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Calculation of dynamic and thermodynamic parameters from spatial data of high spatial resolution of a weather event's specific case study event that occurred on the 16th and 17th of July 2017

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Calculation of dynamic and thermodynamic parameters from spatial data of high spatial resolution of a weather event's specific case study event that occurred on the 16th and 17th of July 2017.

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Abstract The intense weather conditions that occurred on July 16 and 17, 2017 were the reason for further analysis and study of this event. For the results to have a higher confidence level, ERA interim data on a normal 0.125 X 0.125 grid, which are available from the European Center Meteorological Weather Forecasting (ECMWF), available at the Hellenic National Meteorological Service (HNMS) were used. Thermodynamic parameters such as potential vorticity, potential temperature, sensible and latent heat fluxes and static stability were calculated. Finally, all of the above were compared with the more objective of the weather and Eumetsat's satellite imagery.

1 Introduction

First of all, it is considered necessary to have a look of the synoptic environment of this specific case study. In the upper troposphere and the level of 500hPa 1706UTC, we observe that the circulation in Europe is a meridian one and the anticyclone has almost covered West Europe. Also, colder air masses are in the eastern zone along with a runoff disturbance and a wind stress curl. The distribution of the wind level at 500hPa depicted the specific type of disturbance in a characteristic way, where the wind force values on its west side were above 50kt. It is well known that diffluent troughs on a NW flow have the tendency to deepen and relocate the colder air masses into lower geographical levels and relate to the frontogenesis in the upper atmosphere (Schultz and Sanders 2002).

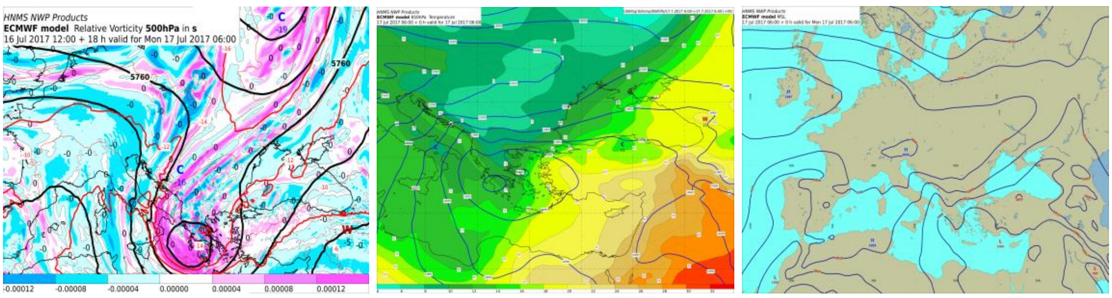

Fig. 1. *Geographical distribution at 170/6UTC (a) geodynamic heights, relative vorticity and temperatures at 500hPa (b) geodynamic heights and temperature at 850hPa (c) Mean sea level pressure*

Also, in the level of 850hPa, it is obvious that between the geodynamic heights and temperatures there is a phase difference of approximately 90°. The above indicates the existence of a well-structured baroclinic structure in the lower layers, where the cold convection is within and the thermal convection in front of the disturbance. According to Lupo et al. 1992, such a structure in the lower layers favors the updrafts. Meanwhile, the surface analysis has depicted the center of the low in Russia, while the anticyclone has been transferred to the western parts of East Europe compressing even more the isobars towards the Balkans and the front has acquired a S-SE direction

2 Data and Methodology

In this study, high spatial gridded data from ECMWF / ERA-INTERIM to a regular grid of 0.125 X 0.125 latitude-longitude was used and the maps were plotted using Metview, a meteorological workstation application designed to be a complete working environment for both the operational and research meteorologist. To make our study more objective, dynamic and thermodynamic parameters such as potential vorticity, potential temperature, relative humidity, sensible and latent heat fluxes and static stability were calculated and studied separately for the upper and lower layers of the atmosphere.

3 Results

3.1 Upper layers.

The dynamic temperature distribution in the 2PVU surface (Fig.1a), the corresponding potential vorticity in the isentropical surface 315K for the 17/06UTC (Fig.1b) and the relative humidity at 300hPa indicate the high values of cold air in the isentropic potential vorticity, which are higher than the 2PVU that lay above the areas of the phenomena. The above show that air from the stratosphere has come down to the upper troposphere (stratospheric intrusion) and has set a tropopause folding, according to the study of Hoskins et al. (1985). According to the study of Uccellini et al., 1986, the tropopause folding and the stratospheric intrusion of cold and dry air in the upper troposphere favor updrafts.

