

Historical flood data series of Eastern Spanish Coast (14th-20th centuries). Improving identification of climatic patterns and human factors of flood events from primary documentary sources

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A. Introduction

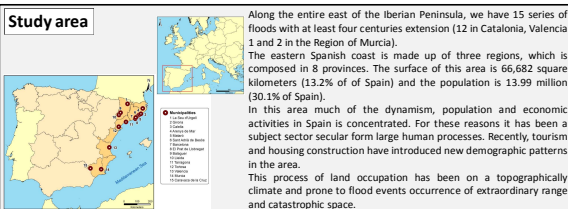
Historical flood events in eastern Spanish coast have been studied by different research groups and projects. Complexity of flood processes, involving atmospheric, surface and human factors, is not easily understandable when long time series are required.

Present analysis from PREDIFLOOD Project Consortium defines a new step of flood event databases: Improved access to primary (documentary) and secondary (bibliographical) sources, data collection for all possible locations where floods are detected, and improved system for Catalonia region (Girona, Barcelona, Tarragona, Lleida, Tortosa). In addition, to cover all sector of Spanish Mediterranean coast, we introduce Valencia city in Turia River basin. South Eastern sector is cover with Murcia and Caravaca cities, Segura River basin.

Extension of area under study required contributions of research teams experienced in work of documentary primary sources (Alberola, 2006; Gil-Guirado, 2013).

Flood frequency analysis for long scale periods show natural climatic oscillations into so-called Little Ice Age. There are general patterns, affecting most of basins, but also some local anomalies or singularities. To explain these differences and analogies it is not enough to use purely climatic factors. In this way, we analyze human factors that have been able to influence the variability of floods along last 6 centuries (demography, **hydraulic infrastructures, urban development**...).

This approach improves strongly understanding of mechanisms producing major flood events on Eastern coast of Iberian Peninsula, with identification and evaluation of natural and human factors involved on that.



B. Methodology

The collected floods require a minimal common characterization in order to be classified. Most of the flood records are still to be completed with more precise and reliable information search, but, for the moment, the most evident traits can be used. The more common elements to an event of any time are those referring to its basic hydrological behaviour and the impacts it caused. The combination of these two criteria has been used in this study to create the following classification system by assessment of impacts:

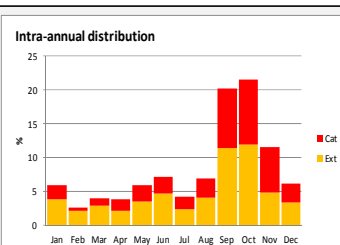
1. Non-overbank flood + disturbance + damage: **Extraordinary flood**
2. Overbank flood + disturbance: **Extraordinary flood**
3. Overbank flood + disturbance + damage: **Extraordinary/catastrophic flood**
4. Overbank flood + damage + destruction: **Catastrophic flood**

In general, the basic criteria are the occurrence of flood and whether it is an overbank flood or not. Then, there are two further levels: first, the capacity to damage nonpermanent elements (vehicles, cattle, stored goods) or light structures (cattwals or temporary wooden structures), and second, the capacity to destroy completely or partially permanent structural elements, either in an urban or in a rural environment: stone bridges, walls and other defensive elements, watermills, buildings, irrigation systems, or roads and railroads. Regarding agriculture, a flood is considered destructive if it has rooted out large fields, or if it has destroyed the harvest or the productive plants (grapevines, fruit trees), removing the productive soil and leaving large fluvial deposits of any kind – in summary, catastrophic situations that will need important economic resources and several years for a full recovery, or that mean the abandonment of the affected elements. The classification system does not take into account human fatalities due to the occurrence of this kind of impact being random in relation with the severity of the flood.

C. Historical flood series

OVERBANKS FROM THE DATABASE					
Location	Region	River	Period	Years	Flood cases
Aranyó/Alfà	Cataluña	Solònies	1800-2002	325	70
Sant Adrià	Cataluña	Besòs	1400-2002	566	13
Besòs	Cataluña	Segura/Ribadesa	1800-2002	332	21
Malgrat	Cataluña	Algars	1800-2002	620	303
Navarrore	Cataluña	Capsgròs	1700-2002	257	37
Calafra	Cataluña	Ter	1800-2002	435	28
Llavors	Cataluña	Llobregat	1500-2002	495	94
Llavors	Cataluña	Ter	1800-2002	680	158
Llavors	Cataluña	Segura	1400-2002	539	26
Llavors	Cataluña	Segura	1200-2002	856	48
Alfà	Cataluña	Algars	1800-2002	222	96
Tortosa	Cataluña	Ebro	1500-2002	692	46
Murcia	Murcia	Segura	1200-2002	727	178
Caravaca	Murcia	Segura	1500-2002	622	76
Valencia	Valencia	Turia	1500-2002	688	302

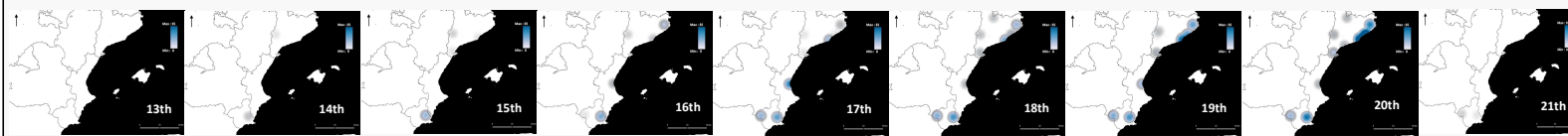
D. Intra-annual distribution



The intra-annual distribution of flood episodes for the entire period considered has a typical Mediterranean climate concentration in late summer months. Extraordinary and catastrophic events are mainly concentrated in that period, when heavy rain episodes are more frequently recorded. Secondly, there is a minimum during May to August associated with those heavy rains episodes those caused by rivers with pluvio-nival hydrological regimes.

