THE SEVERE WEATHER SITUATIONS OF 9-10 JUNE 2012 IN NORTH-WESTERN ROMANIA

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ABSTRACT. - The severe weather situations of 9-10 June 2012 in north-western Romania. The paper analyses a series of characteristics of the severe weather events on the 9th and 10th June 2012 in north-western Romania. The study points out certain similarities and differences between the two situations, based on materials on a synoptic scale, mezoscale and storm scale. Against a different synoptic context, while the element commom to both situations was hailfall - which was more intense and widely spread on 10th June -, the difference consisted in scarce rainfall recorded on 9th June 2012. A series of peculiarities were evident, on mezoscale and storm scale, which determined the evolution of the convective systems on the two days. Thus, both differences (the speed, the tendency) and similarities (high water content on column, high radar reflectivity, etc.) were pointed out in the spatial manifestations of the convective cells.

Key words: severe weather, hail, precipitation, north-western Romania.

1. INTRODUCTION

Atmospheric instability, an uncharacteristic situation of terrestrial atmosphere, represents a manner of thermally balancing it through vertical transport, along with air advection, which is achieved through horizontal transport. The two processes have the role of preserving the energy of the atmospheric system. The uneven distribution of energy factors at the level of terrestrial surface or the presence of barriers of physical nature, can determine, for short intervals of time and in certain spaces, the accumulation of great quantities of energy capable to produce extreme meteorological phenomena.

From the meteorological point of view, *severe weather* means the concrete extreme manifestations of certain phenomena, on a certain area within a certain period of time. In the present situation, it refers to the synoptic and mezoscale conditions which determined the severe weather instability on 9th and 10th June, manifested as hailfall, increase of wind speed and, locally, significant rainfall.

2. DATA BASE AND METHODOLOGY

In conducting this analysis there have been used materials at synoptic level (maps of the baric and thermal field a various altitudes, satellite images of cloud

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formations), at mezoscale and storm scale (processed atmospheric measurements, thematic radar images – reflectivity, Vertical Integrated Liquid, height of cloud formations, etc). To these were added data measured at meteorological and hydrological stations: air temperature, quantity of precipitation, meteorological phenomena, etc). Based on all this material there have been calculated various indices of atmospheric stability, the directions and speed deviation of the movement of convective cells as compared to the main flow, and maps were designed concerning the movement of convective cells within the analysed area. The expressed time moment refers always to UTC time.

3. RESULTS

For the 9th June the *synoptic scale* analysis remarks the existence, at the 500 hPa level, of two trough structures: one with its axis above France, showing a closed nucleus in the east of the British Isles, with the peak of this trough being extended as far as the south of the central western Mediterranean Basin; and the second one above the European part of Russia, to the west of the Ural Mountains (fig. 1, left). On the whole, the north-eastern basin of the North Atlantic Ocean is under the influence of the altitude trough, within which a series of Atlantic cyclones are individualised. The south-eastern part of Europe finds itself under the influence of a structure with ridge aspect, because of the presence of two altitude troughs, which ensures the transport of the warm and humid subtropical air of Mediterranean origin. On 10th June, the altitude trough of the Mediterranean area advances to the east and deepens.Thus, in the south-eastern part of the continent the air circulation becomes southern, ensuring the transport of warm and humid air towards the north-eastern Europe. (fig. 1, right).

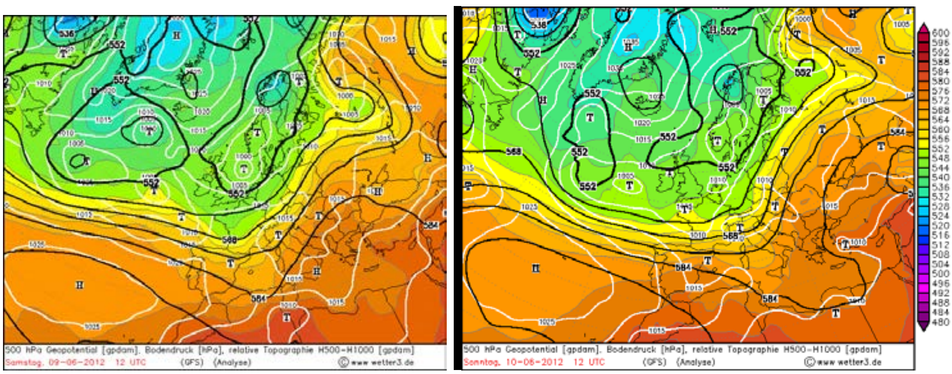

Fig. 1. The 500 hPa geopotential height (gpdm), the atmospheric pressure distribution at sea level (hPa) and the 500-1000 hPa relative topography field (gpdm), on 9th June (left) and 10th June (right), 12.00 UTC (source: http://www.wetter3.de/Archiv).

