Study of the synoptic environment of the specific weather incident on the 16th and the 17th July 2017

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Abstract The warm period has always been of special interest as far as the rainfall systems and their predictability are concerned. The weather incident, not seasonally common, that took place during July 16 and 17, 2017 was a particular synoptic system case not only due to its structure, spatial and temporal evolution, but also due to the intensity and severity of the phenomena. The purpose of this case study is to analyze the synoptic environment of the particular system using troposphere's upper and lower maps that are daily available in Hellenic National Meteorological Service's database by the European Centre for Medium-Range Weather Forecasts (ECMWF) and the real-time weather data, in conjunction with the corresponding images from the Eumetsat satellites.

1 Introduction

Summer weather in Greece is largely determined by two pressure systems. On one hand, the thermal low over Pakistan and northwestern India extends towards the Mediterranean with the development of a low pressure center over Cyprus and on the other hand, the Azores high expands over west and central Europe meeting the Balkan high pressure system. Such atmospheric circulation leads to atmospheric stability and results in clear skies and the form of persistent northerly winds blowing especially over the Aegean, well known as “Etesian winds”.

In summer, maritime tropical air masses reach Greece but, as they move along continental areas, they lose their moisture, taking on characteristics of their new environment and becoming drier. Thus, such air masses which retain their moisture, in combination with the land heating, can cause summer showers and thunderstorms in Greece. Well organized bad weather systems, rare but not unusual, affecting mostly central and north parts of Greece are associated with barometric low pressure over the Scandinavian Peninsula that may bring cold and wet air masses to our region.

The weather event, not seasonally common, that took place during July 16 and 17, 2017 was a specific synoptic system case not only due to its structure, spatial and temporal evolution but also due to the intensity and severity of the phenomena that took place; heavy rain, large hail, intense electrical activity and very strong winds resulted in the loss of a human life, in flash floods, in crops destruction and in damage to buildings and infrastructure.

Purpose of this case study is to analyse the synoptic environment of the particular system, as the pattern recognition skills in forecasting and being able to recall past heavy rainfall events along with their synoptic and mesoscale environments are of utmost significance (Funk, 1991).

2 Synoptic description of the pre-existing conditions from 13 up to 15 July 2017

Considering the 500hPa level analysis at 1200UTC on 13 July (Fig. 1a), a NW flow is visible over Western and Central Europe including the Greek region. This certain flow acquires cyclonic features in North and East Europe that are affected by consecutive disturbances (troughs). In the Scandinavian region, a closed cyclonic circulation, with recorded air mass temperature at -20ºC (or less) -significantly lower than the corresponding -5ºC of the Greek region- is clearly registered. High pressures in Spain - Atlantic Ocean - Northwest Africa regions are recorded.

The corresponding isobaric surface analysis reflects front passages routed by the atmosphere upper level disturbances marginally approaching the Greek region. The Azores - Atlantic Ocean ridge has clearly receded to Western Europe. A strong temperature gradient is been observed at 850hPa between the Greek (25ºC) and the corresponding Hungary-Slovakia region (6-8ºC). A warm intrusion is also characteristic at the Spanish region (in southern Spain, 30ºC to 32ºC is observed).

Of particular interest is the jet stream layout. At 1200UTC on 14 July (Fig. 1c) polar-front jet stream is located longwise UK-Northern France having north-west direction and 120kt-130kt wind intensity, and 24 hours later (at 1200UTC on 15 July) clearly acquires a northern component, prompting traffic to become strongly meridian. Moreover, high pressures established at the west of the jet stream allow colder air masses from Northern Europe to descend to the southern regions.