E. Mapping

E.1 Extraordinary floods



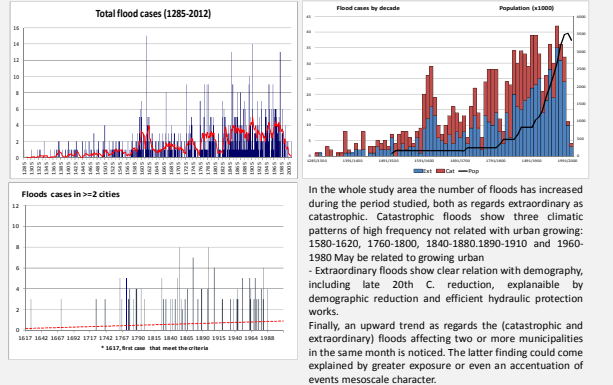
E.2 Catastrophic floods



F. Global results

The results of this study enhanced the findings of the study Barriandos et al. (2014) conducted locally in the region of Maestría by analyzing PREDIFLOOD database. In that study, differences between variability in catastrophic events and the extraordinary are noted. The series of catastrophic events show a natural variability of flood events associated with atmospheric dynamics. On the other hand, the extraordinary variability seems more linked to human processes related to occupation of flood-prone areas. In the study area this occupation has followed an anarchic and chaotic urban planning driven by a growth that accelerated since the mid-20th century due to the massive influx of immigrants and residential speculative processes.

Amplification of PREDIFLOOD with long series of other cities in the Spanish Mediterranean coast (Valencia, Murcia and Caravaca) show that patterns in flood regimes detected in the Maestría are extensible to the rest of the Mediterranean coast because it is noted a similar variability in both, extraordinary and catastrophic events. This validates the method used and makes it extensible to other Mediterranean areas with similar features.

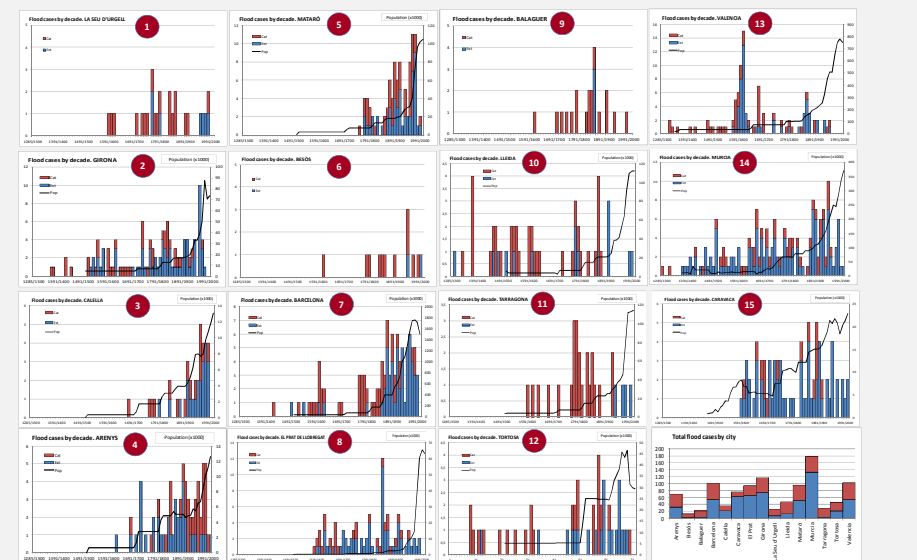


In the whole study area the number of floods has increased during the period studied, both as regards extraordinary as catastrophic. Catastrophic floods show three climatic patterns of high frequency not related with urban growth: 1580-1620, 1760-1800, 1840-1880.1890-1910 and 1960-1980 May be related to growing urban.

Extraordinary floods show clear relation with demography, including late 20th C. reduction, explainable by demographic reduction and efficient hydraulic protection works.

Finally, an upward trend as regards the (catastrophic and extraordinary) floods affecting two or more municipalities in the same month is noticed. The latter finding could come explained by greater exposure or even an accentuation of events mesoscale character.

G. Local results



References:

Alberola, A.: 2006, "Entre la sequia y la inundación. Una aproximación a las avenidas históricas de los ríos valencianos durante el siglo XVIII", in Gérard Chastagnaret and Antonio Gil Olcina (eds.), Riesgo de inundaciones en el Mediterráneo occidental, Casa de Velázquez-Universidad de Alicante, p. 1-30. ISBN 84-95555-89-1.

Barriandos, M., Ruiz-Bellet, J.L., Tuset, J., Mazón, J., Balasch, C., Pino, D., Ayala, J.L.: 2014, "The 'Prediflood' database of historical floods in Catalonia (NE Iberian Peninsula) AD 1035-2013, and its potential applications in flood analysis", Hydrology and Earth System Sciences, 18: 1-17. DOI: 10.5194/hess-18-1-2014.

Gil-Guirado, S.: 2013, Reconstrucción climática histórica y análisis evolutivo de la vulnerabilidad y adaptación a las sequías e inundaciones en la Cuenca del Segura (España) y en la Cuenca del Río Mendoza (Argentina). Doctoral dissertation. Universidad de Murcia, Murcia, España.

