EXCESS RAINFALL IN THE SUMMER 2011, RISK PHENOMENON IN TRANSYLVANIA

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ABSTRACT. Excess rainfall in the summer 2011, risk phenomenon in Transylvania, highlight precipitation quantities that in the warm season become more abundant due to general circulation intensity of the atmosphere, as well as to the increasing role of thermal convection that develops in unstable air masses, which is also reflected in the amount of precipitation. In summer months, the most abundant rainfall falls due to thermal convection in most cases. Excess rainfall may be present in any season of the year.
They are emphasized by the largest amounts of annually, monthly precipitation, by the absolute maximum amounts of precipitation in 24 hours, by the frequency of heavy rains and the days that exceed 10 l /m^2. We can say that the excess rainfall often lead to destruction and unimaginable damage.

Keywords: synoptic situation, cyclones, anticyclone, atmospheric fronts, intra-Carpathians regions.

1. INTRODUCTION

The distribution of rainfall during the year is determined by a number of factors, in which the atmospheric circulation and local conditions are of particular importance. Annual amounts of precipitation vary from one year to another, according to general features of atmospheric circulation. In the years with very frequent and intense cyclonic activity, precipitation quantities are high.

The orientation of the mountain range from north-north-west to south-south-west forms an obstacle to the movement of air masses moving either from the Mediterranean or the Atlantic Ocean. Frontal systems of depressions formed in the North Sea Basin and above Central Europe pursuing the northeast path, also welcomes, in Carpathians, a barrier that sometimes slows the intensification of precipitation in the region immediately adjacent to the mountain range. However, with mountain climbing, although air masses moving especially from the west and north-west of the continent, become poor in moisture, often leaving here, in the central part of Romania large amounts of precipitation.

Due to extremely varied landscape, quantities of water from various types of atmospheric precipitation have a very uneven distribution in time and space.

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During the year, from one season to another, the distribution of water quantities from precipitation modifies due to the variable regime of the general circulation of the atmosphere and solar radiation (Ecaterina Ion-Bordei.2009).

In the warm season, the rainfall become more abundant both due to increased general circulation of the atmosphere and the increasing role of thermal conduction that develops in unstable air masses, which is reflected in the course of rainfall.

In the summer months the most abundant rainfall falls due to thermal convection in most cases (Bogdan Octavia, Rusan N, 2005).

2. METHODOLOGY OF WORK

For this study and enhancement of the conclusions on frequency, spatial and temporal distribution and rainfall intensity as well as risks arising from these, we used classic and modern working methods.

We mention among these: the choice of the area and phenomena introduced in the study, literature review, analysis of data received from weather stations in the study area, analysis based on synoptic maps at different levels that led to the fall of excess rainfall, comparisons between monthly and annual precipitation, the rainy periods and precipitation recorded in 24 hours.

3. JUNE, GENERAL DESCRIPTION

The study area refers to **Alba**, **Braşov, Covasna, Harghita, Mureş and Sibiu** Counties **(Fig. 1).**

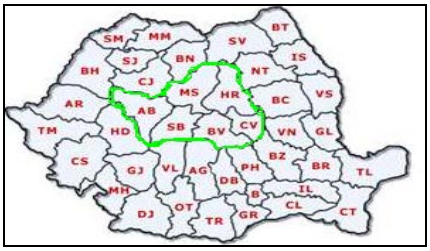


Fig.1. ***The map of Romania with the boundaries of the study area***

June was characterized by increased instability. This month, warnings or daily updates of significant precipitation have been issued (up to 30 l/m^2 and even more in the mountains), accompanied by lightning, hail and wind intensifications, sometimes with storm aspect, as well as nowcasting warnings (*very short duration, up to 3 hours*). Regarding temperature, this month has alternated between hot days (*with maximum temperature up to 33°C*), and cool days, even cold days for this period (maximum temperatures in Transylvania between 11 and 18°C, in June 28, 2011). In terms of precipitation, June was a month rich in such phenomena, and

precipitation have far exceeded the annual average. This month there were days when at certain weather stations precipitation exceeded 50 l/m^2 (*63.2 l/m^2 at Dumbrăveni weather station, 139.9 l/m^2 at Bâlea Lac weather station from Sibiu county, 56.8 l/m^2 at Targu Mureş weather station, 66.6 l/m^2 at Lăcăuţi weather station*(**table 1**). Also the average number of days with precipitation exceeded by twice and even three times at some weather stations (on average eight days this month in the lowlands and 10 days in the mountains), the number of days with precipitation ranged between 13 and 21 (**table 1**) (Dragotă Carmen-Sofia, 2006).