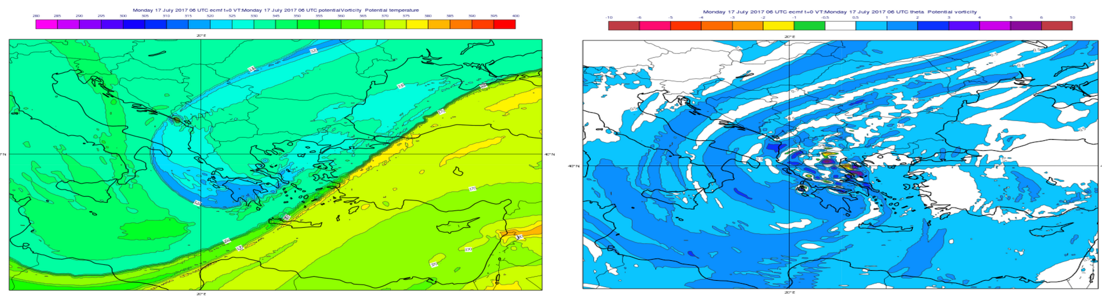

Fig. 1. *(a) Dynamic temperature geographic distribution in the iso-PV surface of 2PVU. The isopleths are per 5K for 1618UTC (b) Potential vorticity geographical distribution in the isentropic surface of 315K. The isopleths are per 1 PVU (for the 17/06UTC.*

When these characteristics are combined with the existence of a strong upper frontal surface of the surface low and partially with the polar jet stream, which relates to the upper disturbance, then the updrafts get even more intensified.

Due to the stratospheric intrusion into the upper troposphere, the impact that the downdrafts carry is depicted by the distribution of pressure onto the isentropic surface of 315K, for the

17/06UTC. Taking into consideration that this specific isentropic surface corresponds to 450hPa, we observe that pressures above the area of the most intense phenomena are almost at 300hPa. The corresponding isobaric surfaces have come down and are located at 450hPa, indicating a “vertical shrinking” of the upper troposphere, a fact that implies the layer lowering of the upper troposphere and, as a result, the creation of upper movements in the lower troposphere, according to the function of the geodynamic tension (Holton, 1992).

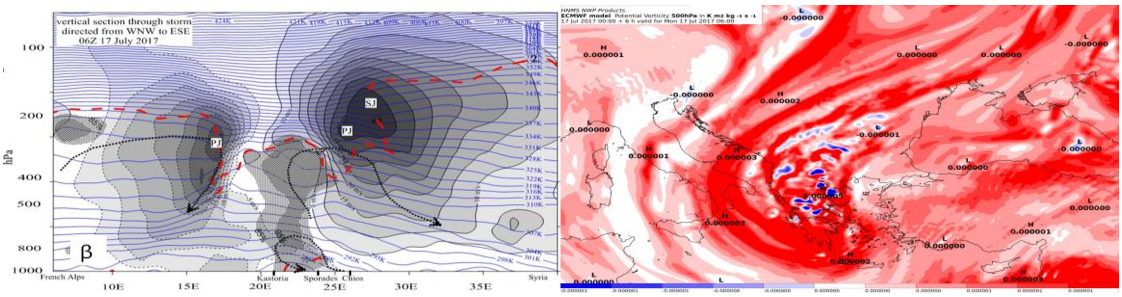

Fig. 2. *(a) Vertical section of the atmosphere alongside the dotted line for the period of July 17/06Z. (1) Blue lines: potential temperature (isentropics) per 3K. Red arrows: Circulation parallel to the section. (2) Red dotted line: dynamic tropopause (PV= 2 PVU). Areas where the vertical component of the wind upon the section surpasses the 5m/s are gradually colored in grey color. Dotted (continual) lines enclose areas with NNE (SSW) winds. The cores of the jet streams are written: polar jet (PJ), subtropical (SJ).). Finally, the areas where the relative humidity surpasses 85 and 95% are shadowed with lines (b) Distribution of the potential vorticity for the 17/06UTC. The isopleths are per 1 PVU.*

The tropopause folding, that takes place within the mechanism of stratospheric air transfer towards the median troposphere along the axis of the jet stream (Reed, 1955), is characterized by high values of the potential vorticity in the upper troposphere (Fig. 2b).

It is characteristic that, while on the west and east side of the area of intense rainfall there are strong jet streams, above the center of this area the wind speed is almost zero. Similarly, for the tropopause, the jet streams blow at 480 and 420 hPa, respectively, on the west and east side of the area with intense rainfall. The above fact does not favor the high cloud levels, since above the center of the area of intense rainfall jet streams extend up to 250 hPa.

