STUDIA UBB GEOGRAPHIA, LVII, 2, 2012, pp. 71-80
(RECOMMENDED CITATION)

THE PRECIPITATION AND TEMPERATURE EVOLUTION, IN CLUJ COUNTY, IN JUNE 2010

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ABSTRACT. – The precipitation and temperature evolution in Cluj County, in June 2010. June, in the Cluj County area, has been a month of extremes, in both heat and precipitation. In this paper, the synoptic situation for June, over Europe and Romania, was analysed. The first part of June was characterized by the persistence of a hot North African ridge over the European territory. Thus, at the beginning of the month, daily maximum temperatures were close to the normal, then, gradually, the maximum temperatures increased from day to day, reaching very high values - up 34 °C by the middle of the month when the temperature-humidity index (ITU) reached and exceeded, in relatively large areas, the critical level of 80. In the second part of June, the target area was characterized by atmospheric instability. At the 500 hPa at isobaric level across the continent the presence of a trough that extends from the north-east- over the central European countries, to the south-west, between two high pressure zones- one located above the North Atlantic (Azores High) and another over the Russian Plain (Eastern European anticyclone), can be detected. The synoptic structure from the altitude characterizes a strong blockage that will favor the polar cold air penetration to the south part of the continent, and cut-off type structure positioned above the Italian Peninsula will quickly cross the Mediterranean basin to the Balkan Peninsula. The presence of the thermal blocking to the east and northeast sides of the Black Sea will cause the stationing and reactivation of the cut-off core by the end of June. Strong convective structures developed- which led to the recording of large amounts of water from showers and heavy rain, that were associated with floods and strong winds, which turned into storms with hail and lightning. For the second half of the month, a particular case dated 06/21/2010 was analyzed, the day which registered the most destructive effects of the floods. The outcome of the floods were, as reported by the Inspectorate for Emergency Situations Emergency (ISU) in Cluj County: the death of a person, the flooding of 250 homes and landslides.

Keywords: *ITU, thermal convection, precipitation, floods.*

1. INTRODUCTION

The maximum temperatures recorded at the weather stations in the county of Cluj in the first days of June were close to normal values; the maximum temperatures increased day by day, reaching values up to 34°C in the middle of the month, when the temperature-humidity index (ITU) reached and exceeded the critical threshold of 80.

Pronounced instability characterized both Romania and the Cluj County area in the second half of June, when the precipitation that fell over extended areas led to the recording of large amounts of rain water from showers and heavy rain that were associated with floods, and the intensification of the wind, which transformed into storms with hail and lightning.

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The morphology of Cluj County induces, during summer, dangerous weather phenomena. Ascending movement on wind exposed slopes, the convergence areas on the sheltered side of the mountain, the water sources and the heat sources on the sunny slopes have strong influences on the dynamics of convective activity, and have a significant role in determining the favorable areas for the initiation of the convection and the subsequent evolution of the convective cells (fig. 1).

Fig. 1. The weather and precipitation stations in the county of Cluj.

The severe phenomena recorded in the second half of June required radar monitoring and observational data provided by the Doppler radars in Bobohalma and Oradea, using OmniWeatherTrack applications and PUP and monitoring of the satellite images.

2. MATERIALS AND METHODS

Data from hourly, daily and monthly meteorological measurements obtained from meteorological and precipitation stations were used. Precipitation and temperature values recorded at all stations in the area were extracted. For the synoptic analysis, ground level and altitude maps of the standard isobaric surfaces of 500 and 850 hPa and reanalysis maps were used. Radar data have been analyzed: reflectivity, composite reflectivity, OHP's (1 hour precipitation) and THP's (3 hour precipitation).

