EPISODES OF DEEP CONVECTION IN THE NORTH WEST OF ROMANIA DURING THE SUMMER OF 2015

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ABSTRACT. – Episodes of deep convection in the north-west of Romania during the summer of 2015. The monitoring of deep convection using radar, allowed the identification of four days, the 25th of May, the 19th, 20th and 24th of July in which the top of the convective clouds reached and overpassed 13 km. The after mass of this convection activity was medium and large size hail, severe wind gusts, frequent lightning and torrential rain. The common feature of these intervals was the presence of warm, unstable air mass. In this environment addition trigger mechanisms occurred such as: synoptic slope of a trough, upper-level troposphere divergence, tropopause folding and upper level cold air advection. Orography plays an important role in triggering convection through the discontinuities that it offers, and its amplification of the convection systems that tend to escalade the mountain slopes.

Keywords: north-west Romania, deep convection, vertical movement.

1. INTRODUCTION

Deep convection has the effect of appearance of cloud systems with high vertical development and the occurrence in a relatively short period of time of extreme phenomena, such as heavy rain, medium to large size hail, and strong wind gust that can develop into a squall. They may have adverse social and environmental effects. Dynamic factors responsible for the production of severe weather, the most important are mesoscale instabilities, they are responsible for the transfer of energy in the convective processes. The most important mesoscale instability is the static one, which is linked to the stability of the air parcel on short vertical distances.

The development of very tall and large clouds implies the existence of very intense vertical currents. The mechanisms that lead to the appearance of the vertical velocity are: adiabatic transformation of the air in the vertical movement, dynamic convection, thermal convection, convergence in the lower layers (in the center of a cyclone, between ridges and troughs, sea and valley breeze, surface fronts, downbursts, dry lines), rising air from dynamic systems of the atmosphere (cyclone), the divergence in the upper layers (Positive Vorticity Advection- PVA, jet stream or jet-streak with the divergence in the front left quadrant and rear right quadrant, the gravitational waves).

The purpose of the study is the identification and the analysis of as many mechanisms that could generate vertical velocity.

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2. DATA AND METHODS

The parameters of the convective cells: height of cloud formations (ECHO TOP), maximum reflectivity and vertically integrated liquid (VIL-grid) have been analyzed using the archive of the Doppler radars WSR-98D, (located at Bobohalma and Oradea) from the database of the ANM. The same database was used to diagnose severe weather situations: synoptic scale charts from ECMWF model and mesoscale charts from the ALARO model. The severe weather indexes were taken from the GFS model and satellite images from the EUMETRAIN site.

3. RESULTS

The common feature, in the cases of instability in the days the 25th of May, 19th, 20th and 24th of July, lies in the identification of cells, isolated or grouped in convective systems, with particularly large heights, they frequently exceeding 11 km, reaching 13...14 km in every day and 16 km on 20 July. The cells have maximum reflectivity over 68 dBz, reaching 73 dBz and sometimes 75 dBz, a VIL-grid that exceeds the frequently 50 kg/sq m, touching each day values of 68 kg/sq m and isolated exceeding 70 kg/sq m. In Table 1 is presented the distribution per day of the number of cells which have reached or exceeded: height (ECHO TOP) of 13 km, maximum reflectivity of 68 dBz and VIL above the threshold of 58 kg/sq m and 70 kg/sq m.

Table 1. ***Distribution per day of the number of cells which have reached or exceeded: height (ECHO TOP) of 13 km, maximum reflectivity of 68 dBz and VIL above the threshold of 58 kg/sq m and 70 kg/sq m***

	May25th	**July19th**	**July 20th**	**July 24th**
ECHO TOP ≥ 13 Km	6	4	9	20
MAXIMUM REFLECTIVITY ≥ 68 dBz	6	6	9	20
VIL ≥ 58 kg/sq m	6	3	6	16
VIL > 70 kg/sq m	2	-	4	2

The extreme instability in those days and the reduced frequency of these cases can be assessed by comparing the cell parameters mentioned above with the statistical analysis already made for them. Thus, the values of the maximum reflectivity of 68 dBz frequently encountered in these days indicates a severe weather situation, according to a statistical survey carried out with the data obtained from the RDBB on the forecast regarding hail for four summer seasons, June to August of the 2004-2007 (Maier, 2009). It suggests that starting from the values of the maximum reflectivity over 60 dBz the probability of hail is 96%, hail with a diameter of 2-4 cm is 48% and over 4 cm is 22%.

Values of VIL over 70 kg/sq m, were determined in 4% of the days from the framework of the statistical analysis of the most intense storms in the north-west of the country from the period June to August for the period 2003-2012 (Maier 2013). Using VIL-ECHO TOP diagram in estimating the wind speed of the downburst (Maier 2011), it is noted that the wind in these cases has exceeded frequently 22 m/s. Instability, indicated by radar parameters, is found also in the recordings from weather stations. In Table 2 is presented a summary, on each day, of the number of warnings/alerts issued and a brief diagnosis of the severe weather phenomena. Convective events occurred against a background of warm weather, hot in the afternoon hours on July 19^{th}, 20^{th} and 24^{th}.