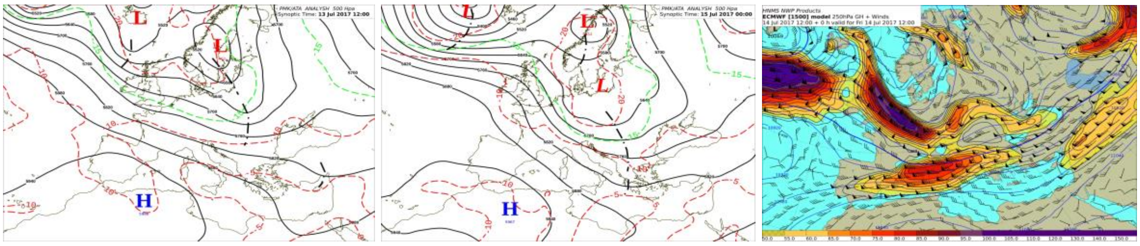


Fig. 1. *a)500hPaAnalysis13/12UTC b)500hPaAnalysis15/00UTC c)Jetstream 14/12UTC*

Considering the 500hPa at 0000UTC on 15 July (Fig. 1b) a drop of geodynamic heights was recorded with the 5760gpm level dropping from the region of Poland to the Greek north frontier region, simultaneously drifting cooler air masses. Considering the 850hPa the 16ºC isotherm is been observed dominating the Greek region, recording a drop of 8ºC in two days.

3 Description of the synoptic - meteorological conditions of 16 and 17 July 2017

Starting from the upper troposphere and the level of 500hPa (Fig. 2a), a meridian circulation in central Europe is observed with a ridge having now covered all of Western Europe. In Eastern Europe, a low-altitude center in the Russian region with cold air masses is observed. A trough is evident in central Europe accompanied by cold air masses with temperatures less than -20ºC.

The disturbance invades southerly transferring cold air masses to the Adriatic Sea and southern Italy. The tightening of the contours that followed is associated with the strong winds that are located to the west. It is well known that disturbances with a northwest type of flow tend to degrade by transferring colder air masses to lower latitudes and are associated with frontogenesis in the lower troposphere (Schultz and Sanders, 2002). The ridge and trough combination results in a southwest flow over Greece, while a drop of the geodynamic heights at 500hPa (Fig. 3a) is observed for 24 hours, followed by a 5-degree Celsius cold transfer. Thus, above the Greek area, a cut-off with a center enclosed by the 5700gpm and a temperature of 15ºC is observed.

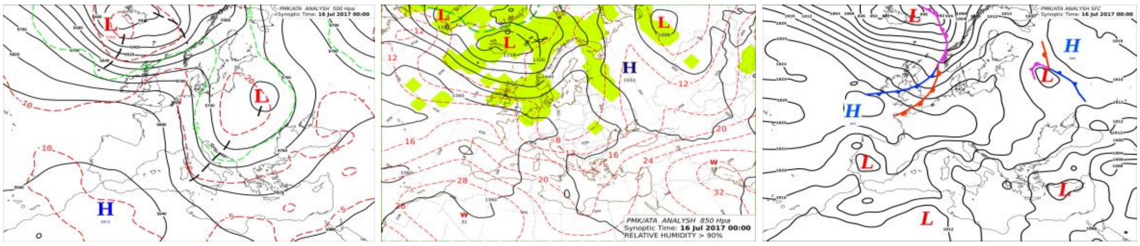


Fig. 2. *a)500hPaAnalysis16/00UTC b)850hPaAnalysis16/00UTC c) Surface Analysis16/00UTC*

At the 850 hPa level, it has been observed that the temperature in the middle Greece goes down from 16° C on 16072017/00 UTC (fig. 2b) to 12°C on 17072017/00 UTC (fig. 3b), but in SE Greece it is in between the 20° C.

At the MSL level (on 16072017/00 UTC - fig.2c) the Azores High has been developed over NW Europe. As we can see, low pressures prevail over the SE Mediterranean and a low with a central pressure of 1004 hPa is located over the territory of south Ionian Sea.

The Azores High (on 17072017/00 UTC - Fig. 3c) has been moved over E. Europe and N. Balkans. Due to these observations we arrive to the conclusion that a convergence zone has been created over the Eastern Mainland of Greece and the N. Aegean Sea. Due to the prevailing high pressures (1020 hPa) over N. Balkans and low pressures (1006 hPa) over Turkey, a strong NE air flow has been created at the area of the N. Aegean Sea.

