OROGRAPHIC EFFECT ON HEAVY RAINFALL IN CHALKIDIKI PENINSULA (GREECE) INDUCED BY A MEDITERRANEAN COLD FRONT: A CASE STUDY ON 7 to 8 OF OCTOBER 2000

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Abstract. The exceptional heavy rainfall, in Chalkidiki peninsula-Greece, of 240 mm in a very short time period of 6 hours (380 mm in 24 hours) is analyzed. This area geographically located in the NW shores of the Aegean Sea, commonly has not the experience of frequent heavy rainfall events, and consequently the natural hydrographic network was not able to restrain this strong rainfall shock. Thus the result of the impact of this phenomenon was floods and damages in the properties of the residents with a very significant cost of hundredths thousands of Euros. This heavy rain phenomenon has been analyzed studying the role of the topography, the role of the nearby warm sea and the prevailing meteorological conditions resulting from the passage of the cold frond. This front was moving almost from south to north passing at first above the warm Aegean Sea surface, where it was supplied with huge amounts of water vapors, giving a total precipitable water value up to 32,0 mm. Then the very humid air forced uplifting, due to the intense relief of the mountainous peninsula, resulting to this torrential rainfall. All the relevant meteorological data and information about atmospheric instability, instability indexes and precipitable water available arising to from five upper air stations and the synoptic charts of surface, 850, 700, 500 and 300 hPa were analyzed in order to describe in details this heavy rain phenomenon.

Keywords- *Heavy precipitation, orographic effect, short time heavy rain, convective effect, Greece*

1. INTRODUCTION

Weather disturbances passing over Greek peninsula affected by its complex topography causing orographic precipitation in the windward side. Mediterranean depressions due to their specified trajectories interact with terrain produced orographically induced circulations.

As the majority of the Mediterranean depressions move from west to east, first, they meet the windward shores of the west Greece and due to the intense relief heavy precipitation phenomena are common. All this area is characterized by a very dense hydrographic network and this part of the country shows a good correspondance in these violent phenomena and floods are rare in this area. It is worth to point out that rainfall amounts over to 4000mm/year have been recorded in several mountainous stations and almost 95% of the hydroelectric plants are consenttrated in this area.

In contrary, in the east part of the mainland, where the annual rainfall amounts are limited ranging between 400 to 700 mm/year, the heavy prolonged rainfalls result in extensive flooding, producing severe damages in properties, roads, bridges and cultivation.

Many references in Greek literature concerning this phenomenon exist. Flokas A. and T. Karakostas (1983) analyze an intense rainfall phenomenon in central Greece, where a rainfall of 201.4 mm in 24 hours (43% of the the average annual rainfall was responsible for dramatic damages. Same destroying results with an amount of 165.0 mm/16 hours in Athens is analyzed by Flokas A. and Giles B. (1979) and another one in the city of Thessaloniki with a rainfall of 98.5 mm/24 hours (Balafoutis Ch., and Gkika S. 1993). In this paper an effort to analyze the intense rainfall, that had stroken the village of Megali Panagia (φ=40° 37’, λ=23° 40’, h=440.0 m) during the period of 7th to 8th of October 2000, is attempted.

There were two special characteristics of this episode, first the 24 hours rainfall totals alone (380.0 mm), and second, and most important the very strong intensity of this phenomenon in a shorter time period of six hours with a total amount of 240.0 mm.

2. THE RAINFALL CHARACTERISTICS

The heavy totals of the rain recorded on 7th to 8th of October 2000 "rainfall day" (the 24 hours from 05:30 UTC of 7th October to 05:30 UTC of 8th October 2000) appeared in a narrow belt running from South (Aegean Sea) to North, affecting the mountainous area of Chalkidiki peninsula (Fig. 1). The place, which suffered from the impacts of this heavy rainfall, was the area around the village Megali Panagia, located in the south slopes of the Holomon mt. An analysis of the tilting siphon autographic raingauge records for the station of M. Panagia made possible a study of the rainfall as a function of the time. Thus, in Figure 2, the graph of the rainfall versus the time is given. The graph shows the rainfall started around 07:30 LT (UTC+2h) on October 7th and intense falls continuing for long time until 07:30 LT on October 8th, with a total amount of 380 mm.