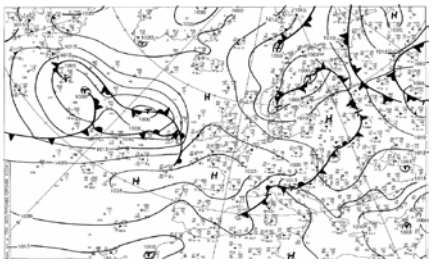
Table 1. Total rainfall and number of days with precipitation in June 2011

Weather Stations	The amount of precipitation (mm) June		
	Total / month	The largest amount of water fallen in 24 hours	Number of days with precipitation
Sibiu	156.5 l/mp	26.5 l/mp / 29.06.2011	15
Boiţa	167.6 l/mp	33.3 l/mp/ 10.06.2011	16
Păltiniş	210 l/mp	49.8 l/mp / 10.06.2011	20
Bâlea	588.4 l/mp	138.9 l/mp/11.06.2011	20
Dumbrăveni	205. 6 l/mp	63.2 l/mp/ 10.06.2011	18
Alba	76.4l/mp	13.5 l/mp/ 30.06.2011	15
Blaj	139.0 l/mp	35.0 l/mp/ 10.06.2011	13
Sebeş	104.4 l/mp	23.4 l/mp/ 25.06.2011	16
Câmpeni	73.8 l/mp	14.6 l/mp/ 25.06.2011	15
Roşia Montană	78.8 l/mp	22.0 l/mp / 30.06.2011	13
Sf. Gheorghe	99.2 l/mp	16.4 l/mp / 25.06.2011	18
Întorsura Buzăului	152.0 l/mp	21.2 l/mp/ 11.06.2011	17
Făgăraş	194.8 l/mp	50.3 l/mp/ 10.06.2011	16
Braşov	110.6 l/mp	23.8 l/mp/ 30.06.2011	14
Tg. Mureş	153.6 l/mp	56.8 l/mp/ 10.06.2011	18
Batoş	131.2 l/mp	47.8 l/mp/ 10.06.2011	16
M.Ciuc	130.3 l/mp	22.8 l/mp / 10.06.2011	21
Odorheiul Secuiesc	139.4 l/mp	40.0 l/mp / 10.06.2011	20
Topliţa	124.0 l/mp	22.8 l/mp/ 10.06.2011	18
Vf. Lăcăuţ	252.3 l/mp	66.6 l/mp/ 11.06.2011	15
Joseni	101.6 l/mp	22.8 l/mp/ 10.06.2011	18
Sărmaş	72.5 l/mp	19.2 l/mp/ 25.06.2011	14
Târnăveni	183.2 l/mp	43.0 l/mp/ 10.06.2011	15
Bucin	139.6 l/mp	52.5 l/mp/ 10.06.2011	16
Baraolt	248.4 l/mp	63.0 l/mp/11.06.2011	19

Regarding the synoptic situation this month we can say that pressure was low at ground level, ranging between 1000 and 1015 mb, except for 2-3 days when it rose up to 1020 mb, and in height at 500 hPa (5500 m altitude), with few exceptions, when it went up to 584 dmgp, the geopotential was kept below normal time period (572 dmgp).

A case has been reported on the 24th of June 2011, in which the atmospheric instability was accentuated and precipitation was long-range and in large quantity.

Precipitation were due to the atmospheric cold front, associated to the Icelandic cyclone that in its movement to the southeast contributed to the accentuated decrease in pressure on the entire column (**Fig.2,3**). With the penetration of this front, temperatures have dropped significantly, favoring the production of storms, lightning and exceptional rainfall. It is worth mentioning that a day before, in June 23, maximum air temperatures, in the Carpathian mountains, recorded values up to 35°C (*isotherms of 20°C*), and after the front has passed temperatures have dropped and had values between 15°C and 24°C (*isotherms decreased to 14 °C*).



