ATMOSPHERIC CIRCULATION PATTERN SEQUENCES PRODUCING TORRENTIAL INTENSITIES IN THE CATALAN COASTAL AREA, SPAIN

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I. INTRODUCTION

Floods have a strong social impact in Catalonia (Fig. 1). According to the Spanish Ministry of the Environment, floods are the natural risk that caused most casualties (Amaro et al. 2010, Llasat-Botiga, et al. 2007).

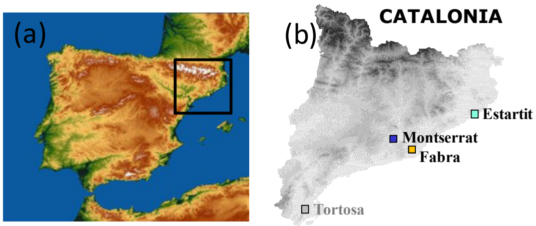

FIG. 1: (a) The Iberian Peninsula. (b) Coloured square rain gauges analysed in the Catalan coastal area.

On average, at least 1 flood per year is recorded in this region. In Barcelona there were 29 floods between 1901 and 2005 (Barrera et al., 2006).

The aim of this study is to obtain the synoptic patterns of the heavy rainfall events in the Catalan coastal area defined according to 1-minute intensity and 24-hour total rainfall. To achieve it we applied multivariate statistical techniques to sequence of 6 hourly synoptic reanalyses in the last 24 hours prior to the event.

II. DATABASES

In the internal project "Generació de les corbes IDF" carried out by the Meteorological Service of Catalonia, 1-minute rainfall intensity was obtained from raingauge registers of 4 weather stations. Although the recorders are scanned from the installation of the recording gauge, the period analysed was from 1989 since we used the ERA-Interim reanalysis (Dee et al. 2011). In this study three of these locations (see Fig. 1) were used to obtain the database of Heavy Rain (hereafter HR) event. The periods used for each station are shown in table 1:

Station	Period	# years
Estartit	1992-2006	15
Montserrat	1989-2003	15
Fabra	1989-1993&1996-2006	16

TABLE I: Period available for each database since 1989.

To establish a threshold to define HR events can be an arduous task because too many factors are involved. (Diakakis N., 2011). This author recommends the use of rainfall intensity to define it. As first approach, we defined a HR event when a 1 mm/1' is registered and the total accumulated rainfall is equal o more than 25 mm in 24 hours.

Table II shows the total number of HR events obtained for each weather station.

Station Name	1 mm/1'	25 mm/24h
Estartit	113	33
Montserrat	93	24
Fabra	50	20

TABLE II: Number of days that exceeded 1 mm/1' and 25 mm/24h.

Although the higher frequency of cyclones during the year is in January in Catalonia (Campins et al., 2007), the higher intensities in HR events are between June and October due to convective precipitation (see Figure 2).

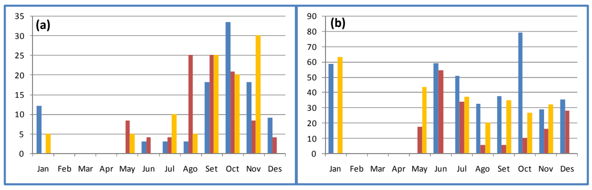

FIG. 2: (a) Monthly distribution of HR events (%). (b) Accumulated rainfall average of HR events (in mm) for Estartit (blue), Montserrat (red) and Fabra (orange).

III. METHODOLOGY

The methodology was structured in three stages (Fig. 2). The first two steps are aimed at obtaining a first classification. The principal component analysis is used to reduce the dimensionality of the data set and the cluster analysis (CA) to obtain the classification. The third step includes a discriminant analysis (DA) with the objective of validating the results obtained (Aran et al., 2010 and Peña et al. 2011).

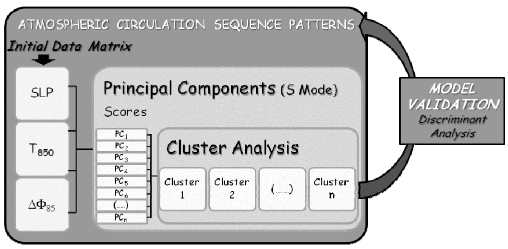

FIG. 3: Diagram of the methodology used

Table III shows the initial data matrix structure for hourly pattern sequence analysis where *x(i,j)* represents SLP, T850 and ΔΦ85 varying over *m* grid points. To work with S-Mode this matrix was transposed.