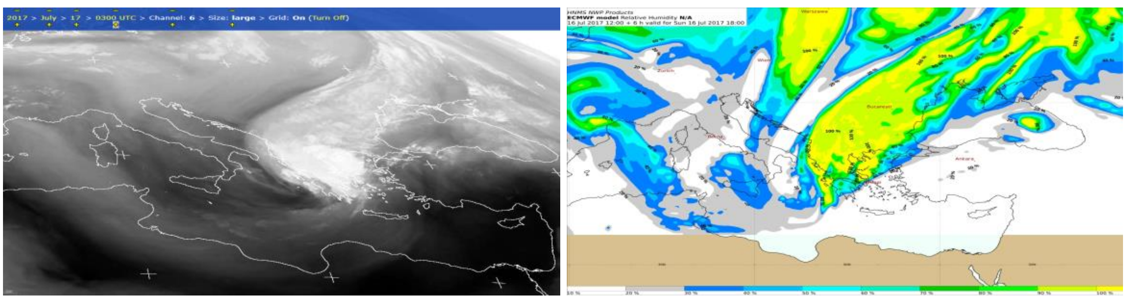

Fig. 3. *(a) WV satellite picture for 17/03 UTC* *(b) Relative humidity at 300hPa for 16/16UTC.*

The WV picture of the satellite depicts a snapshot of the gradient of humidity in Central – East Mediterranean (an important element of the upper layers dynamic), (Fig. 3a), which indicates the partial existence of the jet stream in the particular area (upper level jet streak). It is in accordance with the recorded intensified winds zone, as it results from the analysis of the geodynamic heights at 300hPa and 500hPa. In these cases, the dry zone is in the cold section of the jet axis (Bader et al. 1995) and is related to the existence of a disturbance in the upper troposphere. This disturbance indicates the existence of a positive transfer of vorticity and a cold transfer to the upper layers, respectively, to the cold section of the jet stream, above the area of the enhanced baroclinicity of the lower layers (Barry and Carleton 2001) and it favors the appearance of convection.

The distributions of the static stability at the level of 500hPa and 300hPa, had a more stable structure in comparison to the level of 700 hPa and 500hPa, where the unstable structure of the atmosphere is obvious. As a matter of fact, for the period of 17/15UTC until 17/18UTC the area of NW Aegean Sea did not present any important changes at the level of 700hPa, while, on the contrary, the thermodynamic structure of the atmosphere in NE Aegean Sea became more unstable.

3.2 Lower layers.

The structure and the layout of this specific system, where the warmer masses are in Turkey and East Aegean Sea and the colder masses above the country, were also depicted by the dynamic temperature at the lower layers. However, the distributions of the potential temperature at 925hPa did not present any specific fluctuation in comparison to the fluctuation of the equivalent potential temperature for the 17/12 UTC or at any point of its development in general. It should be noted that the diabatic processes are favored by the higher values of the equivalent potential temperature in comparison to those of the dynamic one.

However, if we study the structure of the lower layers through the scope of the alteration of the potential temperature in relation to height, we will notice that the layer 925/850hPa did not present any specific alteration as far as its static stability is concerned in North Aegean Sea. The area of Central Aegean Sea was the only one that appeared to have the most important alteration in this specific parameter, as well as the area at the eastern side of Sporades, which is related to the surface convergences.

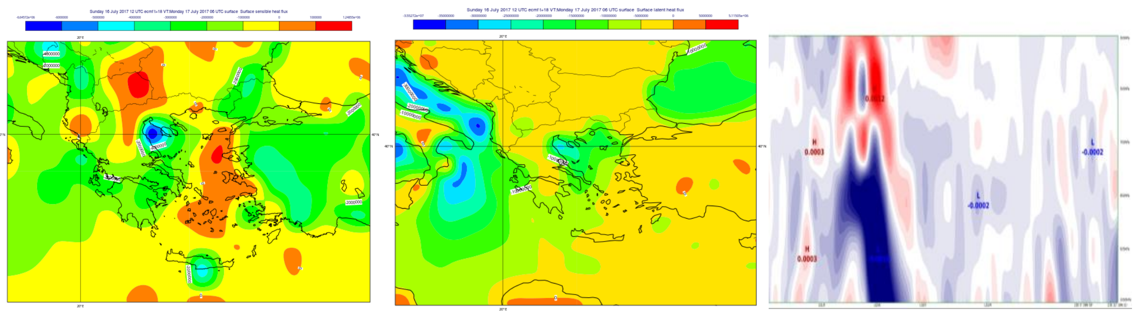

Fig. 4. *Geographical distribution (a) of sensible heat fluxes for the 17/06UTC in W/m^2 (b) latent heat fluxes for the 17/06UTC in W/m^2 (c) cross section of divergence for the 17/12UTC.*