At 12 hrs on 9th June, at ground level, south-eastern Europe found itself in a field of atmospheric pressure close to the mean value (approx. 1013 hPa). In the northern half of the continent a series of depressions of atlantic origin were present, associated with the vast altitude trough existing in the area. The south-western part of Europe was under the influence of the Azores anticyclone ridge (fig. 1, left). On 10th June, the altitude trough above central and western Europe advances towards the east, the depression field at ground level deepens, thus determining the individualisation of some nuclei on the ascending slope of the altitude trough and the formation of a depression in the Po Plain area (fig. 1, right). Consequently, in the central and eastern Europe a frontal structure of quasi-stationary character becomes evident, making the connection between the depressions situated on the ascending slope of the altitude trough and the depression situated to the east of the Ural Mountains .

At *regional scale*, in south-eastern Europe, at 500 hPa level, there exists a ridge with its axis situated over Romania (fig. 2, left). Later on our country reached the descendent slope of the ridge, under a south-western atmospheric circulation. At 850 hPa level, the thermal ridge is characterised over Romania by temperatures of 17-18°C (fig.2, left). Throughout the day of 10 June the geopotential values of 500 hPa isobaric surface decrease, reaching less than 575 gpdm over western Romania, at 18:00. The synoptic configuration was that of an ascending trough slope. During the afternoon of 10th June, at 850 hPa level, the thermal ridge is intensified, with its axis situated over the Eastern Carpathians (fig.3, left).

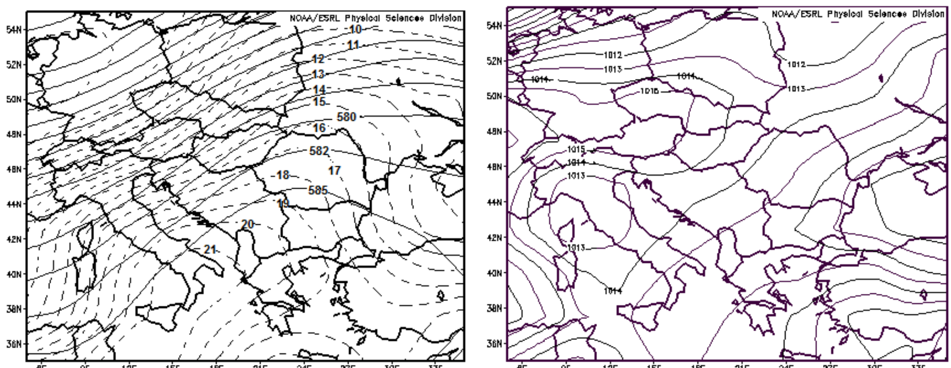

Fig. 2. The 500 hPa geopotential height (continuous lines) and the 850 hPa temperature (interrupted lines) (left), respetively the pressure distribution at sea level (hPa) (right) above south-eastern Europe, 9th June 2012, 12:00 UTC (processed after http://www.esrl.noaa.gov).

On 9th June 2012, at ground level, the pressure field is characterised by values close to average. In western and northern Romania there exists a low corridor. It favours the frontal connection from the western Urals, over Ukraine and Hungary, to the cyclone situated in northern Italy, advancing to the north-east (fig. 2, right). On 10th June, this Mediterranean cyclone will gradually affect Slovenia, Croatia, Austria and Hungary, reaching the south of Poland at 18:00 (fig. 3, right).

Thus, in western Romania the atmospheric pressure decreases from 1014-1015 hPa on 9th June, to 1007-1009 hPa on 10th June.

