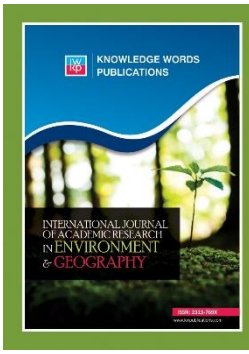

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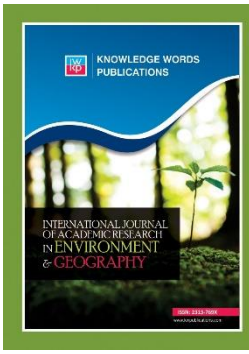

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Considerations on the Exceptionally Rainy Year 2014 in the South-west of Romania

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Abstract

The article analyzes the exceptionally rainy year 2014 in the south-west of Romania, year in which many rainfall records exceeded, for the whole series of meteorological observations at the meteorological stations in Oltenia. The year was marked by 23 excessively rainy periods where there were floods because of the exceptional amounts of precipitations. There were 21 rainfall records, far exceeding the wettest year 2005. Compared to the year 2005, floods were not so catastrofal due to the wide distribution of these rainfall throughout the year. Like 2005, the year 2014 was globally classified as the hottest year, and in Romania, like in most Europe, it was a normal warm year, but exceptionally rainy.

Keywords: Rainfall Records, Mediteraneean Cyclones, Torrential Rains, Floods.

Introduction

Although globally, 2014 was considered the warmest year since the beginning of the systematic measurements, in Oltenia, this year was a normally thermal and exceptionally rainy year, being similar to the exceptionally rainy year 2005, but surpassing it on the rainfalls recorded. Globally, each of the first ten months of 2014 were recorded the warmest months of the Earth since the temperature measurements have started, in 1880 (NOAA), and October 2014 was the 38th consecutive month of October during which the global temperature was higher than the average temperature of the 20th century, reaching 14.74 ° C. October 2014 was the third consecutive month of 2014 with a global temperature record and the fifth in the last six months to set this record. This extended rainy period began after an exceptionally hot and dry summer (summer 2013), in September 2013, and the agricultural year 2013-2014 was the wettest agricultural year in the south-west of Romania, after 1960. An exceptional variability of daily, monthly, seasonal and annual rainfalls has been marked during this period. The year 2014 was marked by many exceptionally rainy consecutive months, with many intervals of heavy and torrential rain. *The rainy intervals were interrupted by two months of dryness:* February, exceptionally dry and November - very dry. The analysis of the climatic conditions in the south-west of Romania, in autumn 2014 is a continuation of the extensive studies on the climate variability (Marinica, 2006; Marinica, 2013; Sandu, Elena, Marinica, Vatamanu, 2012; Octavia, Marinica, Andreea, 2014).

The analysis of these important climate variations, effects and the causes of them will follow.

Results and Discussion

The analysis of the annual rainfall quantities recorded in 2014 in the south-west of Romania (Table 1) shows that in 2014, there were 13 absolute rainfall records throughout the data stream after 1955, meaning from the last 57 years, far exceeding the annual rainfall values recorded until 2005, which was the wettest year, prior to 2014.

These records have been registered at the following meteorological stations:

- Drobeta Turnu Severin, *the value of 1167.9* l/m^2 is the absolute record for this station and the second value which exceeds 1000.0 l/m^2, after the value of 1008.3 l/m^2, registered in 1969, exceeding with 159.6 l / m2 the old record rainfall, after 45 years.

- Calafat, the value of 979.8 l/m^2 is the first absolute rainfall record and the first value of over 900.0 l/m^2 from all the stream data at this meteorological station, exceeding with 170.4 l/m^2 the old record rainfall of 809.4 l/m^2, registered in 2005.