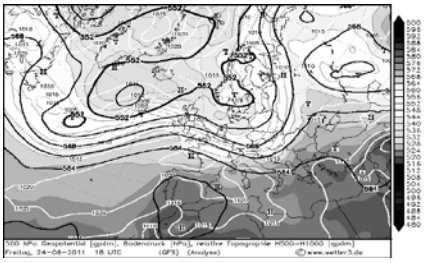


Fig. 2 ***Fig. 3***

Fig.2. ***Synoptic situation at the ground level, over Europe, in June 24 at 12:00.***
Fig.3. ***Synoptic situation at ground level superimposed to that of altitude over Europe, in June 24 at 18:00.***

Precipitation quantities, accompanied by lightning, hail and wind intensification (*17 m/s - 61 km/h*), sometimes taking the aspect of storm, caused significant damage and human victimes. The most affected municipalities have been Alba and Mureş counties. ***According to information received from the Inspectorate for Emergency Situations (IES), in Unirea town from Alba county two children were struck by lightning, one of them died, and in several localities in Mureş county water flooded homes and farmland; storms have damaged several roofs of houses and trees were broken***. And on the 10 th of June there have been significant precipitation with big impact on Cârţişoara, Arpaş and Porumbacu, localities from Sibiu county. Due to large amounts of precipitation fallen during the day of June 10 until the morning of June 11, 2011 (*amount of 236.9 l/m^2 at Bâlea Lake*), floods have occurred on Arpaşu Mare, Arpăşel and Cârţişoara rivers.

Therefore IES teams from Sibiu Service were forced to evacuate over 250 people from 189 town homes in Cârţişoara and 68 houses in Arpaş.

Portions of mountain roads have been affected, many hectares of agricultural land were flooded, bridges and culverts have been affected, some of them have been taken by flood, high voltage poles have been destroyed. In the other counties there were less damage from this day and were limited to the flooding of cellars from Reghin town, Mureş county and Baraolt locality from Covasna county. În Vişlea locality from Braşov county many trees fell in the river bed crossing the locality, affecting the water flow (**Fig.4,5**).

Fig. 4

Fig. 5

Fig. 4,5. ***Images show the consequences of floods caused by the excess rainfall of June 10, 2011***

4. JULY, GENERAL DESCRIPTION

July begins with a strong instability (period 01.07.2011-07.07.2011). During this period warnings were issued or daily updates of significant precipitation (*up to 30 l/m²*), accompanied by lightning, hail and wind intensification, sometimes taking the aspect of storm, and nowcasting warnings. There was a calm period in terms of rainfall (*07.07.2011-10.07.2011*), but with hot days (*temperatures have reached values of 34°C*). The 11.07.2011-15.07.2011 interval is characterized by isolated precipitation in the mountains (at Bucin weather station 39 l/m² and at Sfântu Gheorghe 21 l/m²), but a warm interval, with temperatures that have isolated reached 35.4°C, after that with the exception of 22.07.2011, when the weather was generally nice by the end there was a strong instability, period in which nowcasting warnings were issued and synoptic warnings for quantities of precipitation and other associated phenomena. In some counties, rain showers were accompanied by hail, wind intensification and lightning, causing even greater damage in some areas. Great amounts of precipitation were recorded this month during several days, but with a greater impact were those dated July 29, 2011. The synoptic context in which they occurred had the following configuration: analysis of the soil maps, **fig. 6 and 7**, the action of the Azores anticyclone was weak (*with isobaric of 1015*), with a tendency to withdraw to the northwest, allowing to penetrate cold air especially in the west of the country and the western Transylvania (*we should note that during this period the air temperature decreased significantly, especially in the western*

half of Transylvania, so that the precipitation were due both to thermal convection and relatively cold front). At the same time in south east there is a much warmer and wet air advection due to the entering of a depression thalweg (*a low pressure field under 1015 mbar*), with mediterranean origin, extended to the Balkans and Eastern climbing until the Russian Plain, shifting toward the west of the continent (*a retograd*), with influence upon Romania.

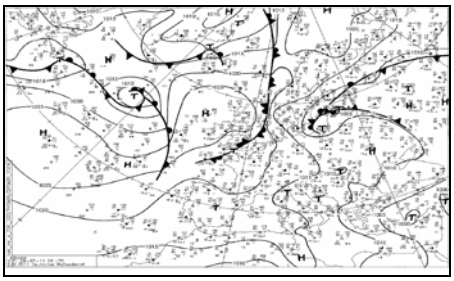


Fig. 6

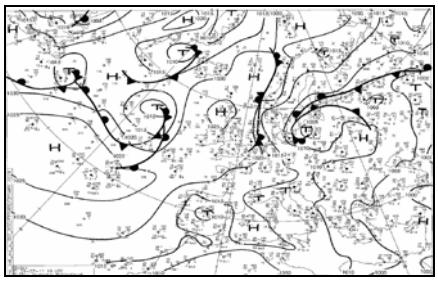


Fig. 7

Fig. 6. ***Synoptic situation at the ground level, over Europe, on 28/29July, at 00.***
Fig.7. ***Synoptic situation at the ground level, over Europe on 29 July, at 12 (According to Meteo France).***

