Mediterranean Storms
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THE 31 MARCH 2002 STA. CRUZ DE TENERIFE FLASH FLOOD: CHARACTERISTICS AND DIFFERENCES WITH SIMILAR EPISODES

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ABSTRACT

On the afternoon of 31 March 2002, the city of Sta. Cruz de Tenerife experienced a devastating flash flood that caused eight fatalities and 20 million euros in damage. Maximum accumulations of rainfall in the Northeastern part of the city exceeded 200 mm in a 3-h period. Many of the meteorological features associated with the Sta. Cruz de Tenerife flash flood typify those of similar events in the Canary Archipelago. Prominent features in the Sta. Cruz case include the presence of a 500-hPa trough; weak to moderate southwesterly flow below and a deep moist warm layer in the sounding. Usually, the Polar Jet stream influences most of the heavy rain episodes in the Canary Islands. However, in contrast to other events as the Maspalomas flood (November 2001), the subtropical jet stream determines the evolution of the Sta. Cruz storm. Another interesting feature of the storm was its quasi-stationary movement in a strong shear environment.

1 INTRODUCTION

Heavy rains along the south-western zone of the Canary Islands are common during a few days most of the years. Previous studies shown that the presence of baroclinic systems and their relationship with the Polar jet played a determinant role in the evolution of these episodes (Cana et al., 2001).

However, this event was related with the Subtropical jet. Another remarkable feature of this event was its quasi-stationary character, which located the storm over the Sta. Cruz de Tenerife city for more than four hours, causing a devastating flash flood at the northeastern side of the city.

In this paper, with the help of the ECMWF analysis charts, the Sta. Cruz de Tenerife sounding and the Gran Canaria radar images, the synoptic and thermodynamic characteristics will be analysed. Finally, a preliminary explanation for the quasi-stationary characteristic storm movement will be suggested.

2 SITUATION AND SOUNDING

On 31 March 2002, forecasters of Centro Meteorológico Zonal de Canarias Oriental (hereafter CMZCO) recognised the threat of storm development during the day, forecasting up to 90 mm in a 24-h period for Tenerife Island. A warm and moist maritime tropical airmass with surface temperatures over 18º C and dew point 14.5º C was forecast to move to the north. In fact, the 12:00 GMT sounding at Sta. Cruz de Tenerife indicated a layer of moist air 160 hPa in depth advecting towards Sta. Cruz de Tenerife and the Anaga mountain range. This layer was characterised by moisture values of approximately 10 gkg^{-1} of water vapour, an ample mixing ratio to fuel any storm.

Additionally, a low-pressure centre of 1010 hPa with a mid level trough was positioned to the south-west of the Canary Islands and moving to the north-east. A relevant characteristic of this case was the presence of the Subtropical Jet Stream over the Canary Archipelago, with up to 70 ms^{-1} at 232 hPa. Veering winds with height, i.e. winds becoming more westerly with increasing altitude, signalled surface warm advection towards the Anaga mountain range. With the approach of the 500-hPa trough from the southwest, mid levels of the atmosphere were forecast to cool increasing the potential for storm development. The sounding also indicates a strong speed shear caused by the Subtropical Jet stream. In such conditions, the storm motion should be to the ENE at approximately 8 ms^{-1}.

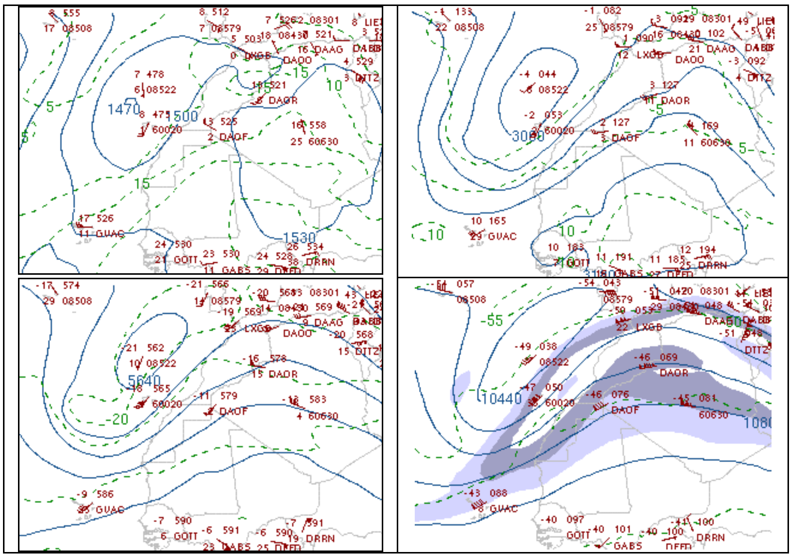

Figure 1. 31 March 2002 85, 70, 50 and 25 kPa ECMWF analysis charts.

