

Torrential events on the Spanish Mediterranean coast (Valencian Region). Spatial precipitation patterns and their relation to synoptic circulation

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ABSTRACT

The Valencian Region is a typical mediterranean area characterized by mild and rainy winters and hot and dry summers. Spatial and temporal distribution of the rain is very irregular and the torrenciality is one of its main characteristics. Torrential events in the Valencian Region show different types of genesis and present specific patterns of spatial distribution. The aim of this paper is, on the one hand, to define the synoptic situations in which torrential precipitations take place in our region, in order to establish a genetic classification; on the other, to analyze the spatial distribution of these precipitations in relation to the genetic classification. The study of torrential rain events during the period 1971-95, allows us to recognize two types of synoptic situations in relation to its genesis: the Eastern advections and the summer convective storms. Each of these two genetic types has a characteristic spatial distribution pattern. One of the most interesting results is that in both genetic types the coastal area of the Gulf of Valencia-Cape of San Antonio is the most torrential in the whole region, and even in the Iberian Peninsula.

1. INTRODUCTION

The Valencian region is located on the East coast of the Iberian Peninsula and is characterised by a complex orography. The main features are its accidented interior zone, crossed by the Betico and Pre-Betico mountain systems in the south and the Iberian mountain system in the north (Fig. 1). The area near the coast is occupied by a series of coastal plains.

This is considered a region of well-marked climatic variations from the spatial point of view (Pérez Cueva, 1994; Martín Vide, 1994). Most of the region presents a semi-arid climate with annual precipitations of between 300 and 500 mm. The extreme south is arid with precipitations below 300 mm (Peñarrocha, 1994). On the other hand, and due to the orography, there are two areas with higher precipitation where annual precipitation is greater than 800 mm. (these are located at the south of the Valencian gulf at the extreme East of the Pre-Betico system, and in the inland northern part of the territory).

One of the most outstanding characteristics of the Valencia region's climate is the torrential nature of its precipitations. It is frequently affected by heavy rainfall episodes resulting in floods that cause material and, sometimes, human losses. The probable daily maxima for the 10-year return period exceed 100 mm throughout the practical totality of the region. This torrential characteristic is especially pronounced in the central coastal sector, where the daily 100 mm shows a return period of only two years and the absolute maxima registered exceed 800 mm in 24 hours (Fig. 2).

The objective of this work is, on the one hand, to define the synoptic situations in which torrential precipitations take place in our region, in order to establish a genetic classification; on the other, to analyze the spatial distribution of these precipitations in relation to the genetic classification. To accomplish this objective we have studied the torrential precipitations events occurred in the Valencian Region during the period 1971-95.

2. METHODOLOGY

Our point of reference in this study is the selection of the torrential precipitation events. We used the threshold of 125 mm. of precipitation in 24 hours. This analysis have been made by conventional informatic methods using the daily precipitation data from observatories of the basic meteorological network in the period 1971-95. A total of 910 records exceed the threshold, encompassed in 34 precipitation events. The data of these events have been revised and some unreliable records have been removed of the analyzed series.