While at the ground, the atmospheric pressure already recorded a low value of 1010 mb, in altitude, at 500 dmgp (**Fig.8 a and b**), the geopotential began to decrease due to the influence of the Icelandic cyclone, thus from the value of 576 damgp recorded during the day, at 12 UTC it decreased to 568 damgp during the night, forming in the western country a „cut off " closed nucleus with 568 damgp. The temperature dropped to -15°C at the altitude of 5000 m (**Fig.9**). Thalweg axis that influenced the weather in our country was oriented north-west to south-east. During the day of 29.07.2011 the circulation ranged between the southwest and southeast favouring the advection in altitude of the warmer and more humid air of Mediterranean origin (http://www.wetter3.de).

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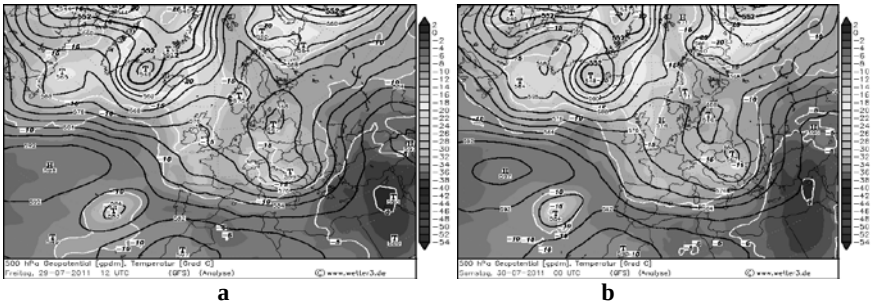
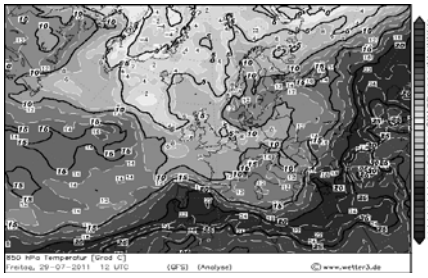


a **b**

Fig.8. ***The Geopotential in July 29 a) at 12°° UTC, b) at 00°° UTC at 500 hPa (5500m altitude) (according to Wetterzentrale3)***



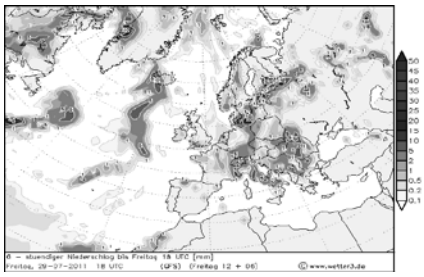


Fig.9 *Fig.10*

Fig. 9. ***29 VII map dated at 12°°UTC, the temperature distribution across Europe, at an altitude of 500 hPa. (Wetter zentrale3).***

Fig. 10. ***The rainfall distribution map of Europe (Wetterzentrale3)***

In the area analyzed on 29.07.2011, at 700 mb (altitude of 3200 m), the relative humidity increased from 60% at 06 UTC (*9 a.m. local time*), to over 90 %, at 12 UTC (3 p.m. local time), signaling significant precipitation, more than 30l/mp^2 (*36.5 l/ m² at Casin in Harghita County*) (**Fig.10**).

The amounts of precipitation this month had a large impact on the environment and society. Between 29.07.2011 at 9 a.m. and 30.07.2011 at 9 a.m., throughout Transylvania there were large amounts of precipitation. As a result of the rainfall that fell on 29.07.2011 in Transylvania, the most affected counties were Harghita and Mureş (**Table 3 and 4**) (Dragotă Carmen-Sofia, 2006).

Table 3. ***Total rainfall and number of days with precipitation in Julie 2011***