Figure 1. The area affected by the intense rainfall (in the square)

Torrential was the rainfall during a less than six hours period (from 21:50 to 02:40 LT) with recorded totals of 240 mm (Fig. 2). From the analysis of the records it is obvious that this rainfall was very remarkable and very rare over the east part of the country, not so much only for its total amounts recorded, as for extremely intensity for a limited six hours time period, resulting in dramatic damages in houses, fields, roads and cars costing more than 3 million €.

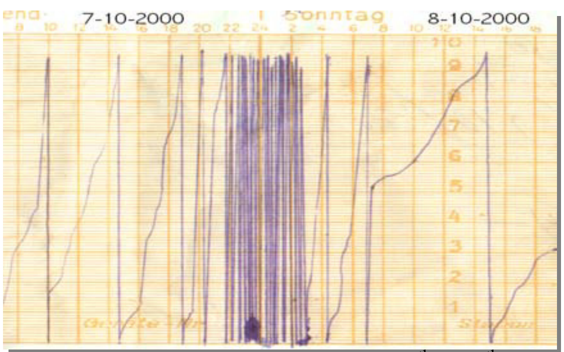


Figure 2. The raingouge record on 7th to 8th of October 2000 in M. Panagia

3. SYNOPTIC ANALYSIS

The development of this memorable rainfall episode over Chalkidiki Peninsula begun, as far as, the upper atmosphere synoptic circulation in the area of NW Europe began as an open wave. The 500-hPa analysis of 0000 UTC 7 October 2000 shows relatively large amplitude trough positioned over Italy and Ionian Sea (Fig 3). At the same time, the upper air charts in the other levels indicate the mature stage of the system, as the open wave trough slowed down and became a close-off circulation is extended almost vertical trough 300 hPa. Vertical systems trough 300 hPa have often been to be slow moving (Panofsky, 1956). This synoptic situation could be one of the ultimate causes of the heavy rainfall episode with an extensive flooding that struck Chalkidiki.

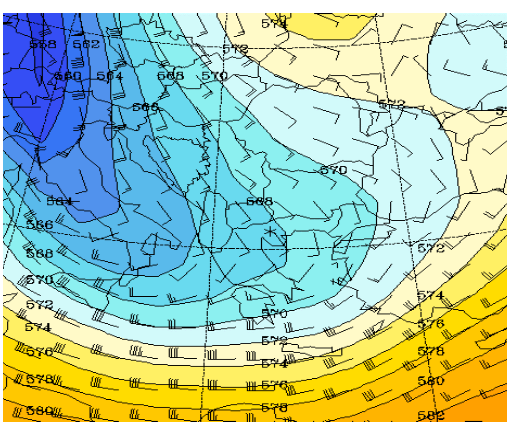
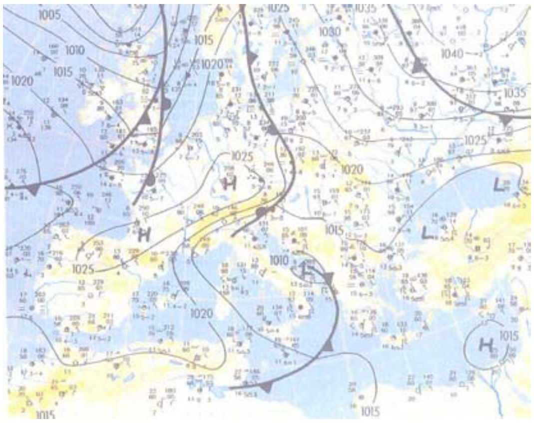


Figure 3. 500-hPa analyses at 0000 UTC on 7 October 2000



Another action reinforcing this episode believed to be the surface convergence over the Aegean Sea due to the topography, which was coupled with the abundant supply of the moist air from the warm Aegean Sea surface. Regarding the synoptic situation at the surface, a cold front coming from west, the well development low-pressure center over Aegean Sea and the high pressure system over NE Europe (Fig. 4), seem to dominate the atmospheric conditions over the studied area.