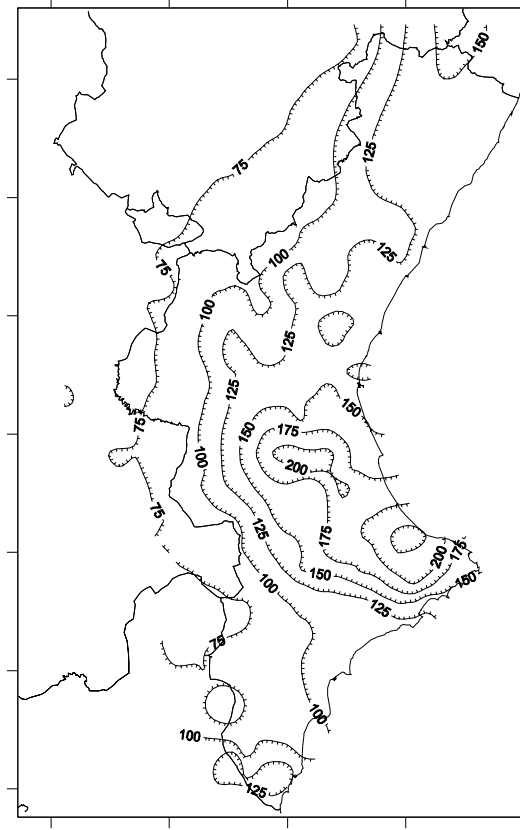


Figure 2: Probable daily maxima precipitation. Ten years return period

The spatial analysis was made through automatic mapping of all precipitation days during the events. The grid's values mapped were calculated with the inversely proportional to square distance interpolation method. This method allows us to suitably reproduce the high level of discretization and irregular spatial pattern distribution of daily precipitations. In the study area there is a dense observation network, except on the Northern zone; the results mapped could have been influenced by this “less dense” network in the North.

3. SPATIAL DISTRIBUTION PATTERNS

Three spatial-distribution patterns have been distinguished based on the localisation of the maximum daily precipitation focus of the selected events:

- 1) Precipitation maxima centred on the south of the Gulf of Valencia (fig. 3). Within this group there are two subtypes. The first shows a littoral arrangement of the maxima focuses, while in the second group the maxima focuses are centred in the interior of the area. 27 out of the total 34 heavy rainfall events have this distribution pattern. In fact, this is one of the most torrential areas in the Iberian Peninsula and in the Mediterranean as well. The orography of this area is extremely well-exposed to eastern humid fluxes due to confluence of mountain chains in littoral and pre-littoral zones (Pre-Betico mountains with WSW-ENE direction and the southeast extreme of Sistema Iberico with SSE-NNW direction). The shape of fluvial valleys reinforce the lift and humidity confluence associated to convection and precipitation.
- 2) Precipitation maxima centred in the northern half of the Valencia region (fig. 4). This is an area affected by torrential precipitation events, although they are less frequent and intense than on the South of the Gulf of Valencia. Only three events show this kind of pattern and the absolute maxima of the precipitation are less important than in the south of the Gulf of Valencia. This type of spatial distribution is related with orographic factors (Iberian chain with SSW-NNE direction) respect to the easterly fluxes, particularly in SE-ESE advections.
- 3) Precipitation maxima centred in the extreme south of the Valencia region (fig. 5). Only two events show this spatial distribution pattern. This is an area characterized by high arid conditions and scarce average annual precipitations (lower than 300 mm in the driest zones). However, this area is affected by important torrential rain events, although they are less frequent than in other mediterranean areas. Nevertheless the daily precipitation records can exceed the 200 mm. This pattern is related to local orographic conditions (east extreme of Sistema Betico mountains, with SSW-NNE orientation). However, the intense precipitation in this arid area could have a more important dependence from other factors (Millán *et al.* 1995) linked with the distribution of SST (sea surface temperature).

4. SYNOPTIC ANALYSIS

Atmospheric-circulation analysis of the precipitation events has allowed us to identify two types of synoptic situations of intense precipitation: 1) easterly advective flows (*llevant*), and 2) summer convective storms.

4.1. Eastern Advective Flows

This meteorological situation is the principal cause of torrential rains and produces the absolute precipitation maxima. Of the 910 registers exceeding the 125 mm. threshold during the 1971-1995 period, 885 correspond to Eastern advections. The maximum obtained in the analysed period in the coastal area of Valencia Gulf is around 817 mm., 213 mm. in the northern half of the Region and the 250 mm in the southern arid area.

Due to the large number of cases involved, we limited our analysis to the events in which 6 or more observatories exceeded the 125 mm. threshold (26 events). They follow the three distribution patterns cited.