Weather Stations	The amount of precipitation (mm) June		
	Total / month	The largest amount of water fallen in 24 hours	Number of days with precipitation
Sibiu	116.2 l/mp	24.8 l/mp / 24.07.2011	14
Boiţa	103.3 l/mp	24.2 l/mp/ 24.07.2011	10
Păltiniş	135.2 l/mp	33.0 l/mp / 29.07.2011	17
Bâlea	143.3 l/mp	31.3 l/mp/1 30.07.2011	12
Alba Iulia	81.7 l/mp	20.1 l/mp/ 01.07.2011	12
Blaj	56.4 l/mp	21.6 l/mp/ 20.07..2011	15
Sebeş	98.2 l/mp	32.0 l/mp/ 01.07.2011	12
Dumbrăveni	86.4 l/mp	36.4 l/mp/ 16.07.2011	16
Câmpeni	139.4 l/mp	25.2 l/mp/ 20.07.2011	20
Roşia Montană	125.0 l/mp	16.8 l/mp / 25.07.2011	18
Sf. Gheorghe	82.8 l/mp	19.8 l/mp / 12.07.2011	14
Întorsura Buzăului	101.6 l/mp	18.8 l/mp/ 11.07.2011	14
Făgăraş	66.3 l/mp	14.6 l/mp/ 29.07.2011	16
Braşov	53.8 l/mp	13.8 l/mp/ 24.07.2011	15
Tg. Mureş	98.4 l/mp	20.2 l/mp/ 20.07.2011	17
Batoş	107.0 l/mp	28.0 l/mp/ 30.07.2011	16
M.Ciuc	114.3 l/mp	22.2 l/mp / 17.07.2011	15

Table 4. ***Total rainfall and number of days with precipitation in Julie 2011***

Weather Stations	The amount of precipitation (mm) June		
	Total / month	The largest amount of water fallen in 24 hours	Number of days with precipitation
Odorheiul Secuiesc	61.6 l/mp	23.4 l/mp / 17.07.2011	10
Topliţa	81.4 l/mp	19.4 l/mp/ 21.07.2011	19
Vf. Lăcăuţ	130.9 l/mp	26.6 l/mp/ 19.07.2011	13
Joseni	110.8 l/mp	39.4 l/mp/ 21.07.2011	17
Sărmaş	98.9 l/mp	35.1l/mp/ 21.07.2011	17
Târnăveni	71.2 l /mp	12.8 l/mp/ 20.07.2011	14
Bucin	138.6 l/mp	38.8 l/mp/ 12.07.2011	17
Baraolt	66.7 l/mp	25.4 l/mp/21.07.2011	15

According to the information received from Harghita IES, in addition to county and municipal roads, in Mihăileni area there were flooded: about 100 culverts, 5 bridges, 200 cellars, 200 wells, 250 households and annexes, 20 ha of agricultural land (**Fig.11**).

Fig. 11 Images from Harghita and Mures, with the consequences of the rainfalls on 29VII 2011

5. AUGUST, GENERAL DESCRIPTION

August begins with strong instability (1-3 August), signaling that the rainfall exceeded 30 l/m² (*36.1 l/m² at Stânceni, Mureş county, 34.0 l/m² at Sicasău, Harghita county and 51.8 l/m² at Bâlea Lac, Sibiu county*). The interval 4-9 August is characterized by high temperatures that reached 35°C on 8 August. The range 9 to 11 August is characterized by a strong instability, when in large areas quantitatively significant precipitation were reported (at almost all stations studied rainfall exceeded 15 l/m²), reaching even 40 l/m² at Dumbrăviţa, 40,4 l/m² at Babarunca, 54 l/m² at Teliu, 50,8 l/m² at Râşnov, 44,8 l/m² at Moeciu de Sus, all from Braşov county, and in the mountains 64.4 l/m² at Bâlea Lac from Sibiu county. We should mention that rainfall was accompanied by lightning, hail, wind intensification, sometimes of the storm looking.

Except 16 August when the weather was unstable, with precipitation, especially in the west of Transylvania, where at the pluvio station Vadul Motilor, in Alba County there were registered 39.7 l/mp. By the end of August, even if there were days with precipitation, they had no negative environmental impact, we

can even say that they were very beneficial, after an interval of several days when temperatures reached and exceeded 35°C in many localities in Transylvania (*37°C on 24 and 25 August, in Alba Iulia and Sibiu*), and the index of thermal discomfort, temperature-moisture called ITU reached and exceeded the critical limit of 80 units. Note that damage caused by precipitation of this month were insignificant compared with June and July.

6. CONCLUSIONS

The distribution of the days with precipitation in the analyzed area is dependent both by characteristics of general circulation of the atmosphere and the particularities of relief.

In terms of variability of rainfall periods during summer, along this study we have noted a clear tendency to reduce them in the last month of the analyzed period.

We can say that the rains during the warm season (*especially in June-August*) are fast and quantitatively significant that often lead to unimaginable damage. This is due primarily to cumulus clouds (*Cumulonimbus clouds developments, the top of these clouds can reach the tropopause*) that form in this season, and also to some frontal passages, more rare that have a major impact in changing weather when crossing Europe.

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