3. EXCESSIVE HEAT IN THE FIRST HALF OF JUNE

In the beginning of June, the daily maximum temperatures recorded were lower by 2.5 - 6°C than the normal values (21-22°C) of the period. Afterwards, the temperatures increased day by day, reaching at the end of the first decade of June values of 29-31°C, temperatures that are higher than the average daily maximum of 23-24°C. Continuing this increasing trend, at the beginning of the second decade of the month, on the 13th of June 2010, the maxima reached the highest values of June (32-34°C). The value of 34°C was recorded in Cluj-Napoca and Dej, temperatures of 33°C were recorded in Turda and 32°C in Huedin. Then, a gradual decrease of the maximum temperatures occurred, but they were still higher than the normal values of the period (22-24°C). In the third decade of the month, on June 23rd, the beginning of a cooling period is observed, which lasted until 27th June. Beginning with 27th June, the maximum temperatures were getting close to the normal values for the period (24-25°C). The temperature - humidity index (ITU) has reached and exceeded the critical threshold of 80 in large areas, on the 11th, 12th and 13th of June. For the synoptic analysis, the NCEP-NCAR reanalysis maps were used, as well as maps of altitude of geopotential and temperature from 850 to 500 hPa and ground level maps. In the first three days of the month, at the 850 hPa level, the presence of a trough with a core of 136 gpdm in filling, having the 140 gpdm izopleth over Romania, and the 144 gpdm closed, with temperatures of 5-8°C, is highlighted. The western part of the continent is dominated by the presence of a ridge advancing to the north and center parts of the continent, gradually merging with the high pressure area in the east of the continent. From June 4th the geopotential and temperature are increasing, such that on June 6th 154 gpdm and 10°C were recorded, and then on June 7th the temperature rised up to 15°C. Warm advection was maintained for several days and increased on the 12th and 13th of June, when temperatures of 20°C were recorded. The warm ridge from the level of 850 hPa determined maximum ground temperatures between 30 and 35°C during several consecutive days. The NCEP/NCAR reanalysis maps (fig. 2) shows that in early June the mean temperature values were within the range of 17-19°C.

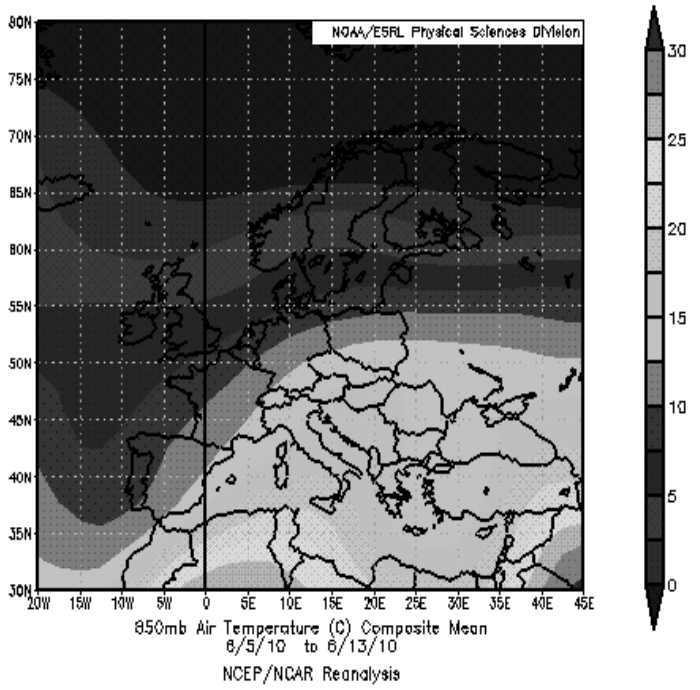

Fig. 2. Average distribution of isotherms at the 850 hPa level in the period 06/05/2010 - 06/13/2010.

