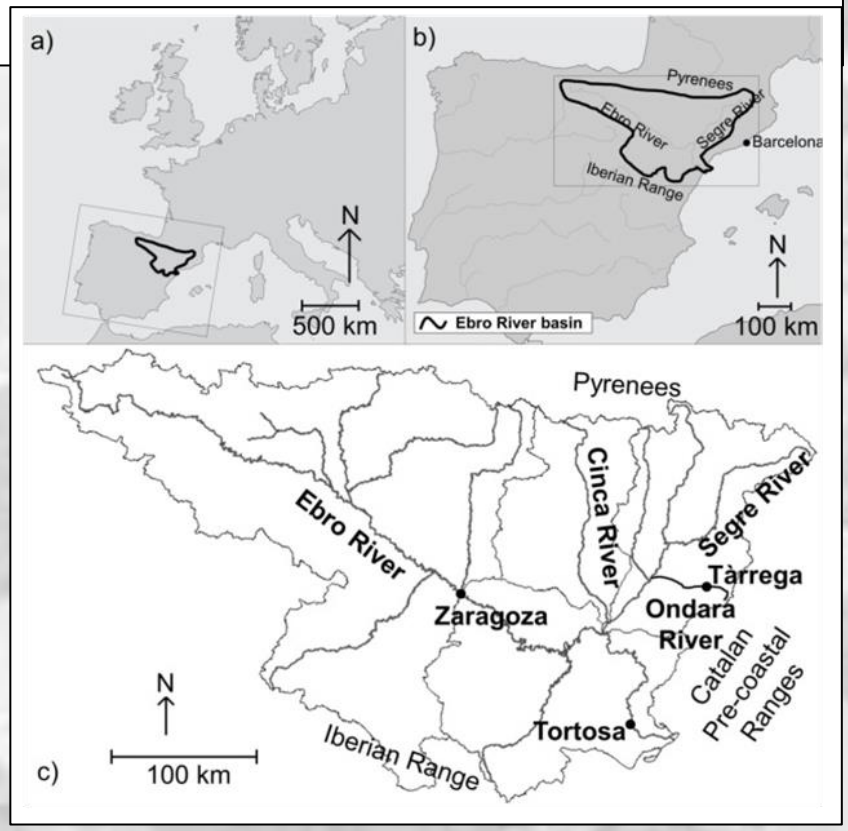
1. OBJECTIVE

The aim of this study is to analyse the **large scale atmospheric variability modes** and the **synoptic atmospheric patterns** connected with the most severe floods events affecting Tortosa (1871-2010), at the low course of the Ebro river (NE of Iberian Peninsula).

2. AREA OF INTEREST

Tortosa is located in the Ebro river basin, only 40 km upstream the river mouth in the Mediterranean sea, and its catchment area is 99% of the total Ebro basin area.



3. DATA

Large-scale atmospheric circulation modes were inferred from **the monthly Sea Level Pressure** (SLP) grid taken from 20th Century V2 Reanalysis Project (20CRP).

These data were provided by NOAA/OAR/ESRL PSD, Boulder, Colorado (Compo et al., 2011) and extend the temporal coverage of the NCEP/NCAR Reanalysis Project (Kalnay et al., 1996). The 20CRP is a mission to produce reanalyses of weather maps covering the period from 1871 onwards with a horizontal spatial resolution of 2°.

The synoptic patterns were inferred from **the daily Sea Level Pressure** (SLP) grid taken from the 20CRP from 1871 onwards with a horizontal spatial resolution of 2°.

The flood data base of Tortosa have been used to determine the major floods episodes (Peak flow > 3000 m^3/s). These major floods are defined by the day of the event plus the previous three days.

4. METHODS

Multivariable Analysis
Sea Level Pressure (SLP) Anomalies

LARGE-SCALE ATMOSPHERIC CIRCULATION MODES (MODE) over Western Europe

Methodology (Hurrell et al, 1995; Folland, 2009)

- **PRINCIPAL COMPONENT ANALYSIS**
- Applied to **Monthly SLP Anomalies in S-mode**
- Covariance Matrix
- Scree Test to extract the most relevant components
- No rotation
- The analysis is applied to:
  - 20th Century Reanalysis
- **PERIOD: 1871-2010**

ATMOSPHERIC SYNOPTIC TYPES (SYNOPTIC) over WE related to severe floods South Catalonia

Methodology (Huth et al., 2006)

- **PRINCIPAL COMPONENT ANALYSIS**
- Applied to **Daily SLPA in T-mode**
- Correlation Matrix
- Scree Test to extract the most relevant components
- Rotation Varimax
- The analysis is applied to 20th Century Reanalysis **the day of the event + previous 3 days**
- **PERIOD: 1871-2010**

Association between Large-Scale Atmospheric Circulation Modes (MODE) and Atmospheric Synoptic Types (SYNOPTIC)