Table 2. ***Warnings issued and a brief diagnosis of the severe weather phenomena recorded***

	25 may	19 july	20 july	24 july
number alerts issued	8	3	7	7
number warnings issued	1	-	2	-
severe instability period	14.35-20.00 (OVR)	14.15-19.25 (OVR)	9.50-15.30 (OVR)	13.10-20.30 (OVR)
weather within 24 hours	warm and unstable afternoon, night	warm and unstable afternoon	warm, hot, unstable during the day	Hot, canicular isolated, unstable in the afternoon and evening
ITU $\geq$ 80	-	local	isolated	extended
high temp. (deviation)	23-29 ºC (+5 ºC)	30-35 ºC (+7 ºC)	28-32 ºC (+4 ºC)	31-36 ºC (+8 ºC)
low temp. (deviation)	12-14 ºC (+3 ºC)	16-20 ºC (+4 ºC)	14-20 ºC (+3 ºC)	14-21 ºC (+4 ºC)
SEVERE PHENOMENA				
torrential rain	Aciua 47.1 l/sq m/210 min Supuru de Ios 25 l/sq m/125 min Satu Mare 19.2 l/sq m/22 min Bănişor 27.4 l/sq m/20 min Sărmăşg 27 l/sq m/30 min Gherța Mare 28.2 l/sq m/15 min Cicârlău 31.7 l/sq m/40 min Dara 26.1 l/sq m/44 min Dragomireşti 45.4 l/sq m/50 min-	Jibou 21. 2 l/sq m	Stârciu 21.4 l/sq m/20 min Bănişor 26.9 l/sq m/40 min Ciucea 38.2 l/sq m/50 min Bucium 19.7 l/sq m/15 min Iara 21.6 l/sq m/45 min Buru 22.7 l/sq m/30min	Gilău 40.4 l/sq m/60 min Dragomireşti 34.3 l/sq m/60 min
wind gust	Supuru de Jos 26 m/s Satu Mare 31 m/s Baia Mare 15 m/s	-	Turda 22 m/s Zalău 15 m/s Cluj-Napoca 14 m/s	Dej - squall 18 m/s Cluj-N – squall 14 m/s Baia Mare, Zalău, Huedin 12 m/s
hail	Zalnoc şi Nuşfalău the size of a pigeon egg Supuru de Jos 70 mm Satu Mare 52 mm Sărmăşag 20 mm	-	Baraj Vârşolț - the size of an egg	Beliş, Gilău, Cluj-N, Parva, Cristeştii Ciceului –grain size Dej - 10 mm

On 25th May, 19th July and 24th July, instability begin in the mountain area or in the vicinity, thereof, as a result of boundaries that appear caused by the daytime heating. In the morning of 20 July, the convective systems advance through the north-west extremity of the country, in the form of a rapid eastward moving squall line. Based on observations made using the radar, we notice that in all four cases analyzed, the fast development of the cells, the sudden increase in parameters: maximum reflectivity, VIL, ECHO-TOP. The differentiation between these cases occurs in the degree of organization of cells, their horizontal extent and their life span.

On the 25th of May, as a result of a convergence line in Western Sălaj County and Satu Mare County, in the presence of a high degree of instability, two of the cells that evolve through that area, develop a supercell structure identified by radar algorithms as TVS and MEZO, fact that indicates a severe weather threat. The aftermath of this phenomena, in this case, were large size hail, strong wind gusts, torrential rain (Table 2).

The area affected was considerable because of the lifespan of more then 4 hours and the average speed of 30 km/h of the cells. In this period the surface level pressure is low, the ALARO weather model forecasts mesoscale cyclones in the north-west part of the country. Development of cloud formations, in this case, is stimulated by ascending at synoptic scale, as a result of the advance of the trough centered to the south-west of the country. In the upper troposphere is a difluent movement of air (figure1). It may be noted the descend of the surface of PV 1.5 (dynamic tropopause) over the area of interest (figure 2), it denotes the existence of areas with maximum positive vorticity.