At the 500 hPa isobaric level, above Europe, the presence of a trough linked to the Icelandic Cyclone (extended from northwest to southeast of the continent) is observed in the early days of June. In the south-west of our country, the presence of a low pressure center with a value of 547 gpdm is noticed; it is overlapped by a cold core of -20°C characteristic to the cut-off type. It has the isoplethes of 548, 552, 556 and 560 gpdm closed. In the following days, the core is gradually weakening; on June 3rd at 12 UTC the center value was of 559 gpdm and the izoplethes of 560, 564, 568 and 572 were closed. On June 4th the core of the low pressure area is centered on the south of Italy, only the 568 izopleth gpdm remains closed on our country, to be incorporated into the trough, and the temperatures, increasing, reach -10°C. The western part of the continent is dominated by the presence of a ridge with values of 584 gpdm (in Spain), and a warm air mass with high temperature values of up to -10°C, which will be expanded towards the northern and central parts of Europe, joining with the high pressure area in the eastern part of the continent. From June 5th to 13th the geopotential is growing (576 gpdm on June 5th, 584 gpdm on June 10th) and the temperature values are maintained at high values (-10°C). These values remain almost unchanged until the 13th of June. The mean values of the meteorological elements in the middle troposphere during this period can be observed on the NCEP /NCAR reanalysis maps (fig. 3). At ground level, in early June, frontal systems operating across Europe are noticed, one in the far eastern part of the continent and another one linked to the low pressure area of the Icelandic Cyclone, with values at the center of 990 hPa, which affect the western part of Great Britain, the western France, the southern Italy and whose movement towards the eastern parts of the continent will affect our country. In Western Europe, the Azores High ridge that was initially extended towards the northern part of Europe until it reached the British Isles, will include during the following days the central part of Europe, and, by uniting itself on the 5th of June with Scandinavian Anticyclone ridge will determine a field of high pressure over northern Europe. Over Romania, until June 4th, a low-pressure field with values of 1000-1005 hPa is present; after the 4th of June, the pressure is increasing. In the following days, the ground pressure remains weakly organized, with fluctuations around the value of 1015 hPa.

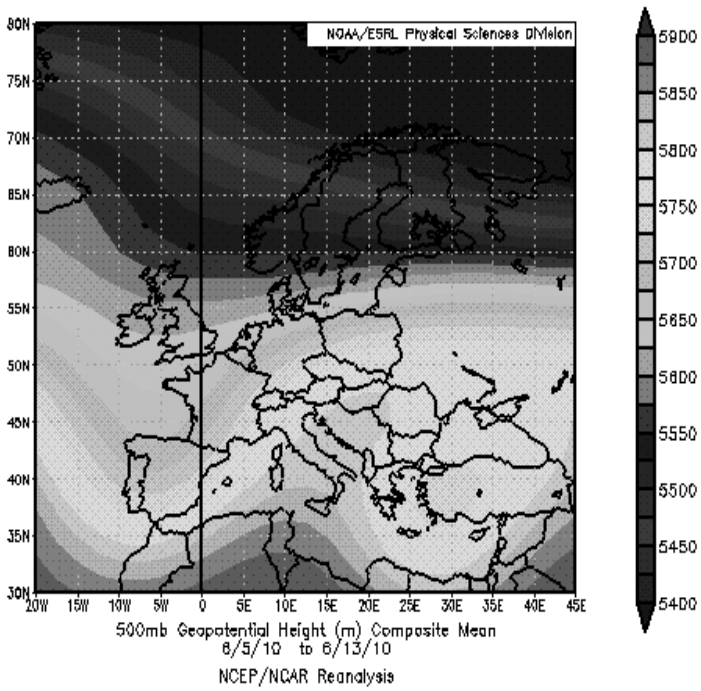

Fig. 3. Average distribution of the isopleths at the 500 hPa level in the period 06/05/2010 - 06/13/2010.

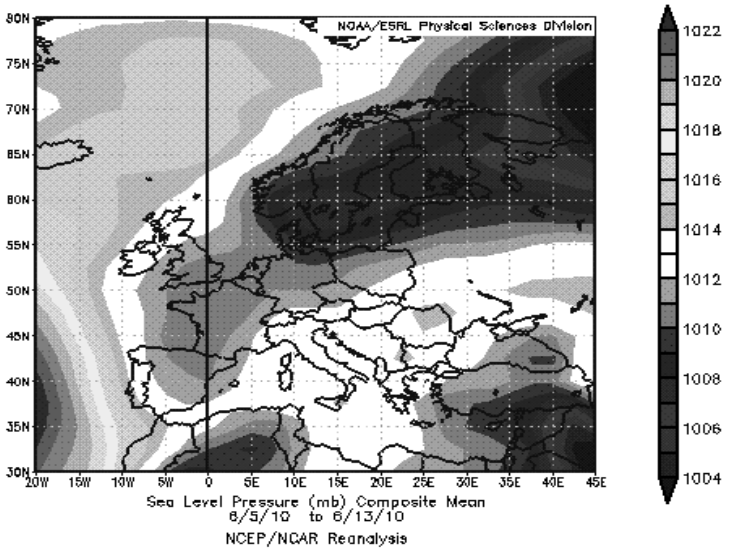

Fig. 4. Average distribution of isobars at the ground level in the period 06/05/2010 - 06/13/2010.