Figure 4. Surface chart analysis at 0000 UTC on 8 October 2000

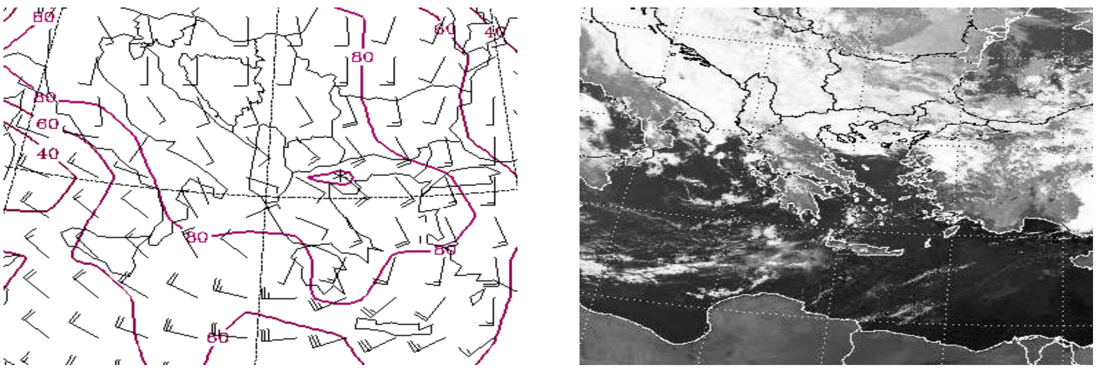


Figure 5. The winds and the rel. humidity at 700 hPa (left) and the cloud cover (right)

The surface systems, the upper level flow patterns and the local topography resulted in a massive convergence region in the Halkidiki peninsula. It is believed that, as the convergence existed with southeasterly winds (20 knots) in lower levels (Fig 5, left) and a moist air stream was continuously forced to rise over the mountainous barriers (h=1165 m), the relative humidity at the level of 700 hPa was increased up to 100% exactly over the studied area (Fig 5, left) and the system produced high rainfall intensities. These estimations confirmed first, studding the satellite pictures from that day where an intense cloud system covers all the area of interest (Fig5, right) and mainly trough the sounding analysis of the synoptic stations around Aegean Sea. Figure 6 shows the sounding analysis on 1200 UTC 7 October 2000, at Macedonia airport (φ=40° 31’, λ=22° 58’), located at the NW coast of the peninsula, just W-NW of Megali Panagia (~ 50 km apart). The lifting condensation level was as low as 373 m (970 hPa) at that time. This implies that a small amount of lifting would be sufficient to form clouds, and convective (potential) instability can be released due to strong orographic lifting.

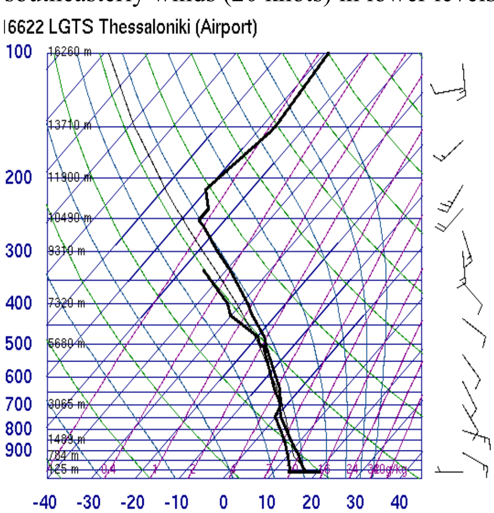


Figure 6. Soundings for 7 October 2000 (12 UTC) at Macedonia airport

Further, the sounding of Macedonia airport illustrates also the environment conditions over the area. The calculated modified CAPE (B^+) is 1738 J/kg and the Showalter Index was 2.8 denoting the probability of showers and thunderstorms. There the total precipitable water (Toduri and Ramis, 1997) amounted to the high value of 31.38 mm and the surface dew point measured on the order of 17.4 °C, and the air temperature at 20.4°C. These conditions indicate the potential for an outbreak of severe storm as the topography acts as a source of lifting and initiates the convection (Johns and Doswell, 1992). The combination of the synoptic conditions, the mesoscale circulation, the topography and the nearby warm Aegean Sea finally were responsible for this exaggerated and catastrophic rainfall.

4. CONCLUSION

The case study investigated an example of a local heavy rainfall on 7-8 October 2000 development on a limited part of the north Aegean Sea coast, when a slow-moving cold front approaches from the west with a southerly flow conditions. The orographic effects on the production of the localized heavy rainfall, of 240 mm/6 hours (380 in 24 hours), is pronounced due to the additional lifting of the moist air coming from the warm Aegean Sea. This orographic effect, the subsynoptic-scale convergence and the rising motion area in front of the “cold frond” moved toward the Chalkidiki peninsula, in relation with the existing high values of CAPE index and precipitable water, high amounts of humidity in the lower troposphere and high value of the surface dew point temperature were finally responsible for this very intense rain-shower.

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