The sounding shows two layers of strong capping, where T and Td depart form another in the mid levels of the troposphere (up to 6º C at 794 hPa, 9º C at 609 hPa). As mentioned previously, this two lid (specially the lower one) could postponed the convection to the first hours of the afternoon. Thus, the convective cells that break trough the cap had a greater potential of becoming severe due to stronger updraft and potentially explosive growth (Lannici and Warner, 1991).

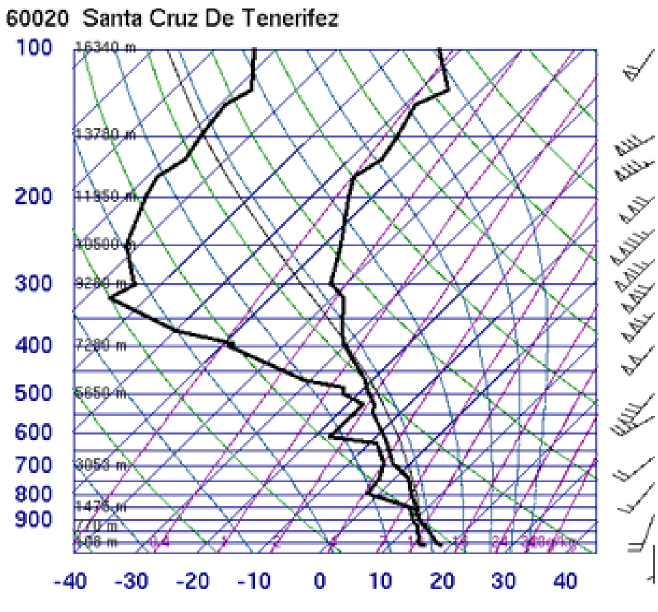

Figure 2. Sounding at Sta. Cruz de Tenerife at 1200 GMT on 31 March 2002, three hours before the starting of the heavy rains.

Attending to most common thermodynamic indexes, LI (-1.40º C) depicts a marginally unstable thermodynamic environment, which agrees with KI (31.5 º C), CAPE (318.8 J/kg) and CINH (-5.75 J/kg). Besides, both SWEAT (280.2) and SI (0º C) suggest that there is a moderate risk for severe thunderstorms. The Bulk Richardson number (10.64) depicts conditions of strong vertical wind shear and weak CAPE that, given sufficient forcing, supercell development could evolve. Therefore, the 1200 GMT sounding shows the adequate conditions of a severe storm development in the next hours.

3 RADAR IMAGES

The CMZCO has a meteorological radar (5620 MHz) placed at the top of Gran Canaria island (1780 m), which allows to observe the evolution of the event. The radar is about 80-100 km far from the Sta. Cruz de Tenerife storm, depicting the precipitation echoes between 2500 and 3500 m. Figure 3 shows the radar image at 15:15 GMT, the moment of the highest rain intensity (up to 56 dBZ at 15:30). This radar image reveals also the elongated shape of the storm cloud system, caused by the wind flow at the medium and high levels of the troposphere. Notice how other storm systems appear at the SW side of Gran Canaria, which moved fast to the NE, instead of remaining stationary over the islands.

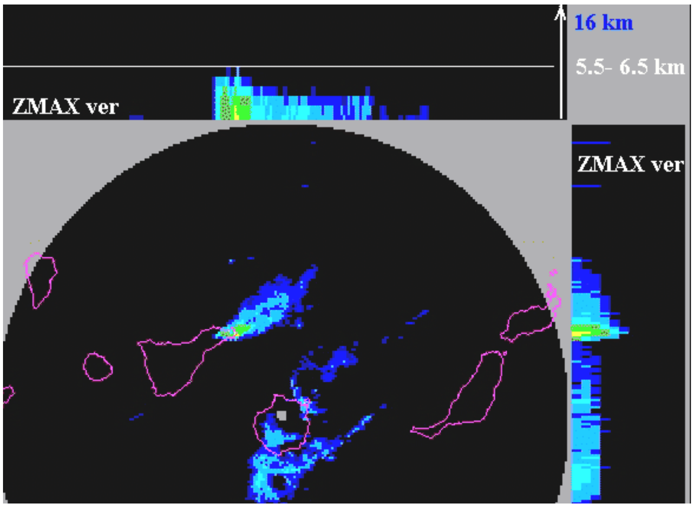

Figure 3. Radar image of the Sta Cruz storm. 15:15 GMT, 31 March 2002. The yelow area depicts the 56 dBZ area (INM courtesy).

4 A DYNAMICAL EXPLANATION FOR THE GENESIS OF THE EVENT

Using the Sta. Cruz de Tenerife 12:00 GMT sounding, the Froude number was calculated (F = 0.8). Following Lin and Wang (1996), when $0.60 \le F \le 0.90$, there exists both wave breaking aloft and upstream blocking. Once blocking occurs, the downstream propagating internal jump starts to retrogress, propagating upstream. This remarkable characteristic was reported by the CMZCO staff, which observed how the storm become quasi-stationary and started to move backwards, just as the numerical simulations of Ling and Wang predict. However, a complete numerical simulation of the event must be made to verify this hypothesis for the storm genesis.

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