Beginning with the 13th of June, the eastward movement of a low pressure area from the western part of the continent causes the pressure in our region to drop, reaching 1010 hPa. The frontal system linked to this area will affect Romania starting with the 14th of June. From the NCEP/ NCAR reanalysis map in fig. 4, the fact that the mean value of the pressure is between 1012-1014 hPa can be observed.

From June 1st to June 13th the following amounts of water resulting from precipitation in Cluj county were registered: 14.8 l/m^2 at Turda, 23.9 l/m^2 at Huedin, 14.4 l/m^2 at Băişoara and 39 l/m^2 at Vlădeasa peak.

The temperature - humidity index (ITU) reached and exceeded the critical threshold of 80 at Dej (at 15:00) and Cluj-Napoca (at 17:00) starting on the 11th of June 2010. On the 12th of June, when the maximum air temperatures reached levels of 32-34°C, warnings were issued for Dej (at 12:30), Cluj-Napoca (at 15:30) and Huedin (at 15:30). Warnings were also issued on the 13th of June for Dej (at 11:30), Cluj-Napoca (at 12:00) and Turda (at 12:30). The time at which this warnings were issued was rushed ahead, such that in the first day (11th of June), they started at 15:00 and 17:00 respectively, and on the last day (13th of June) they started at 11:30 and 12:30 (fig. 5).

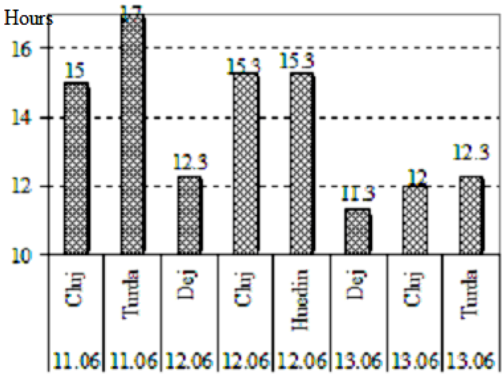

Fig. 5. Time at which the ITU warning was emitted, in Cluj county.

4. ATMOSPHERIC INSTABILITY IN THE SECOND HALF ON JUNE. CASE STUDY: THE 21ST OF JUNE

The events in the second half of June 2010 occurred in the context of synoptic - scale blocking movement.

4. 1. Synoptic situation

In the second part of June, the continuity of an accentuated air instability in our country's region, the high temperatures, high humidity and the physical and geographical conditions (extension, shape and altitude of the relief) favored the development of convective structures and prompted large amounts of rainfall, exceeding the monthly averages.

Thus, according to the meteorological and precipitation stations in the county of Cluj, during the month of June 2010, the value of the precipitation totaled an amount of between 236.6 mm at Beliş, 230.9 mm at Bonţida and 83.5 mm at Salatiu. In relatively large areas the quantity of water exceeded 100 l/m^2. In the second part of June (14th - 30th of June) amount of water from rain and showers accompanied by lightning were recorded as follows: 147.6 l/m^2 at Cluj-Napoca, 194.9 l/m^2 at Huedin, 119.5 l/m^2 at Dej, 157.8 l/m^2 at Turda, and in the mountain area 85.4 l/m^2 at Băişoara and 143.8 l/m^2 at the Vlădeasa Peak. Strong wind was recorded in Cluj-Napoca on 16th of June and in Turda on 18th of June. Gust was recorded on the 14th, 15th, 16th, 18th, 21st, 22nd, 23rd, 24th, 28th and 29th of June, hail occured on the 14th of June at Apahida and Vlădeasa Peak, on the 18th of June in Turda, the 20th of June at Borsa and 21st of June at Huedin.

