SYNOPTIC AND MESOSCALAR ENVIRONMENT ASSOCIATED WITH THE HEAVY LOCAL RAINS OF 16 AUGUST 2010 IN THE SOUTH OF THE IBERIAN PENINSULA

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I. INTRODUCTION

This is a meteorological analysis of the deadly flash flood that occurred in south of Spain, in Córdoba Province the night of 16-17 August 2010.

Three fatalities resulted, a man and woman dragged downstream near Aguilar de la Frontera. Another man was killed by a collapsed wall in his home at Bujalance. (FIG.1)

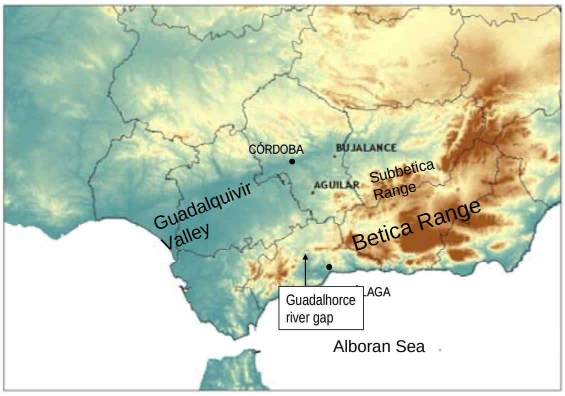

FIG. 1: Geographic situation of Aguilar de la Frontera and Bujalance.

The distribution of heavy precipitation was highly localized. Only in two of the weather stations in Aguilar the precipitation accumulated on day 16 rose above 200 mm, and only in the three stations of Aguilar and in that of Bujalance, it rose above 100 mm. This distribution is confirmed by the accumulation product of the Sevilla radar (FIG. 2)

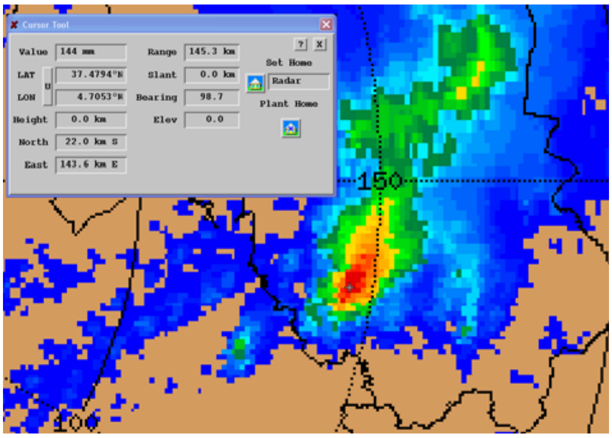

FIG. 2. Accumulated precipitation on day 16, as seen by Sevilla radar. The information in the inset is about the point of Aguilar.

The graphic of FIG.3 represents the precipitation in the automatic weather station of Laguna de Zoñar (Aguilar) in intervals of ten minutes. The maximum values of accumulated precipitation were

23 mm in 10 minutes,
41 mm in 20 minutes
60 mm in 30 minutes,
111.6 mm in one hour,
162.4 mm in two hours and
212.6 mm in less than twelve hours

As a reference the August monthly average total precipitation in the station Cordoba-Airport is only 3 mm.

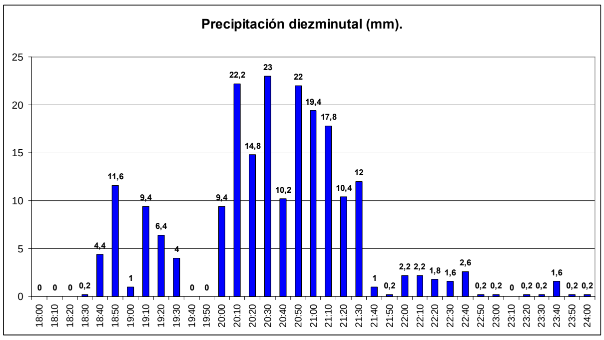

FIG. 3: Precipitation in the automatic weather station of Laguna de Zoñar (Aguilar) in intervals of ten minutes.

II. UPPER AND LOW LEVEL ENVIRONMENTS

The synoptic and mesoscale conditions in which heavy rain events occur in USA in warm season are well documented (e.g., Maddox et al. 1979; Doswell et al. 1996; Brooks y Stensrud 2000; Schumacher y Johnson 2005, 2006). Heavy rainfall events often occur beneath the equatorward jet-entrance region of an upper-level jet streak where broad QG forcing for ascent can provide a favorable environment for deep-layer moistening and destabilization (e.g., Uccellini and Johnson 1979; Bosart and Lackmann 1995). Within this favourable environment synoptic-scale environment, mesoscale features such as baroclinic zones (e.g., Maddox et al. 1979; Junker et al. 1999; Moore et al. 2003; Schumacher and Johnson 2005, 2006) and mountain barriers (e.g., Maddox et al. 1978; Caracena et al. 1979; Pontrelli et al. 1999) can act as focusing mechanisms for vigorous ascent.