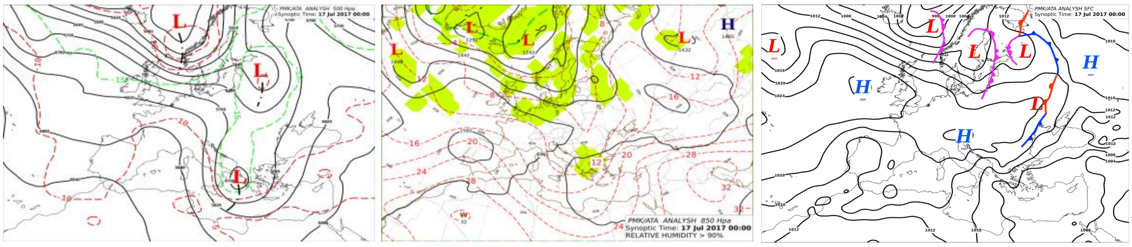


Fig. 3. *a)500hPaAnalysis17/00UTC b)850hPaAnalysis17/00UTC c) Surface Analysis 17/00UTC*

At the 700 hPa level (on 17072017/00 UTC - Fig. 4) we can see that high humidity air masses prevail in the mainland (relative humidity over 90 %). Humidity comes on from the circulation of the cold air masses over Adriatic Sea and Ionian Sea. Due to the temperature of the Ionian Sea surface is estimated at 25°C, the air masses become unstable.

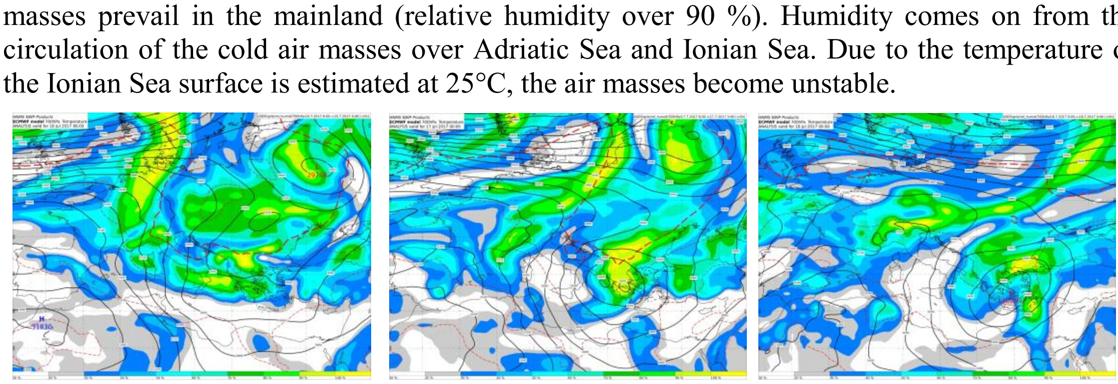
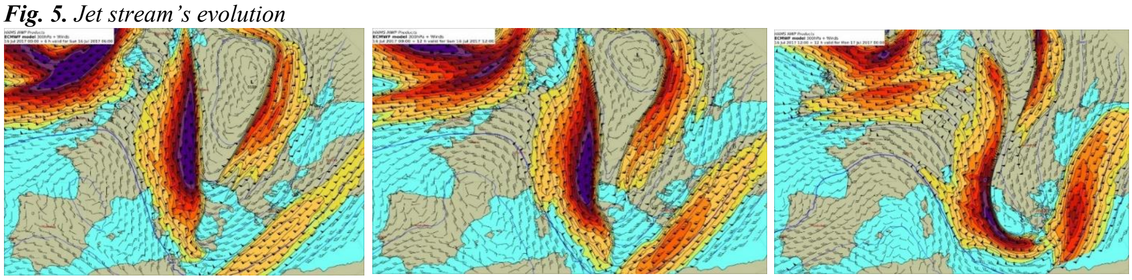


Fig. 4. *a)700hPaAnalysis16/00UTC b)700hPaAnalysis17/00UTC c)700hPaAnalysis18/00UTC*