Table 1 – The monthly and annual rainfall values recorded in Oltenia[1] in 2014 (l/m^2)

Meterological station	Hm	I	II	III	IV	V	VI
Dr. Tr. Severin	77	70.4	26.8	75.3	123.2	176.4	93.8
Calafat	66	54.8	9.2	77.3	149.4	92.8	72.6
Bechet	65	***52.2***	***4.4***	81.7	124.6	112.6	***70.6***
Bailesti	56	63.4	12.7	85.7	***99.9***	***86.2***	95.6
Caracal	112	63.5	5.5	80.1	117.0	112.4	98.2
Craiova	190	81.7	8.2	97.1	125.0	154.8	133.8
Slatina	165	80.8	8.1	79.9	152.8	132.0	74.4
Bâcles	309	50.5	17.9	73.0	128.5	154.6	167.7
Tg. Logresti	262	73.0	17.7	75.8	139.3	131.0	**187.2**
Dragasani	280	64.0	9.9	62.3	151.4	**179.4**	161.4
Apa Neagra	250	**101.5**	**32.6**	**107.8**	**197.4**	211.2	123.8
Tg. Jiu	210	86.6	29.8	78.1	133.0	99.4	87.4
Polovragi	546	74.8	32.0	76.9	137.4	161.6	90.4
Rm. Vâlcea	243	81.8	18.5	64.7	161.7	139.4	132.2

Voineasa [1]	587	3.9	6.0	28.7	122.9	148.2	90.1
Parâng	1585	22.4	17.1	49.0	123.6	174.4	169.8
Media Oltenia	-	64.1	16.0	74.6	136.7	141.7	115.6
Ob. Lotrului	1404	28.1	25.3	38.2	47.2	90.4	118.2
Halânga	76	74.1	30.5	57.3	114.9	166.6	109.1
Statia Meteorologica	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Anual**
Dr. Tr. Severin	117.6	27.4	230.6	61.8	45.1	119.5	1167.9*
Calafat	157.9	32.0	127.4	45.2	50.6	110.6	979.8*
Bechet	77.2	***12.6***	124.6	47.4	35.8	96.8	***840.5*** *
Bailesti	141.6	41.4	206.1	38.4	37.8	125.6	1034.4*
Caracal	***58.5***	23.6	**175.2**	52.0	***20.4***	130.9	937.3*
Craiova	92.8	55.6	160.6	51.8	34.9	150.9	1147.2*
Slatina	174.0	38.4	52.4	47.0	24.8	166.5	1031.1*
Bâcles	177.6	92.2	172.8	***25.4***	27.5	21.7	1109.4*
Tg. Logresti	216.2	39.6	57.4	59.8	26.4	116.6	1140.0*
Dragasani	196.6	59.0	41.8	55.8	35.0	139.9	1156.5*
Apa Neagra	167.6	84.6	109.6	**152.8**	**64.8**	**218.0**	**1571.7***
Tg. Jiu	173.4	43.2	60.6	107.4	31.1	149.1	1079.1
Polovragi	**290.4**	16.8	51.6	107.2	26.0	106.3	1171.4
Rm. Vâlcea	230.0	87.2	***28.4***	48.6	29.4	113.0	1134.9*
Voineasa	261.1	**116.2**	83.4	81.2	34.3	***6.5***	982.5
Parâng	268.7	118.6	87.5	124.2	25.6	67.1	1248.0
Media Oltenia	**175.1**	55.5	110.6	69.1	34.3	114.9	1108.2*
Ob. Lotrului	**299.6**	95.2	78.3	124.5	37.8	66.3	1049.1
Halânga	130.3	37.3	144.1	64.3	37.0	114.0	1079.5

Processed data by ANM – CMR Oltenia SMA Craiova

- Bechet, the value of 840.5 l/m^2 is the absolute rainfall record for this meteorological station, exceeding with 22.9 l/m^2 the previous record of 817.6 l/m^2, registered in 1957. At Bechet, we mention that only three annual rainfall values exceeded 800.0 l/m^2. These are: 817.6 l/m^2 in 1957, 807.8 l/m^2 in 2005 and 840.5 l/m^2 in 2014, the last value being recorded after 9 years compared to 2005, while the value in 2005 was recorded after 49 years, which shows an increase of frequency in exceptional rainfall values, valid for all the meteorological stations in Oltenia.