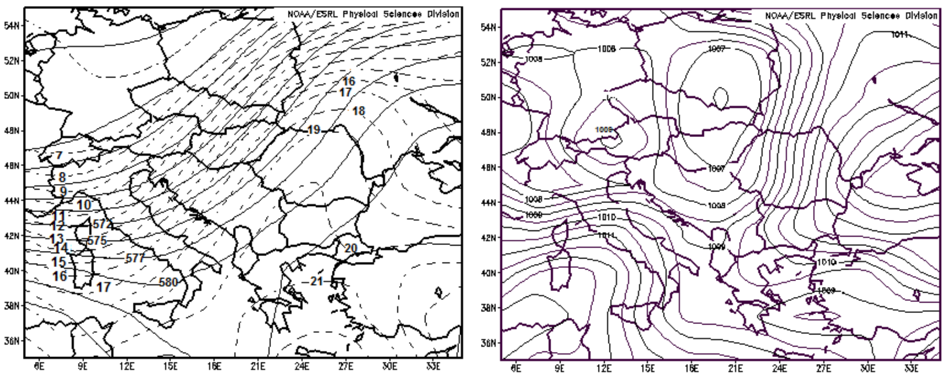

Fig. 3. The 500 hPa level geopotential height (continuous lines) and the 850 hPa level temperature (interrupted lines) (left), respetively the pressure field at sea level (hPa) (right) above south-eastern Europe, 10th June 2012, 18:00 UTC (processed after http://www.esrl.noaa.gov).

On 9th June, in north-western Romania, the day starts with minimal temperatures between 11-20°C. During the morning, under a predominantly clear sky, the temperature increases, so that at 14:00 (the starting moment of the thermal convection on this day) it reaches between 27.7 and 30.1°C.

During the night of 9/10 June, between 21:30-04:30, the north-western part of Romania is crossed by two well deliniated convective systems. The first, generated over the Pannonian Plain, evolves from SW towards NE between 21:30-02:30. The frontal system intensifies due to the high temperatures registered during the day, and it will cause rainshowers and electric discharges, associated with important material damages (road and railway, agricultural fields, etc.). The second system affects north-western Romania between 01:00-04:30, crossing the northern half of the Western Plain. It displays a linear structure, with north-southern orientation, moving WSW to ENE above the Someş and the Crişana Plains, respectively SW to NE in northern Transylvania and Maramureş.

Under the increased cloudiness during the night, the minimal temperatures in the morning of 10 June are high (15-18°C). The decrease of cloudiness and warm air advection in the low troposphere during the day determine the temperature increase comparable to the values recorded at 12:00 of the previous day, especially in the western part of the areal.

The mezoscale analysis for 9th June is based on the following elements: the presence of an altitude trough over western Romania; the thermal blocking in the low atmosphere as a result of the thermal ridge increase; the humid air advection from the south-west; the presence of a relatively low pressure field at sea level; the presence of a quasi-stationary front in the western Pannonian Plain; a high wind shear (20m/s) in the 0-3 km layer, which favours the convective cells formation; orography, which enables convection development. On 10th June the following phenomena were observed: the deepening of the altitude trough and its moving towards the east; the decrease of air temperature at 500 hPa level and intensification of the thermal ridge at 850 hPa level, which stimulates and intensifies the thermal convection; the humid air advection from the south-west; the decrease of pressure field at sea level and the movement of a Mediterranean depression over the Pannonian Plain; the increase of the quasi-stationary front; the high wind shear (over 25 m/s) in the 0-6 km layer; high cloudiness during the night, which favours the increase of air temperature and the convection initiation during the day.

According to the Cluj-Napoca atmospheric sounding, the thermal advection shows its warm character in the lower atmosphere, and, respectively, the cold character in the upper one. On 9th June, the warm advection is more intense at 925 hPa level (790 m), which determines an increase of 4.4°C as compared to the previous day. On 10th June, the warm air advection, observed until 700 hPa level, is most intense at 850 hPa level, recording a 3.6°C increase as compared to the previous day. Moreover, the hodograph analysis for 9th June shows a warming up to 665 hPa (3547 m), followed by a cold advection in the upper layers. On 10th June, the warm advection appears between ground level and 775 hPa (2300 m) level, while in the upper layers a cold advection is predominant. This thermal distribution favours atmospheric instability, especially on 10th June.