All the fields used for the analysis of the environment come from operational ECMWF deterministic atmospheric model.

Upper and mid level maps of the day before, at 12 UTC, are showed in FIG.4. In FIG.4a, over a coloured WV Meteosat Image, the fields of wind and geopotencial height at 250 hPa show the next elements: poleward of the Canary Islands, and eastern of Azores, a trough positively tilted; at west of Azores a ridge; and over North Africa an anticyclone. In FIG.4b, over an IR10.8μ image, at mid-levels (500 hPa), the same elements and also a equatorial inverted trough can be observed. The northern stretching axis of the deformation area conformed by these troughs and highs (white bold lines in FIG 4b) exports both, deep moist tropical air, and dry air from the Atlantic toward the west coast of North Africa, as can be seen in the field of total column precipitable water in FIG.4b, forming a dry line at mid level.

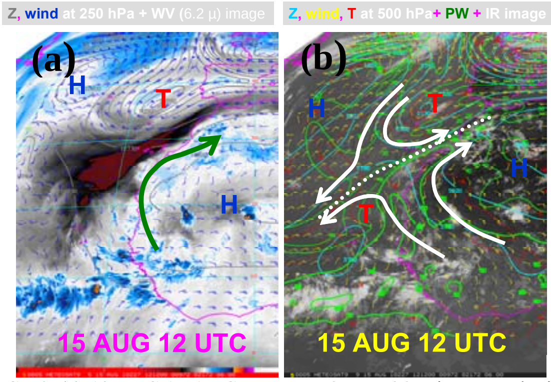

FIG. 4: (a) 12 UTC 15 AUG Meteosat-9 WV 6.2 µ image and wind and geopotencial height at 250 hPa; (b) 12 UTC 15 AUG Meteosat-9 IR10.8 µ image and total column precipitable water (green) and geopotencial height at 500 hPa (cyan).

Hours later, a mid level cyclogenesis took place over the coast after a frontgenesis process. It occurred when the baroclinic jet, associated to the forward side of the mid-latitude trough, moved over the dry line. The cyclogenesis caused a deep-layer moistening and a thermal destabilization in the south of the Iberian Peninsula, and also the building of an outflow upper level jet, that transformed the former jet streak in an anticyclonic jet streak, as can be seen in FIG.5.

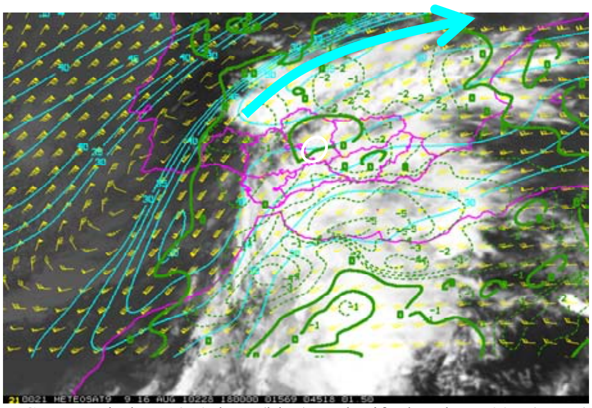

FIG. 5: Winds at 250 hPa (blue) and Lifted Index 700 (green) plotted over Meteosat IR 10.8µ image at 18 UTC on day 16.

FIG.6 shows that at 18 UTC the area southward of the maximum wind and eastward of the upper level positive anomalies of potential vorticity, PV, associated to these mid-latitude trough, was very cloudy, with high humidity and low PV in the 250-300 hPa layer (mostly from 0.0 to 0.2 UVP), and that the model identified areas of colder cloud tops of IR Meteosat image and areas with PV very close to zero, resulting from convection, which are highlighted in pink in FIG.6. It should be noted that convection line LL', refected in both, the field of PV and the satellite image, was apparently a major ingredient of the event and appears promoted by direct vertical circulation associated with the entrance zone of maximum jet stream aloft. The incidence of convection line LL' in the event is quite evident when one observes the sequence of IR images.

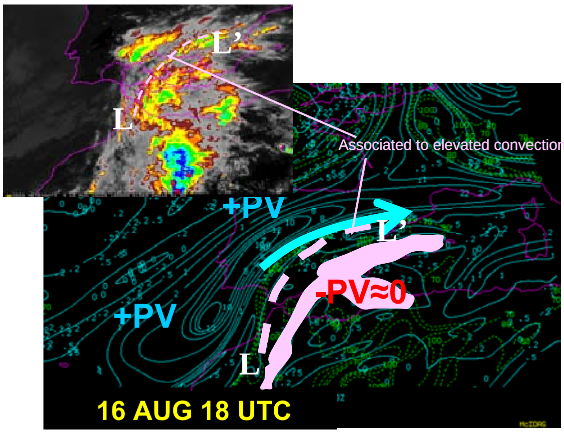

FIG. 6: IR meteosat image and contours of: relative humidity at 250 hPa (only values > 75% with dashed green lines) and PV at 250-300 hPa (solid blue lines); jet streak is plotted as a cyan arrow and regions with PV≈0 are pink shaded,

FIG.7 shows the maximum wind gusts at surface in the ten minutes prior to 20:00 UTC measured in the AEMET automatic weather station network. The wind convergence on the area Aguilar (red arrows) between the westerly flow along the Guadalquivir Valley, reflecting a wind relative maximum in low levels, and southerly flow through the Guadalhorce gap, was maintained throughout the episode. The inset of the FIG.7 shows the relatively low temperature of the thunderstorm cold pool in Aguilar de la Frontera.