Danard (1964) showed that the effect of latent heat is such that it can reinforce and broaden the upward motions in areas of high precipitation values and it can also contribute to the creation of weak downward vertical motions in the surrounding area, while, at the same time, it can reinforce the convergence in lower layers and deviate in the upper layers. The geographical distribution of the latent heat fluxes for the 17/06UTC (Fig 4a) depicts negative flows in North Aegean Sea, where the most intense phenomena were recorded. However, what is more characteristic is the deviance of the sensible heat fluxes (Fig 4b), where the negative values are recorded in Northwest Aegean Sea, while the positive values were recorded in East Aegean. This shows that the thermal mass from the area of Turkey was horizontally transferred in accordance with the wind direction at the lower layers and met the colder mass at the western areas. Even though the heat air in the lower layers did not favor the diabatic processes, the sea surface reinforced the air with water vapors favoring the emission of latent heat. Moreover, the depiction of the wind zone convergence at the lower layers for the 17/12UTC in Northwest Aegean Sea is very characteristic as well as its deviation towards the upper layers (Fig 4c), where the most intense upward motions were recorded, as it was mentioned in the previous paragraph.

What reassures the above-mentioned elements is the depiction of the heat difference between the sea level and the adjacent colder air. Even though we are in the middle of a warm period, both in the area Ionian Sea and North Aegean Sea, we observed negative differences during the outburst of the intense phenomena. Such values correspond to cold invasions at low layers, during the cold periods, along with the blow of mainland wind into the thermal sea of the Mediterranean.

Finally, according to the study of Fita et al. (2007), the appearance of increased values in the potential vorticity in the lower troposphere, which depict a localized maximum of it, are a strong proof of the existence of diabatic heating source. This specific characteristic, however, is not a sufficient condition on its own. In this specific case the depiction of the vertical distribution of potential vorticity in North Aegean Sea between Sporades – Lemnos for the 17/06UTC and 17/18UTC, depict the high values of potential vorticity (>1.5PVU) for the area of Northwest Aegean Sea both in low and upper layers. On the contrary, in Lemnos for the 17/18UTC the highest values of the potential vorticity were detected mainly in the upper layers, a fact that reinforces the influence of the diabatic processes in the areas of convergence.

4 Conclusions

1. Jetstream's position in the upper troposphere in response to the 500hPa level established a meridian circulation at eastern European traffic, favoring the fall of cold air masses in Southeastern Europe.
2. The enhanced temperature gradient in the lower layers combined with the corresponding arrangement of the winds was a particularly stimulating factor for upward motions in the region mainly of the north-western Aegean, since the hottest air from the Turkish region was swept into the colder air that was in the Central- Northern Greece.
3. 3. Potential vorticity's values > 2PVU combined with a tropopause folding and dry stratospheric intrusion, have been particularly effective in enhancing phenomena.
4. The upper layers showed a decrease in static stability as expected and appeared to have the most catalytic role in the development of the case under consideration.
5. The lower layers did not exhibit a corresponding change in their static stability except the north-western Aegean, where the other thermodynamic factors were like those of a winter system.

References

Bader MJ, Forbes GS, Grant JR, Liley RB, Waters AJ (1995) Images in weather forecasting. A practical guide for interpreting satellite and radar imagery Cambridge University Press

Barry RG, Carleton AM (2001) Synoptic and Dynamic Climatology. Routledge, 620pp

Danard M.B. and G.E. Ellenton, 1980: Physical influences on east coast cyclogenesis. Atm. Ocean., 18, 65-82

Fita, L., R. Romero, A. Luque, K. Emanuel, and C. Ramis (2007), Analysis of the environments of seven Mediterranean tropical-like storms using an axisymmetric, nonhydrostatic, cloudresolvingmodel, Nat.HazardsEarth Syst. Sci., 7,1

Hoskins BJ, McIntyre ME, Robertson AW (1985) On the use and significance of isentropic potential vorticity maps. Q J R Meteorol Soc 111: 877-946. doi: 10.1002/qj.49711147002.

Holton J.R., (1992) An Introduction to Dynamic Meteorology, Third Edition, Academic Press, San Diego.

Hoskins BJ, McIntyre ME, Robertson AW (1985) On the use and significance of isentropic potential vorticity maps. Q J R Meteorol Soc 111: 877-946. doi: 10.1002/qj.49711147002.

Reed R. J., 1955: A study of a characteristic type of upper level frontogenesis. *J. Meteor.,* 12, 226-237.

Uccellini L.W, D. Keyser, K.F. Brill and C.H. Wash, 1985: The Presidents Day Cyclone of 18-19 Feb. 1979: Influence of upstream trough amplification and associated tropopause folding in rapid cyclogenesis. *Mon. Wea. Rev.,* 113, 962-988.

Schultz DM, Sanders F (2002) Upper – Level Frontogenesis Associated with the Birth of Mobile Troughs in Northwesterly Flow . Mon Wea Rev 130: 2593-2610