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Regimes of intense precipitation in the Spanish Mediterranean area

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ABSTRACT

In the present study severe rainfall (≥100 mm in 24 h) in the southern Mediterranean area of the Iberian Peninsula (Spanish provinces of Malaga, Granada, and Almeria) is analyzed. The spatial pattern of heavy rainfall was characterized using cluster analysis with data pertaining to 5 years (2006–2010). The areas most affected by heavy rainfall were the western and coastal areas of the province of Malaga, the border area between the provinces of Malaga and Granada, and the eastern part of the province of Almeria (5 clusters). The average synoptic patterns associated with each cluster were also obtained. A low in the western or southwestern Iberian Peninsula and southerly/southwesterly moist flow at low levels were the most frequent patterns. Two episodes of heavy rainfall that occurred during the autumn of 2012 were also studied, revealing the importance of deep convection.

1. Introduction

The factors affecting the development of precipitation are complex (Rotach et al., 2009), and its forecasting is therefore difficult. This problem is exacerbated by the increase in spatial and temporal resolution (Llasat and Siccardi, 2010). Heavy rainfall is generally associated with a high moisture content, vertical movement, and static instability (Maddox, 1979; Doswell et al., 1996). There are indeed many studies addressing cases of heavy rainfall. Thus, for example, Schwartz et al. (1990) analyzed the evolution of the convective environment during episodes of heavy rainfall, and Winkler (1988) studied the synoptic patterns typically associated with very intense precipitation.

A number of studies have attempted to find the key factors for heavy rainfall. These include precipitable water (Hoxit et al., 1978), static instability (Funk, 1991), moisture at low levels (Winkler, 1988), short waves upstream from the area of heavy rainfall (Giordano and Fritsch, 1983), dynamically forced vertical movements associated with wind maxima high in the troposphere (Ma and Bosart, 1990), moisture flux convergence at low levels (Banacos and Schultz, 2005), and orographic lifting of conditionally unstable air masses (Lin et al., 2001). Research efforts have also focused on the study of episodes of heavy rainfall in different areas. Examples can be found in the work of Grumm et al. (2002) and Schumacher and Johnson (2006) for the USA, Nishiyama et al. (2007) for Japan, Teixeira and Prakki (2007) for Brazil, Chen et al (2007) for Taiwan, Federico et al. (2008) for Italy, and Sokol and Bliznak (2009) for the Czech Republic.

In the case of Spain, heavy rainfall is relatively frequent, especially on and around the Mediterranean coast and during autumn. Jansà et al. (2001) reported that approximately 90% of heavy rainfall falling on the Iberian Peninsula and its surroundings was associated with warm and moist flows at low levels, generated by extratropical cyclones. Ramis et al. (2009) studied heavy rainfall in the western Mediterranean and found that deep convection was the main cause. The impact of conditional instability and warm and moist flows in

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the initiation of severe thunderstorm in the Mediterranean was analyzed by Cohuet et al. (2001). This was also addressed by Martín et al. (2006), who studied one heavy rainfall event in the western Mediterranean Basin using a mesoscale model. Several studies have classified the meteorological patterns associated with heavy rainfall. Romero et al. (1999) analyzed the average geopotential fields at the 925 hPa and 500 hPa pressure levels associated with heavy rainfall, and Martín-Vide (2002) classified the days with precipitation higher than 200 mm in the Spanish Mediterranean coast. Riesco et al. (2013) reported that the severe rainfall episodes in the southern Iberian Peninsula may be classified in three types according to moisture flux at the 850 hPa pressure level and the lifted index (LI).

The use of information obtained from statistical or case studies of rainfall episodes obtained from post-event investigation is needed to improve the forecasting of precipitation and is the basis of effective operative warning for flooding due to extreme rainfall, such as that based on the European precipitation index (Alfieri and Thielen, 2012). The present contribution analyzes the spatial pattern of heavy precipitation in the

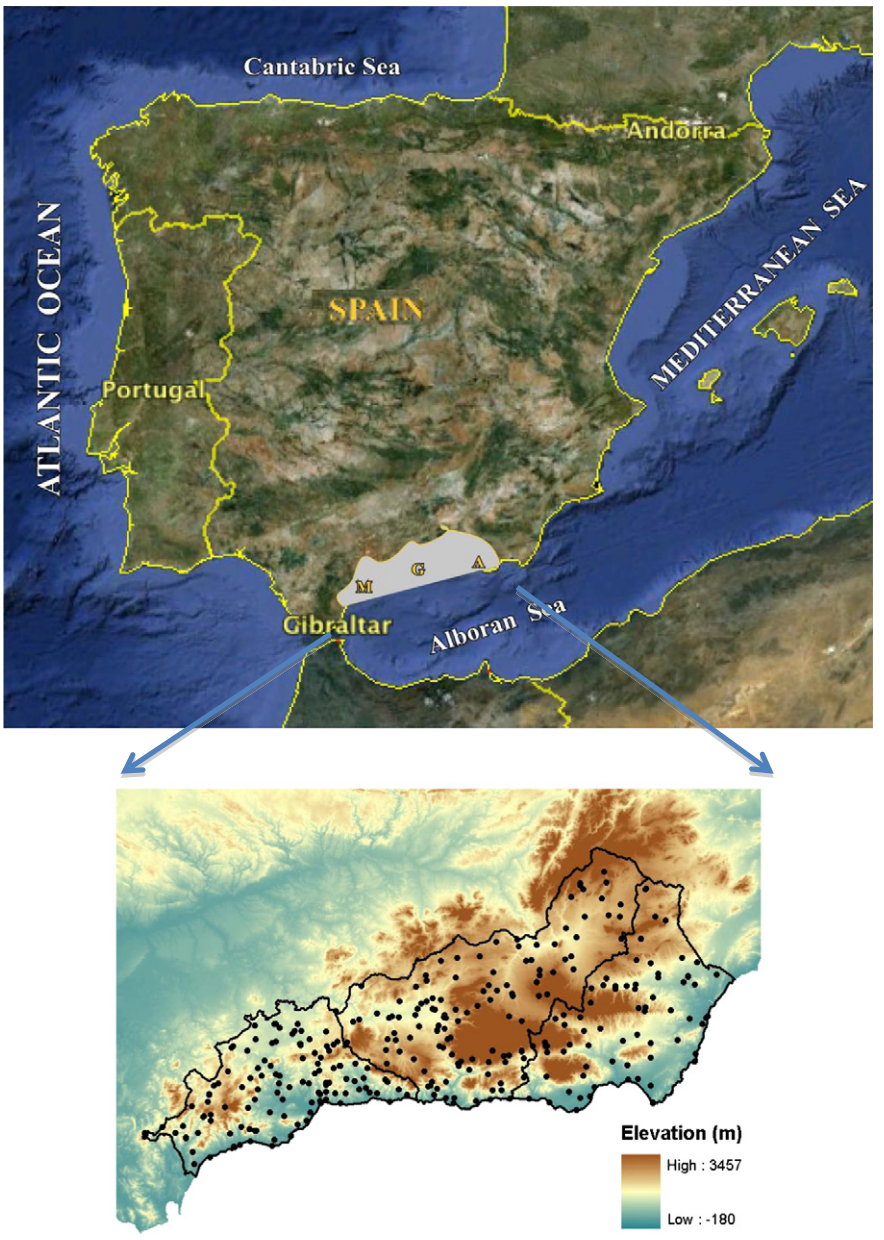

Fig. 1. (a) Location of study area in the Iberian Peninsula, indicating the provinces of Malaga (M), Granada (G), and Almeria (A). (b) Available AEMET rainfall stations, orography and limits of the provinces.