	First sequence			Last sequence
Last day of sequence (key day)	$x_{1,1+e}\cdots x_{m,1+e}$	$x_{1,2+e}\cdots x_{m,2+e}$	...	$x_{1,n}\cdots x_{m,n}$
	$x_{1,1+e-1}\cdots x_{m,1+e-1}$	$x_{1,2+e-1}\cdots x_{m,2+e-1}$	...	$X_{1,n-1}\cdots x_{m,n-1}$
	$x_{1,1+e-2}\cdots x_{m,1+e-2}$	$x_{1,2+e-2}\cdots x_{m,2+e-2}$	...	$x_{1,n-2}\cdots x_{m,n-2}$
	...	...	...	...
First day of sequence	$x_{1,1+e-e}\cdots x_{m,1+e-e}$	$x_{1,1+e-e}\cdots x_{m,1+e-e}$	...	$x_{1,n-e}\cdots x_{m,n-e}$

TABLE.III: Data matrix structure (Source: Philipp A., 2008).

IV. RESULTS

In this work the results obtained with the CA are shown since the DA didn't improve the initial classification obtained with the CA. The numbers of clusters obtained were 5 for Estartit, 3 for Montserrat and 4 for Fabra.

Figure 4 shows the main synoptic characteristics and the precipitation field of the synoptic patterns of Estartit HR events. The main pattern (C1 with 48% of the cases) of Estartit corresponds to the pass of a trough (NW-SE axe orientation) warm and wet air over the Catalan coast in October. The higher intensities are located over the pre-litoral range and in the coast. The frequencies of the other configurations are very similar (between 12 and 15 %). Cluster 2 (C2) could seem similar to C1 but thanks to the use of sequence it can be said that the main intensities are due to a retrograde trough from eastern regions. C3 corresponds to a deep and cool low over north of Catalonia. The southern and interior are not affected by this synoptic configuration at least in terms of rain intensities. C4 is an N-S oriented trough that affects only locally the coastal area. C5 is a W-E trough over the Pyrenees with a low in the Iberian Peninsula with an important supply of wet air due to eastern winds over the centre and north of the coast.

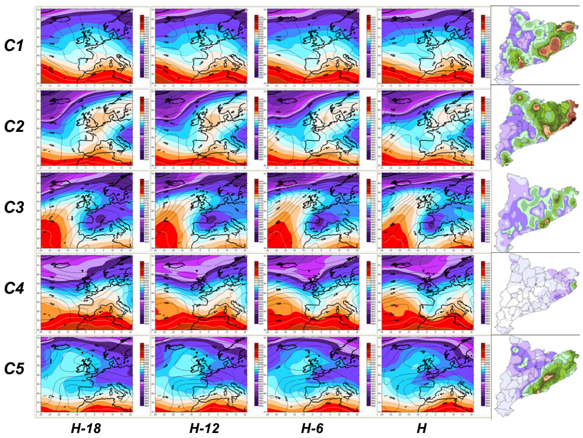

FIG. 4: For each centroid of the cluster (Ci) the first four columns are mean values of ERA-Interim reanalysis of thickness 850-500 hPa (shaded) and mslp in hPa (solid lines). Fifth column: total precipitation of the centroid of the cluster and for the day of the event.

All the three synoptic configurations of Montserrat (not shown) depict the pass of a through but with slight difference in its path and in the intensity of its ridge. C2 with a frequency of 58 % is similar to the main pattern of Estartit. In the same way, the main synoptic pattern of Fabra (55%) corresponds to the main pattern of Estartit. The precipitation pattern is also similar but not the amounts.

V. DISCUSSION

In this poster we have presented the results obtained with the CA as the DA didn't improve the initial classification obtained with the CA (see Methodology above) as Peña et al. (2010) found for strong wind classification. We think that the length of data series is too short to apply DA in other to improve the CA.

This work has been a preliminary analysis. In short the Fabra and Montserrat data series will be available from 1920 and 1936 respectively and with the use of Tortosa (see Figure b) raingauge records we will be able to discern better the main characteristics of the HR events in the Catalan coast.

In order to have larger databases we will work with 20th Century Reanalysis from NCAR. Despite of its coarse grid resolution it is likely that increasing the number of events the synoptic classification will improve.

VI. REFERENCES

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