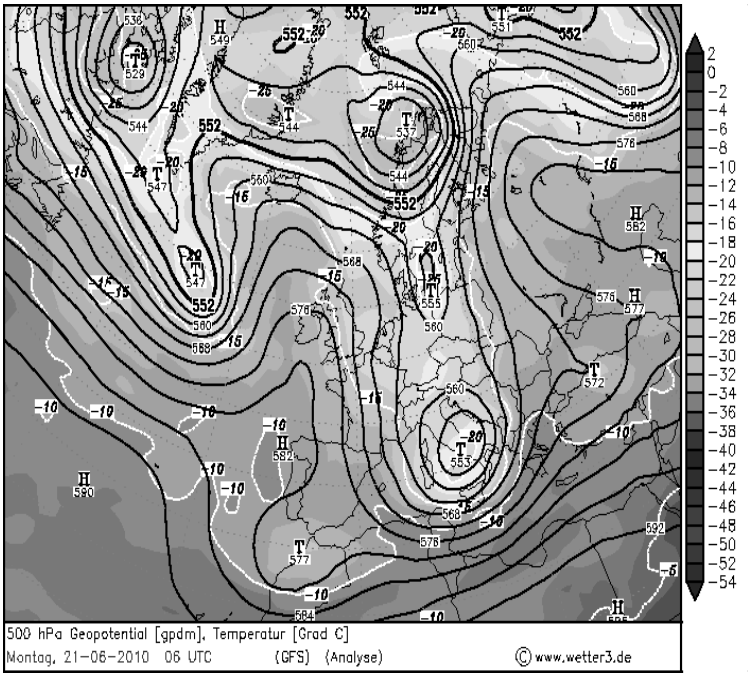

Fig. 6. Geopotential field and the distribution of the isotherm, in the 21/06/2010, at the 500 hPa level, at 06 UTC.

On the 21st of June all the weather stations recorded the greatest amount of water of the month. Values above 30 litters per square meter per 24 hours were recorded at Mărişelu (30.5), Rădaia (37.2), Luna de Jos (38.2), Gilău (42.8), Apahida (57.3), Recea Cristur (54.3), Borşa

(55.2), Beliş (81.0). In the time interval June 14th to June 30th 2010, a total number of 28 warnings for immediate hazardous weather phenomena in the Cluj county and 10 warnings and general information for the north-west part of Transylvania were issued. The detailed analysis of the weather phenomenon produced on the 21st of June 2010 revealed a period with prefrontal and frontal instability; the weather observations taken from the weather and precipitations stations indicate the following convective phenomena: heavy rain, wind gusts, strong wind, lightning and hail. The 21st of June was marked by pronounced instability in which the synoptic situation was as follows: at 500 hPa isobaric level, above Europe, the geopotential structure decreased in altitude, having a low pressure center with values of 551 gpdm centered over the Italian peninsula. Cold air mass related to it had low temperatures of -20ºC, specific of cut-off type. The 552, 556, 560 gpdm isopleth were closed; further north, above Denmark, another low pressure center was present, with values of 554 gpdm at the center- both pressure centers were separated from the same trough. The cut-off nucleus above the Italic peninsula, moving towards the east of the continent, came across the Adriatic Sea, and its periphery caused pronounced instability in our country. On the 21st of June, at the 850 hPa level, a hot ridge with temperatures of 15°C dominates in the eastern part of Romania (the Black Sea), and the 10°C isotherm was situated in the western part of the country throughout the day, the interest area having temperatures between 12-14ºC (fig. 6).