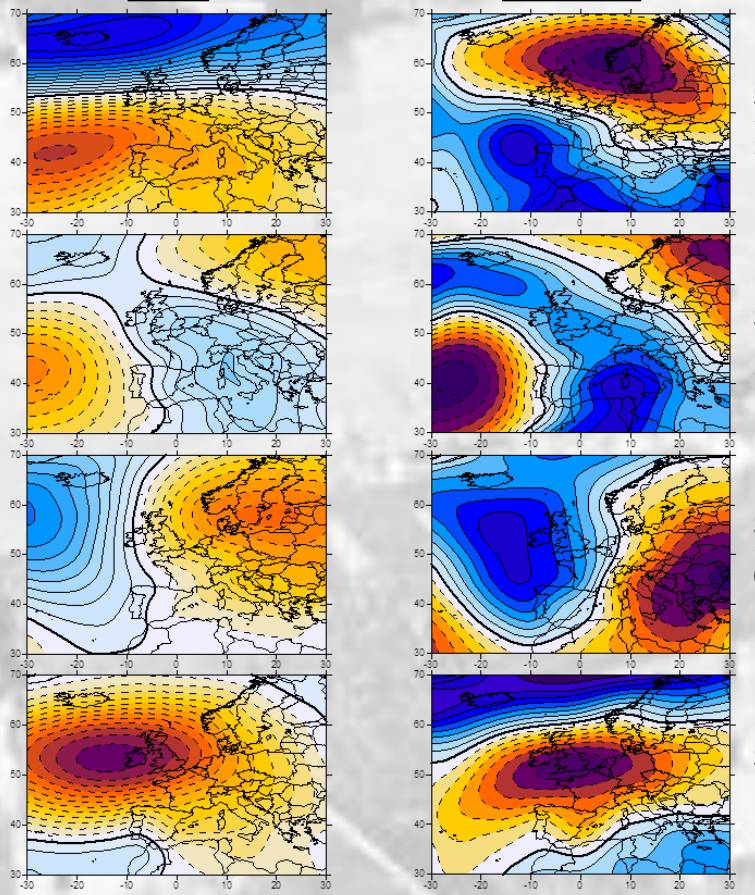
4. RESULTS

Association between large-scale atmospheric circulation modes (MODE) and atmospheric synoptic types (SYNOPTIC)

Pearson's Correlation Coefficient between MODE and SYNOPTIC

		SYNOPTIC			
		PAT1	PAT2	PAT3	PAT4
MODE	C1	-0.64	-0.04	0.32	0.63
	C2	0.30	-0.40	-0.43	0.56
	C3	0.48	0.03	0.67	0.24
	C4	0.03	0.89	-0.25	-0.05

MODE **SYNOPTIC**



C1:
North Atlantic Oscillation (NAO).
39% of total variance.

C4:
Scandinavia pattern (SCAND).
9% of total variance.

C3:
East Atlantic Pattern (EA).
14% of total variance.

C2:
East Atlantic/Western Russia pattern (EATL/WRUS).
22% of total variance.

CP1:
SOUTH-EASTERN FLOW (SEF).
25% of total variance.

CP2:
MEDITERRANEAN LOW (ML).
21% of total variance.

CP3:
SOUTH-WESTERN FLOW (SWF).
18% of total variance.

CP4:
EASTHERN FLOW (EF).
14% of total variance.

5. DISCUSSION

THE ANALYSIS OF ATMOSPHERIC VARIABILITY MODES SHOWS A POSSIBLE CHANGE IN THE FLOOD PATTERN

MONTH	YEAR	NAO	EATL/WRUS	EA	SCAND
1	1871	**-1.173**	-0.839	-0.722	-0.266
9	1884	**-0.675**	0.419	0.417	**0.452**
10	1907	0.145	0.171	-0.453	**1.39**
3	1916	**-0.328**	-0.234	-0.638	**0.682**
5	1921	0.744	-0.131	0.102	**0.647**
10	1937	**-0.148**	-0.581	0.07	**0.808**
2	1952	0.58	-0.392	-0.348	-0.301
1	1960	-0.11	-0.585	**0.876**	-0.652
1	1961	-0.09	-0.476	**0.679**	-0.782
5	1971	0.168	**0.926**	0.096	0.145
11	1982	0.723	**0.279**	-0.306	-0.316

Cold pattern

Warm pattern

1. In the cold period (1871-1940) predominates the NAO in negative phase and/or the SCAND in positive phase:

- Anticyclonic blocking over the Scandinavian peninsula provoking a marked wave in the jet-stream and lows pressure systems affecting the south of Catalonia.
- This pattern is associated with high peak flows in Tortosa (>4500 m^3s^{-1}).

2. The warm period (1940-2010) predominates EA and EATL/WRUS modes in positive phase and/or the NAO in positive phase / SCAND in negative phase :

- Advection of warm air from low latitudes with fluxes of south over Catalonia.
- This pattern promotes floods with flat peak flow (<4500 m^3s^{-1})

5. CONCLUSIONS

1. Evidence of the influence of atmospheric circulation dynamics on flood frequencies in the low part of the Ebro river basic in Tortosa site is obtained when flood intensities and indices of atmospheric modes from 1871 and 2010 are compared.

2. The largest floods in the Ebro basin during the last stages of LIA are explained by the negative phase of the NAO, with trajectories of the low-pressure centres southward of its habitual location

3. During recent Global Warming period the dominant pattern is the NAO and EA modes in positive phase, related to Atlantic cyclones and long-lasting rainfall over the Ebro basin

Thank you for your attention!