The indices of atmospheric stability, determined through atmospheric soundings (see Poppler, 1988), are presented in table 1. On the 9th June, their low values characterise an unstable atmosphere. On 10th June, all indices exceed threshold values, anticipating a high instability of thermal convection. The indices determined with reference to the air humidity near ground level (KI_{mod}, TTI_{mod}) can better predict the atmospheric instability than the others (KI, TTI). On 9th June, the high value (-170.5) of CIN (Convective Inhibition) shows a higher probability of convective activity if the convection temperature (26.7°C) is exceeded.

Table 1. The atmospheric stability indices calculated for 9 and 10 June 2012, based on atmospheric soundings by Cluj-Napoca Observatory

Indices / Date	KI	KI_{mod}	VT	CT	TTI	TTI_{mod}	LI	CAPE	CIN
9 June	27.3	30.7	25.7	21.3	47	50.4	0.6	74.9	-170.5
10 June	34.7	37.4	32.1	25.1	57.2	59.9	-4.3	817.3	-221.1

Another element under analysis was the deviation of the movement direction of convective cells against the main flow (see Tudose, Haidu, 2012). In order to determine this deviation, the directions of the layer 400-850 hPa were used. It was noticed that 87% of the convective cells recorded deviations of the mean movement directions lower than ±45°, while for 4.3% of them the deviation was higher than ±90°. The highest deviations characterise the low speed cells. For 9th June, the positive deviations were predominant, corresponding to the convective cells movement to the left of the main flow. On 10th June the negative deviations (to the right of the current) proved more frequent.

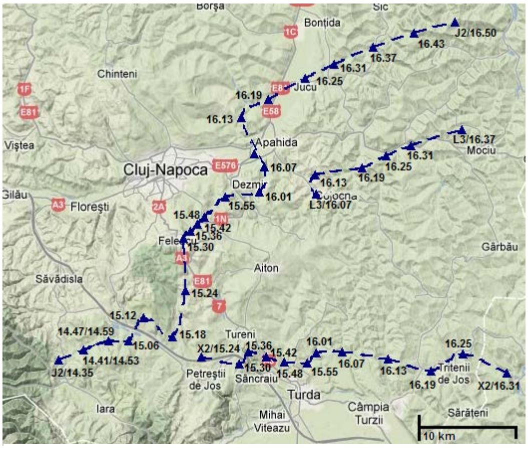

Figure 4. ***The trajectories of J2, X2 and L3 convective cells on 9th June 2012.***

On 9th June, the first convective cells appear at 12:14 above the Someşul Mic Valley, upstream from Cluj-Napoca, moving towards ENE.

Later on, new cells develop in the Cluj and Dej Hills area (12:33), and, respectively, in Muntele Mare Mountains (14:30). The development of cells in Băişoara area starting at 14:33 is most interesting (fig. 4). All the cell parameters (reflectivity, water content, etc.) rise, but their speed is relatively low, due to the vertical development of the cells. After one hour, at 15:24, the cells devide, and there appears a new system (X2) moving from west to east. This phenomenon corresponds with the decrease of cells parameters. Then, the J2 cell continues its movement eastward from the Feleac Hill, in parallel to the Racilor Valley. The cell speed remains low (5-6 m/s), contributing to the vertical development of the cell. Between 15:30-16:01 the northern side of the cell reaches the southern districts of Cluj-Napoca, recording hail stones of 1.5 cm in diameter. Within this interval the convective system is most developed: VIL-70kg/m^3, reflectivity-71 dBz, hail stone estimated diametre-3.25 in. At 16:07 a new storm fragmentation is produced, with the appearance of a new nucleus (L3), moving towards ENE (fig. 4). Then the supercell system starts to decrease.

The 10th June was characterised by an more intense instability. The convective cells appear relatively early, initially on the northern and north-western side of the Apuseni Mountains (The Vlădeasa Massif, Pădurea Craiului Mountains, Plopiş Mountains), and then on the eastern side (The Gilău-Muntele Mare Mountains). The general movement of the convective systems is SW-NE, respectively S-N in the Western Plain area. For exemplification, the Z2 cell movement is selected, which appears at 13:00 on the north-eastern side of the Plopis Mountains, moving SW-NE as far as Lake Vârşolţ (13:36). The development of the supercell system was enabled by the low speed movement (4-7m/s) (fig. 5). Subsequently, the cell movement changes, following a south-north direction, as far as Răteşti (Satu Mare county), and its speed rises to 7-13 m/s (fig. 5). In this area the cell parametres are the highest: VIL 60-75 kg/m^3; reflectivity 62-69 dBz; estimated hail stone diametre 1.75-3.25 in. Around Răteşti village the hail stone diametre reached chicken-egg size. After 14:43 the direction changes back to SW-NE, the system starting to dissipate.