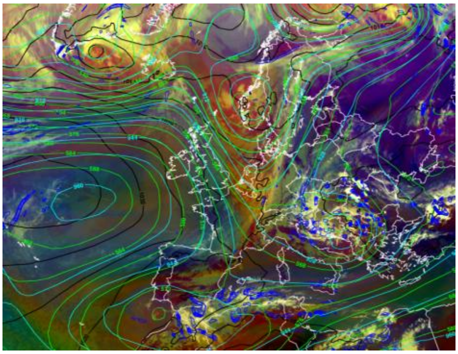

Fig. 1. Groud level pressure (black), ***geopotential height: 500 hPa (green), 300 hPa (blue), divegence 300 hPa (dark blue) and satellite images of air masses 25 may 12 UTC EUMETSAT***

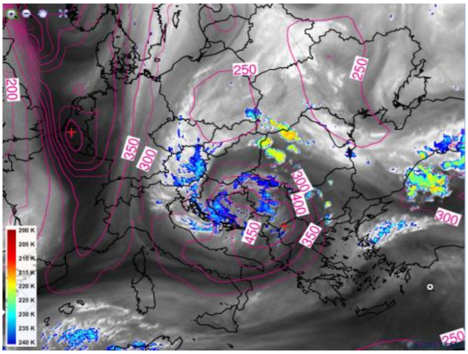

Fig. 2. ***PV=1.5 height, Satellite images: IR 10.8 (cloud top temperature) and water vapor (VW 6.2) 25 may 12 UTC EUMETSAT***

On July 19th convection cells are isolated, occurring in areas where available convective energy (CAPE) is high, with a lifespan up to 2 hours, slow speed of 5...10 km/h, in this case the affected area is small (Table 2). Ground pressure is around 1015 mb and in this case ALARO model forecasts cyclonic mesoscale formations. In the upper troposphere the circulation is weak, with a short wave trough at 500 hPa (figure 3) recognizable also in the evolution of the surface of the PV=1.5 (dynamic tropopause figure 4).

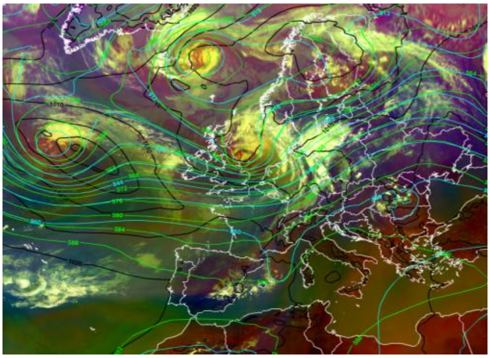

Fig. 3. Groud level pressure (black), *geopotential height: 500 hPa (green), 300 hPa (blue), divegence 300 hPa (dark blue) and satellite images of air masses 19 july 12 UTC EUMETSAT*

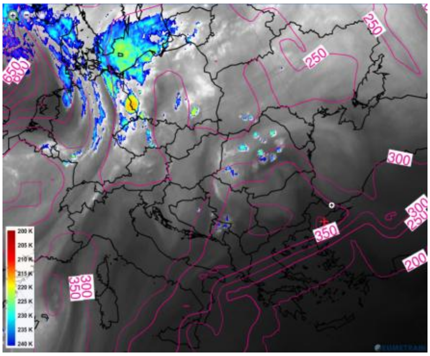

Fig. 4. ***PV=1.5 height, Satellite images: IR 10.8 (cloud top temperature) and water vapor (VW 6.2) 19 july 12 UTC EUMETSAT***

On July 20th, the convective system is organized in a line. At ground level were a weak depression and a warm, unstable air mass. ALARO model shows cyclonic mesoscale formations in the mountain area on the instability line. Vertical velocity sources are: fast moving cold frontal passage (in altitude) in the first half of the day, difluence in the upper troposphere (figure 5), the descent of the 1.5 PV (figure 6) surface with cold air penetrating the upper troposphere. Dynamic lifting in the mountain area intensifies the convective instability. Associated severe phenomena are mentioned in (Table 2).

Fig. 5. Groud level pressure (black), *geopotential height: 500 hPa (green), 300 hPa (blue), divegence 300 hPa (dark blue) and satellite images of air masses 20 july 12 UTC EUMETSAT*

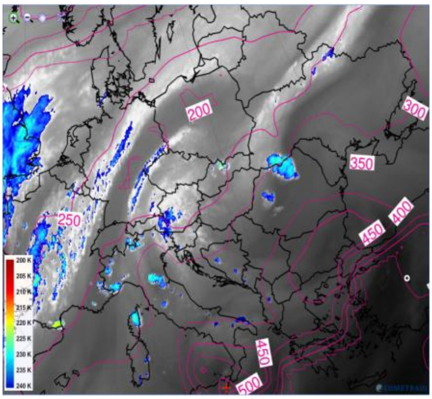

Fig. 6. ***PV=1.5 height, Satellite images: IR 10.8 (cloud top temperature) and water vapor (VW 6.2) 20 july 12 UTC EUMETSAT***

On July 24th, amid a high degree of thermal instability in the presence of a relatively low surface pressure with mesoscale cyclone formations forecasted by model ALARO, the first cells appear at noon on the southern slopes of the Orientali Carpathians. They move towards southwest slowly. The development of the cells is stimulated by the fact that in the middle troposphere, the ridge is retreating slowly to the east (south of the country is a short wave trough) and the existence of a divergence in the upper troposphere (figure 7). In figure 8 can be seen the variation of the dynamic tropopause close to the northwestern part of Romania. In this case the number of cells with potential for severe weather is great, and can be attributed to the fact that the degree of instability was very high.