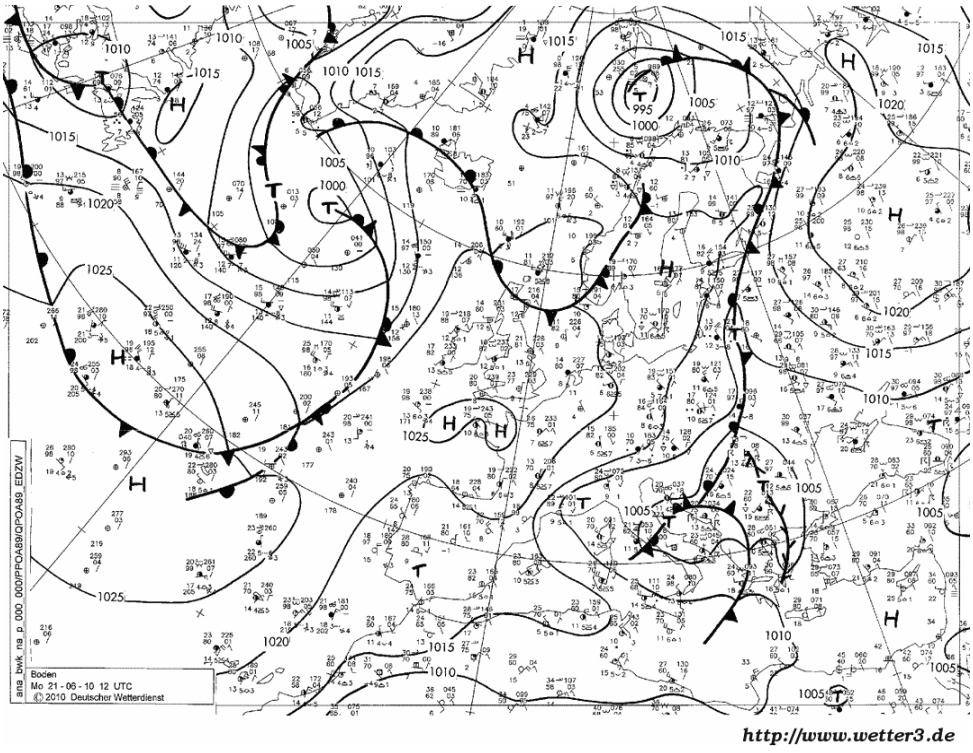

Fig. 7. Ground level field and the front position, on 06/21/2010, at 12 UTC.

At the ground level, on the 21st of June 2010, the western part of the continent was under the domination of the Azores High Ridge and the eastern part was still dominated by an anticyclone field, Eastern European Anticyclone ridge. Europe was crossed from north to south by an atmospheric front, the frontal line descending from the Kola Peninsula over the Baltic States, Ukraine, Western part of Romania, Croatia and the Adriatic Sea, down to the Mediterranean (fig.7). The cold front that crossed over our country in the next hours was preceded by a strong squall line located ahead of the front. Over Romania, the pressure drops below 1010-1005 hPa; this drop was caused by the movement towards north of the Mediterranean Cyclone zone.

Thus, in Sălaj County, the maximum quantity of fallen water was of 95.3 l/m^2 at Buciumi. In Cluj county, the water amount was of 81.0 l/m^2 at Beliș. In Satu Mare County, 68.0 l/m^2 at Corund were recorded and in Maramureș county 51.8 l/m^2 at Șieu-Rozavlea were also recorded. In Bistrița-Năsaud county, 24.8 l/m^2 were recorded at Bistrița.

4. 2. Radar analyses

All nowcasting warnings that were issued for Cluj county were based on the data and radar images received from the WSR98D radar from Oradea and Bobohalma, using OmniWeatherTrack and PUP applications, which allow the display on the screen of the radar products. On the 21st of June 2010, several convective cells were developed, initially in the western part of the county, then in the eastern part.

For the OHP products (1 hour precipitation) which show the horizontal distribution of rainfall expected over a period of one hour, and the THP products (3 hour precipitation) which show the horizontal distribution of rainfall for a period of three hours, the threshold of 25 mm and 45 mm were used as lower limits for the accumulation of the amounts of precipitation that can cause damages. At 9:38, the OHP product near the city of Huedin had maximum rainfall amounts of up to 76.20 mm and the THP product, at 12.54, estimated that for three hours, the maximum values of rainfall were of 101.60 mm (fig. 8).

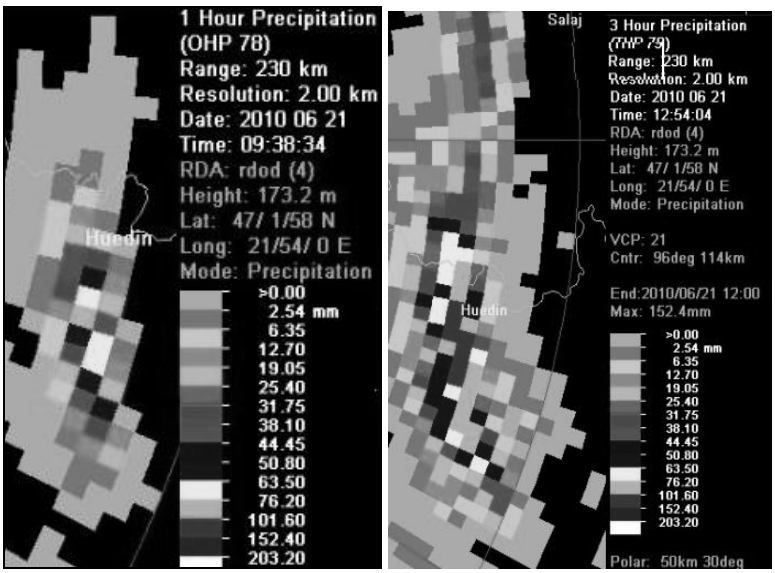

Fig. 8. OHP, at 9:38 UTC and THP, at 12:54 UTC (RDOD).