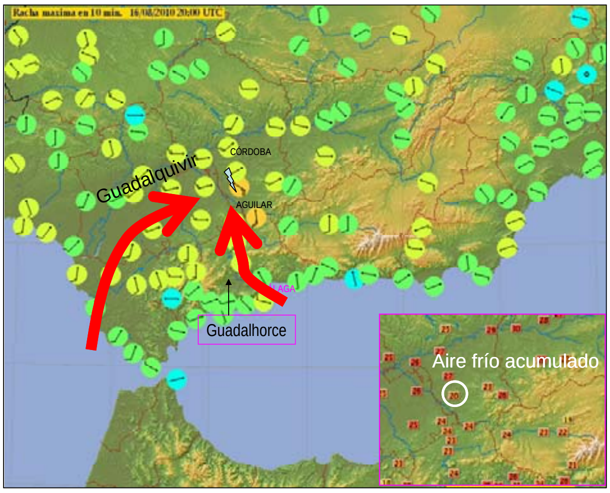

FIG. 7: Maximum wind gusts at surface in the ten minutes prior to 20:00 UTC as measured in the AEMET AWS network. In the inset on the bottom right corner, 2m-temperatures at 20:00 UTC are plotted. The temperature of Aguilar is rounded by a white circle.

III. INTERPRETATION

An interpretation that emerges from the analysis of the fields in high and low levels of the troposphere is shown in FIG. 8.:

• A first thunderstorm in the area of convergence wind in the area of Aguilar created a cold air pool.

• The horizontal vorticity associated to the cold pool and the horizontal vorticity over the relative maximum westerly wind in low levels along the Guadalquivir interacted to create upward movements that probably did not exceed the lifting condensation level (FIG. 8a).

• The arrival of high level convection organized in the line LL' associated to the ascents in the thermally direct vertical circulation in the entrance region of the jet streak

(FIG 6) over the convergence area triggering the deep convection from lower levels (FIG. 8b).

• This process was repeated while the line LL' was sliding over the area

• The wind speeds and mid-level wind shear was weak, causing the storms were of slow-moving and high precipitation efficiency.

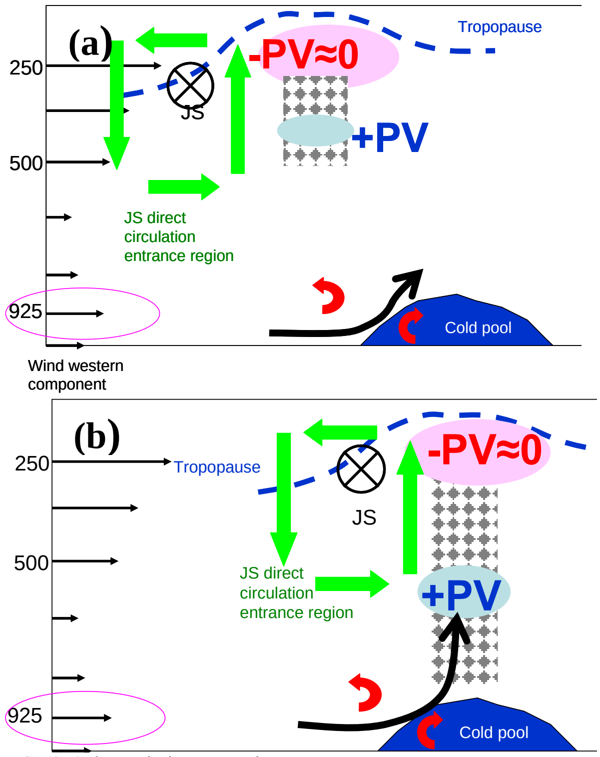

FIG. 8: Schematic interpretation

IV. RESUME

An extraordinary heavy precipitation event occurred in Aguilar

A tropical trough; a mid latitude positively tilted upper-trough, and the mid level African anticyclone interacted for transporting tropical moisture towards subtropical West Africa.

A mid level cyclogenesis took place in the western African coast that generated a deep-layer moistening and destabilization in the south of the Iberian Peninsula, and strengthened an upper level jet streak.

The thermally direct vertical circulation in the entrance region of the jet streak and a relative max of winds in low level look have been determinant in regenerating once and again the convection over a surface cold pool produced for the previous thunderstorm on Aguilar, and

Wind speeds through mid levels and vertical wind shears were weak, promoting slow-moving storms and increased precipitation efficiency.

V. REFERENCES

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