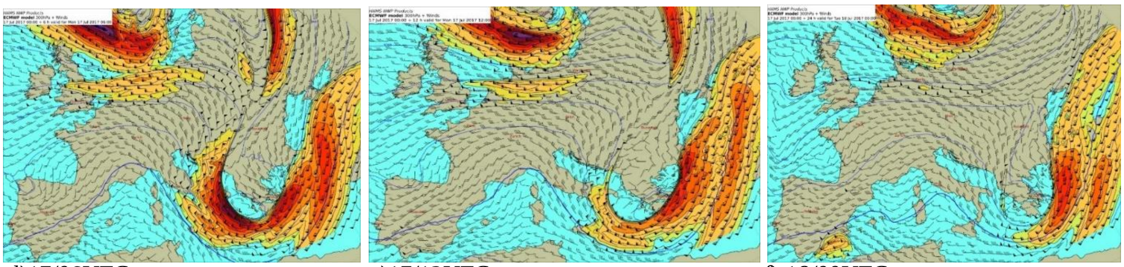
Also, we have to note that the location of the jet stream was the most important reason for the spatial and temporal evolution of the phenomena. As it is shown (Fig. 5) the jet stream is in coherence with the air flow pattern at the 500 hPa level, so, the updrafts are observed in the jet stream's left exit.

Thus, according to the above, we can assume that the intense phenomena are expected to occur mainly in West - Central Greece and South Ionian Sea. On 17072017/12-17072017/18 UTC the updrafts have been observed at the area of Aegean Sea.

Fig. 5. *Jet stream's evolution*



a)16/06UTC *b)16/12UTC* *c)17/00UTC*



d)17/06UTC *e)17/12UTC* *f) 18/00UTC*

The real weather situation for 16072017/06UTC included increased clouds with phenomena in the country's northern regions. In the rest of the country the weather was mostly clear, while in the Aegean Sea, the winds were blowing with northern-northeastern directions with their Intensity increased in certain locations.

Fig. 6. *Weather snapshot at 16/06UTC: (a) Metar-Lightning, (b) IR- MSG and (c) Radar rainfall intensity*

The expected, due to the season, thermal instability has been assisted by the atmospheric circulation in the upper atmosphere, and this is why those phenomena were located in the body of the mainland. In the late night, phenomena have been observed also in the southern mainland and the south Ionian Sea (Fig. 6 and 7) as a definite cyclonic circulation over a quite warm sea.

At 0900 UTC 17 July 2017 as the center of the low, at the 500hPa level, lay over south Ionian Sea strong northwesterly-westerly winds blow at high levels over western and southern parts of the low, depicting the location of the jet stream. At the same time the 850hPa circulation center was located further east over Peloponnese indicating the baroclinicity of the

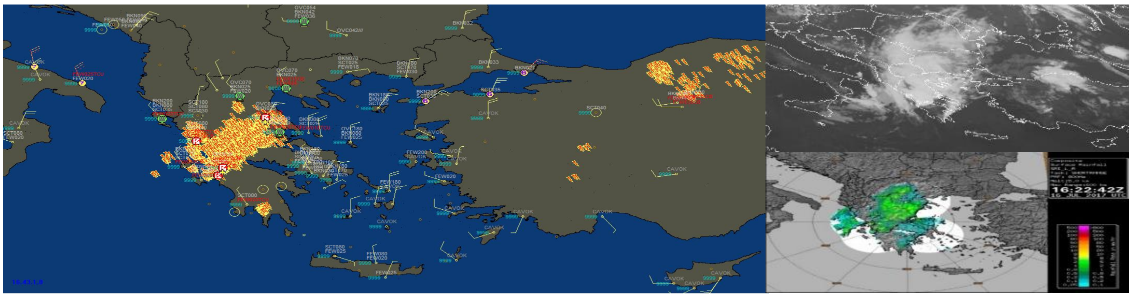


Fig. 7. *Weather snapshot at 16/18UTC: (a) Metar-Lightning, (b) IR- MSG and (c) Radar rainfall intensity*

system. According to Lupo et. al. (1992), this baroclinic structure in the lower layers favors the updrafts. Heavy thunderstorm phenomena occur over west-northwest Peloponnese as a result of the low pressure system while intense thunderstorm activity is observed along the convergence zone over northwestern Aegean Sea and heavy rainfall hit mostly the latter region (Fig. 8).