Characteristics of the Eastern Advection:

- a) A high-pressure centre localised over the European continent drives the advection. Its track over the Mediterranean sea produces a rise in surface humidity along the advection. There is a clear relationship between long-range advections and extreme rainfalls.
- b) Advections from the East become unstable in the presence of cold air at high and medium levels associated with troughs or depressions near the Iberian Peninsula. The majority of the intense rainfall events analysed here are associated with isolated upper-level depressions at the south of the Valencian region.
- c) The atmospheric circulation presents a low zonal index, with varied circulation patterns:
 - Troughs related to omega-shaped waves in the upper-level atmospheric circulation. The circulation within the trough may evolve towards an isolated upper-level depression (i.e., a cold air pool aloft, or "*gota fría*"). Deepening of the waves gives rise to high-over-low circulations (Bluestein, 1993), with an anticyclonic cell to the north and an isolated upper-level depression to the south. Both types of circulation can be grouped in blocking situations. The Figure 3 (3/11/87) shows the distribution centred in the area south of the Gulf of Valencia, although with the maximum focus localised in the interior. In comparison to the former distribution pattern, this is less frequent, with 7 cases. Nevertheless, it is the spatial distribution associated with the most extensive torrential precipitation events and with the highest registered values, e.g., 817 mm in Oliva and 790 mm in La Pobla del Duc.
 - Troughs with North-South axis with a secondary depression moving South. This results in a rapid change in the westerly

circulation to one of surface-easterly and isolated depression aloft. The Figure 5 (21/02/85) shows that torrential rainfall events also occur in the southernmost part of the Valencian region, in spite of its arid nature. Only two events have their maximum focuses localised in this area, but they show high values (200 mm in *Laguna de Torrevieja*). The figure shows the formation of another focus similar to the type focalised over the southern littoral of the Gulf of Valencia, although in this case with lower local maximum values.

4.2. Convective Situations

In the Valencia region, convective situations are secondary in importance respect to Eastern advections. Only 25 recordings exceed the 125 mm. threshold for the 1971-1995 period, and these are encompassed in 8 heavy-rainfall events. Due to the reduced number of events, we have analysed all those in which the threshold was reached at an individual observatory. The spatial distribution of these events pertains both to type 1 (6 events), with the maxima focalised in the most littoral part of the Gulf of Valencia (maximum absolute of 220 mm.), and to type 2 (2 events), with the maxima centred in the northern half of the Valencia region (maximum absolute of 200 mm.). These situations give rise to more local precipitation focuses than do those corresponding to Eastern advections. With the used threshold, no events with maxima were registered in the south of the region nor in the interior from the Gulf of Valencia.

These situations reflect the formation of the thermal low in the interior of the Iberian Peninsula, which is typical of the summer months. Normal pattern in these situations is to form isolated storm nucleii in mountainous areas of the northern half of the peninsula. If aided by unstable upper-level conditions, these storm nucleii can become more powerful and affect the whole peninsula. The situations show the formation of the peninsular thermal low, although with pronounced features of transition towards Eastern advection situations. In spite of the fact that the Mediterranean advection is weaker, there is a clear feeding of humid air towards the coasts of the Valencia region. On the other hand, the upper-level circulation is very similar to that explained in the previous point, with important troughs and depressions. Figure 4 (8/08/83) shows that of the eight events of this type, only two show maxima centred in the northern half of the region. This episode shows local maxima of 160 mm. in Sagunto and 129 mm. in Benavites. The synoptic circulation shows features of transition towards Eastern advections, with humid eastern fluxes on surface and an important depression aloft.

5. CONCLUSIONS

In conclusion, our analysis of torrential precipitation events in the Valencia region during the 1971-95 period reveals that:

1. One of the most outstanding characteristics of the Valencia region's climate is the torrential nature of its precipitations. This torrential characteristic is especially pronounced in the central coastal sector, where the absolute maxima registered exceed 800 mm in 24 hours.
2. With the exception of one group, localization of the torrential rains shows a close relation to topographic factors.
3. Eastern advections are the principal cause of torrential rains and produces the absolute precipitation maxima.
4. In the Valencia Region, convective situations are secondary in importance respect to Eastern advections, and the events related with intense precipitation show marked features of transition towards Eastern advection situations.

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