- Bailesti, the value of 1034.4 l/m^2 is the absolute rainfall record, being the first value over 1000.0 l /m^2 at this station, which exceeds with 184.4 l/m^2 the previous record of 850.0 l/m^2,

[1] The values marked with * are rainfall records for the period after 1955. Obârşia Lotrului and Halânga meteorological stations with short stream data can not be taken into consideration for the average values, that is why they are included as annex rows in tables.

[2] Bâcleş, Voineasa and Obârşia Lotrului meteorological stations became autonomous (automatic functioning): in July 2011 (Bâcleş) and December 2009 (Voineasa and Obârşia Lotrului), and as a result the rainfall sensor is covered in the cold season, so the monthly rainfall data in the winter months at these stations are incorrect. As a result, the annual amounts after these years are also incorrect.

registered in 2005, the previous record before 2005 being of 740.3 l/m^2, registered in the rainy year 1970, which confirms, for this station as well, the increase of the annual rainfalls and the frequency of the exceptional values.

- Caracal, the value of 937.3 l/m^2 is the absolute rainfall record for this meteorological station, exceeding with 35.5 l/m^2 the previous record of 901.8 l/m^2, registered in 2005, which was the wettest year prior to the year 2014. This value is the second value over 900.0 l/m^2 from all the stream data and exceeds with 177.8 l/m^2 the previous record of 739.5 l/m^2 of the last century, prior to 2005, recorded in 1979, which confirms, for this station, the increase of the annual rainfalls and the frequency of exceptional rainfall values.

- Craiova, the value of 1147 l/m^2 is the second of over 1000.0 l/m^2 from all the stream data, exceeding with 64.9 l/m^2 the previous record of 1082.3 l/m^2 in 2005 and with 354.8 l/m^2 higher than the record in the last century of 792.4 l/m^2, registered in 1972, which confirms, for this station, the increase of the annual rainfall and the frequency of annual exceptional values. It can also be noticed that at this station, until 2005, no annual value reached 800.0 l/m^2, which confirms the quite exceptional character of these two values in 2005 and 2014.

- Slatina, the value of 1031.1 l/m^2 is the absolute rainfall record and the first value which exceeds 1000.0 l/m^2, being higher with 32.0 l/m^2 than the old rainfall record of 999.1 l/m^2 recorded in 2005 and with 232.8 l/m^2 higher than the record of the last century of 798.3 l/m^2 registered 34 years ago, in 1980. These significant differences for this station confirms the increase of the annual rainfall values and the frequency of exceptional rainfall values.

- Bâcles, the value of 1109.4 l/m^2 is the absolute rainfall record, the first that exceeds 1000.0 l/m^2, higher with 200.4 l/m^2 than the old rainfall record of 909.0 l/m^2 registered in 2005 and with 287.7 l/m^2 higher than the record in the last century of 821.7 l/m^2 registered 46 years ago, in 1972. These particularly significant differences also confirm the increase of the annual rainfall values and the frequency of exceptional rainfall values, for this station.

- Tg. Logresti, the value of 1140.0 l/m^2 is the absolute rainfall record, the first that exceeds 1000.0 l/m^2, higher with 161.4 l/m^2 than the old record rainfall of 978.6 l/m^2 registered in 2005 and with 234.4 l/m^2 higher than the record in the last century, of 905.6 l/m^2 registered 46 years ago, in 1972. These particularly significant differences also confirms, for this station, the increase of the annual rainfall values and the frequency of exceptional rainfall values. It can be noticed that for this meteorological station, only these three values of 905.6 l/m^2, 978.6 l/m^2 and 1140.0 l/m^2 exceeded 900.0 l/m^2.