The amounts of water recorded at the weather and precipitation stations for which warnings were issued (32 l/m^2 at Huedin between the hours 9:35 and 10:35 UTC, 27.6 l/m^2 at Beliş from 10:00 to 11:00 UTC, at Călata between 8:30 to 10:30 UTC - 33.6 l/m^2 and between 10:30 to 12:30 UTC - 39.1 l/m^2), confirmed the predicted precipitation. Due to the intense and sustained convective activity, the temperature at Huedin did not exceed the maximum of 22ºC.

In this context, on the 21st of June 2010 the weather was generally unstable. The sky was cloudy and, on extended areas rain fell accompanied by lightning and short-term strong wind (47 km/h in Turda; in the high mountain areas, the wind speed was up to 72 km/h at the Vlădeasa Peak). Isolated small-sized hail was reported at Huedin. In small areas torrential rains were recorded. The maximum amount of water that fell was of 81.0 l/m^2 at Beliş. Maximum temperatures ranged from 22ºC at Huedin to 28°C at Dej, and the minimum were between 14ºC at Huedin and 18ºC at Dej.

In many places, the storms caused damages and casualties among the population. A 21 years old man in Morlaca (Cluj County) died after the car he was in was taken by the elevated waters of the Tibat and Domoş streams. From the ISU reports: in the towns of Huedin, Morlaca, Sâncraiu, Săcuieu, Călata, Poeni (Cluj County), 250 households were flooded, and the E60 highway was covered with water. There have been floods in Turda, Mărtineşti and Copăceni. All the events were reflected in the local press.

5. CONCLUSIONS

June 2010 was analyzed in a synoptic and mesoscale context, highlighting the differences between the first half of the month and the second half.

From the 11th of June 2010 until the 13th of June, heat warnings for thermal discomfort were issued, when the temperature-humidity index (ITU) has reached and exceeded the critical threshold value of 80 on extended areas.

In the second part of the month, the atmospheric instability was influenced by the development of convective structures related to the altitude nuclei of cut-off type and the presence of several frontal systems that have crossed our country.

The synoptic structure from the altitude characterizes a strong blockage that will favor the polar cold air penetration to the south part of the continent.

As a result of the ground-altitude synoptic context, the last decade of June was extremely unstable.

The structure of cut-off type positioned above the Italian Peninsula will quickly cross the Mediterranean basin to the Balkan Peninsula. The presence of the thermal blocking to the east and northeast sides of the Black Sea will cause the stationing and reactivation of the cut-off core by the end of June.

Instability manifested itself during the day and evening hours, when showers fell accompanied by lightning and strong wind.

On small areas, rains had torrential character and hail fell. The sum of precipitation fallen in June 2010 is close to the absolute maximum of June: 246.3 mm / month, in the year 2009.

High values of the quantities of precipitation in June 2010 (compared to the climatologically normal) were recorded at Turda 172.6 mm (77.9 mm), Cluj-Napoca 166.8 mm (85.9 mm) and Dej 134 mm (87.0 mm).

On the 21st of June, the most intense effects of rainfall in June were recorded: one death in Morlaca; 250 flooded households in Huedin, Morlaca, Sâncraiu, Săcuieu, Călata, Poeni, floods in the cities of Turda, Copăceni and Mărtineşti and landslides were recorded in Domosu and Horlacea.

Note. *Acknowledgements* This work was possible with the financial support of the Sectoral Operational Programme for Human Resources Development 2007-2013, co-financed by the European Social Fund, under the project number POSDRU/107/1.5/S/76841 with the title „Modern Doctoral Studies: Internationalisation and Interdisciplinarity".

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