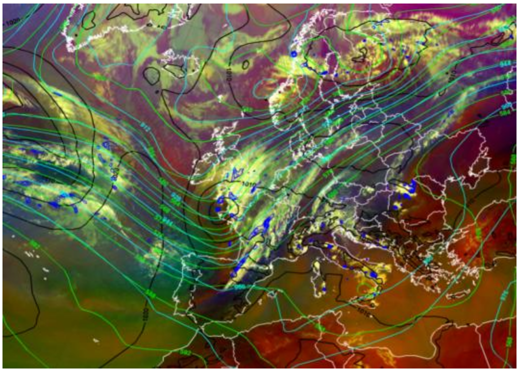

Fig. 7. Groud level pressure (black), *geopotential height: 500 hPa (green), 300 hPa (blue), divegence 300 hPa (dark blue) and satellite images of air masses 24 july 12 UTC EUMETSAT*

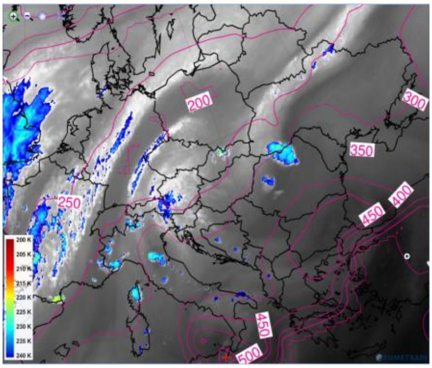

Fig. 8. *PV=1.5 height, Satellite images: IR 10.8 (cloud top temperature) and water vapor (VW 6.2) 24 july 12 UTC EUMETSAT*

In the table 3, after the 12 UTC time analysis of the ECMWF model are calculated: the values of ground level pressure, the values of geopotential/air temperatures and deviations from the daily average, at standard levels of 850, 700 and 500 mb in the north-west of the country.

Table 3. ***Ground level pressure, geopotential height, temperature and deviations from the daily average at 850, 700 and 500 mb levels in north-west***

	25 may	**19 july**	**20 july**	**24 july**
SLP (mb)	1008.5	1015	1012.5	1012.5
Z (dmgp)/ T (°C) at 850 hPa deviations from the daily average	145 / 14 +3 / +6	154 / 18 +3 / +5	151 / 18 0 / +5	152 / 18...20 +1 / +5...6
Z (dmgp)/ T (°C) at 700 hPa deviations from the daily average	306 / -1 0 / +1	317 / 8 +6 / +5	313 / 7 +2 / +4	315 / 7 +4 / +4
Z (dmgp)/ T (°C) at 500 hPa deviations from the daily average	567 / -16 +2 / +2	585 / -10 +10 / +3	582 / -9 +7 / +3	582 / -10 +6 / +2

In all the cases ground pressure is slightly lower than normal, favorable for vertical ascents. Geopotential values, slightly above the daily average in almost all cases, indicates that cyclonic disturbances, with the ascending at the synoptic scale they bring, have a marginal effect on the area of interest.

The degree of instability was assessed on the basis of parameters: CAPE-MU and LI from the model GFS and after the 12 UTC analysis of the model the values of VTI (indicates the vertical transport of unstable air) are calculated with the formula VTI = T (850 mb) - T (500 mb). In all cases there stands a high degree of instability and VTI values above 25, which indicates the possibility of occurrence of a severe storm (table 4).

Table 4. ***Instability indices CAPE-MU and LI, after GFS model and VTI values after ECMWF model at 12 UTC***

	25 may	19 july	20 july	24 july
ML CAPE (J/kg)	< 1200	< 600	< 700	< 1500
LI (ºC)	-4....-2	-2	-2	-4...-2
VTI (T500 - T850)	30	28	27	30

4. CONCLUSIONS

It notes the existence of a high degree of instability in all cases. In the days of May 25, 19 and July 24 the convection is of thermal origin. It becomes pronounced in areas with high static stability, particularly great on May 25 because of an area of convergence (ensures supply of warm and humid air cells).

On the 20th of July the convection is of dynamic origin, a cold front passage. In the mountain area, the intrusion of cold air over the warm air mass is more pronounced and the phenomena are more violent.

Vertical movements are stimulated due to: the presence of a depression field, with mesoscale cyclonic cores, rising air at a synoptic scale in a trough, divergence in the upper troposphere on May 25th, 22nd and on 24th of July. The folding of the tropopause (PV 1.5 surface), on May 25th and July 20th, intensified the vertical movements.

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