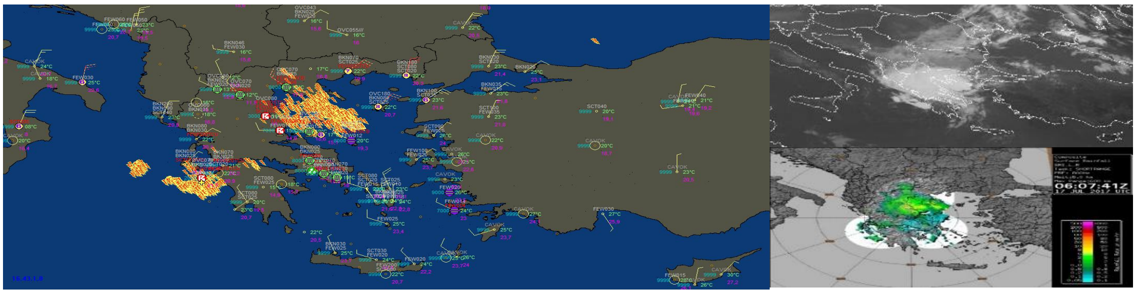


Fig. 8. *Weather snapshot at 17/06UTC: (a) Metar-Lightning, (b) IR- MSG and (c) Radar rainfall intensity*

The analyses at 500 and 850 hPa levels, late in the afternoon, show the low's movement to the east-northeast and the system by that time had become almost barotropic. The electrical activity also was moved to the northeast Aegean Sea while the intensity of the phenomena was gradually weakening Fig. 9).

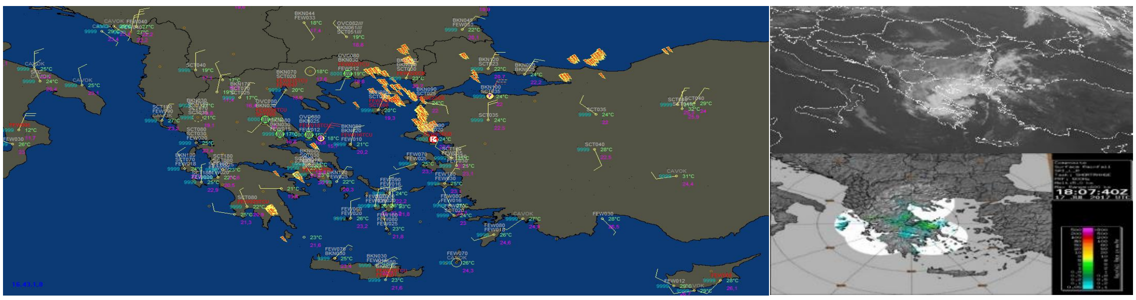


Fig. 9. *Weather snapshot at 17/18UTC: (a) Metar-Lightning, (b) IR- MSG and (c) Radar rainfall intensity*

The jet stream's location was a key factor in the spatial and the temporal evolution of the phenomena. As it is shown in Fig. 5 stormy weather can be depicted over central – south mainland over South Ionian Sea and over Aegean Sea, in the jet stream's left exit.

It is worth mentioning that this weather event was rare but not weird and must be attributed to the meridian flow that Scandinavian low pressure imposed. According to Maheras (1982) the frequency of "cold air pool" conditions during summer is 10% while the frequency of the occurrence of thunderstorms related to this type of weather rises to 50%. Thunderstorm activity in summer time mostly affects inland areas due to the fact that land's temperature is greater than that of the sea.

4 Conclusions

1. The present study analyses the synoptic conditions favored the occurrence and the conservation of this specific weather event on the 16th and the 17th July 2017.
2. The pre-existing circulation patterns played an important role in determining the conditions and moisture content in the area of interest while during the examined period there were many contributing factors.
3. The upper level trough and the cut off over the studied area the second day, the cold advection in the upper level, the frontogenesis and the convergence zone, the sunlight absorption by the land surface.
4. Above and beyond, the position of jet stream played fundamental role in precipitation and storm development of this weather event.

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