As already shown, on 10th June both important rainfall and, in particular, hailfall were recorded. As for the intensity of precipitation, the heaviest rainfall recorded was in the Sălaj county: Românaşi - 18.5 mm in 2 min, Almaşu - 32.0 mm in 10 min. Other high values: Mesteacănu - 63.8 mm in 120 min, Bănişor - 23.0 mm in 85 min, Buciumi - 30.2 mm in 20 min, Gârbou - 25.3 mm in 35 min, in Salaj county; Aşchileu - 43.0 mm in 150 min, Vlădeasa 1400 - 23.1 mm in 40 min, Căşeiu - 19.6 mm in 55 min, Recea Cristur - 15.7 mm in 116 min, in Cluj county; and Cristeşti Ciceu - 20 mm in 60 min, Telciu - 26.5 mm in 90 min, in Bistriţa-Năsăud county. As for hail stone diametre, the largest were: the chicken-egg size ones at Răteşti (Satu Mare county) and the pidgeon-egg size ones at Almaşu, Dragu, Bucium (Sălaj county). Other hailfall events were recorded at: Dej (12 mm diametre) and Huedin (9 mm), in Cluj county; Zalău and Gârbău (6 mm), Hida and Românaşi (cherry size), in Sălaj county; Telciu (hazelnut size), in Bistriţa-Năsăud county.

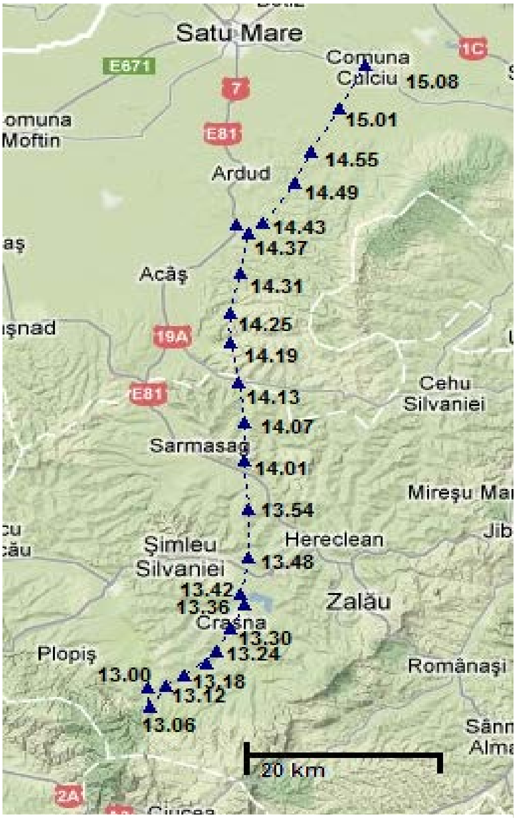

Figure 5. ***The trajectory of Z2 convective cell on 10th June 2012.***

4. CONCLUSIONS

The paper analyses the two situations of pronounced atmospheric instability of 9 and 10 June 2012 in north-western Romania.

The instability was more pronounced on 10th June, when the synoptic situation was characterised by: the approaching of an altitudinal trough; the intensification of the thermal ridge in lower troposphere; a cold air advection in middle and upper layers of the troposphere. A Mediterranean depression moving towards the Pannonian Plain influenced the more intense convective activity in NW Romania. The south-western warm and humid air circulation favoured a high water content on column, as well as the increase of the hail stone size.

The daytime temperature increase and the presence of the Apuseni Mountains caused the start of thermal convection, and the wind shear in the 0-6 km layer meant an important factor in the convective system development.

The relatively reduced movement speed of convective cells in their initial stage enabled their development up to supercell stage, as well as their fragmentation, especially on 9th June, when the speeds were lower than on the next day.

The low speed convective cell direction of movement was influenced by the characteristics of the terrestrial surface, especially by the relief.

The potential of convective storms development is well pointed out by the CIN values, which suggest the great potential energy reserve of the atmosphere.

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