- Dragasani, the value of 1156.5 l/m^2 is the absolute rainfall record, being the second value exceeding 1000.0 l/m^2, higher with 122.0 l/m^2 than the old rainfall record of 1034.5 l/m^2 registered in 2005 and with 257.5 l/m^2 higher than the previous record, in the last century, of 899.0 l/m^2 registered 48 years ago, in 1966. These particularly significant differences also confirm, for this station, the increase of the annual rainfall values and the frequency of exceptional rainfall values.

- Apa Neagra, the value of 1156.5 l/m^2 is the absolute rainfall record, the first that exceeds 1500.0 l/m^2 and higher with 132.5 than the old rainfall record of 1439.2 l / m2 registered in 1999, with 147.9 l / m2 higher than the previous record of l/m^2 the last century, of 1423.8 l/m^2 registered 15 years ago, in 1999 and with 189.6 l/m^2 than the old rainfall record of 1382.1 l/m^2 registered 45 years ago, in 1969. These particularly significant differences also confirm, for this station, the increase of the annual rainfall values and the frequency of exceptional rainfall values.

The value of 1571.7 l/m^2, registered at Apa Neagra, which belongs to the Pades commune in the Gorj county, is the absolute annual maximum for all the meteorological stations in Oltenia (Table 1).

[3] Until 2010, in Craiova, a single annual rainfall value was ≥ 800.0 l / m2: the annual amount of 834.3 l / m2 in 2010.

- Rm. Vâlcea, the value of 1134.9 l/m^2 is the absolute rainfall record, the second that exceeds 1000.0 l/m^2, higher with 49.6 l/m^2 than the old rainfall record of 1085.3 l/m^2 registered in 2005 and with 230.6 l/m^2 higher than the record of the last century, of 904.3 l/m^2 registered 48 years ago, in 1966. These particularly significant differences also confirm, for this station, the increase of the annual rainfall values and the frequency of exceptional rainfall values. For this station, one can notice that only these three values of 904.3 l/m^2, 1085.3 l/m^2 and 1134.9 l/m^2 exceeded 900.0 l/m^2.

For the compact period of rainfall observations (1977 – 2014), the annual average of rainfall values calculated for the entire region of Oltenia[4] were between 340.2 l/m^2 in the excessively dry year 2000 and 1108.2 l/m^2 in the excessively rainy year 2014 (Table 2).

Of all the series of meteorological observations, the first year when the overall average for the entire region has exceeded 1000.0 l/m^2 was the excessively rainy year 2005 with an average of 1016.4 l/m^2, and the second year was 2014, with an average of 1108.2 l/m^2, exceeding, after nine years, the value in 2005, of 91.8 l/m^2, which is a significant increase for this parameter. In the last century, the average maximum rainfall record for the general average, for the whole region is 830.0 l/m^2, registered in the rainy year 1979 and its first spectacular exceeding of 186.9 l/m^2, higher with 22.51% was registered after 26 years, in 2005. A second spectacular exceeding of 378.2 l/m^2, meaning almost half percentage – 45.56 % was registered after only 9 years.

Table 2 – The annual average rainfall values calculated for the entire region of Oltenia, during a compact period of measurements[2] 1977 – 2014

Year	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
Average	605.7	665.6	***830.0***	815.9	754.0	639.1	479.5	697.7	558.5	566.8
Year	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Average	629.3	592.3	550.1	522.4	736.5	428.4	506.4	545.2	689.3	628.6
Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Average	636.8	717.0	778.9	***340.2***	629.7	718.7	684.2	753.6	**1016.4**	729.2
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**		
Average	***836.9***	625.7	759.0	833	461.2	580.9	734.8	**1108.2**		

Processed data by ANM – CMR Oltenia SMA Craiova

A modest overrun, with only 6.9 l / m2 was registered in 2007, in spring and the first two months of dry summer, because of the heavy rains from August to November.

These particularly significant differences confirm, for the entire region, the increase of the annual rainfall values and the frequency of exceptional values. The multiannual average

rainfall value, for the entire region, calculated for the compact observation period at all the meteorological stations, since the last century, is 621.4 l/m^2, and for the entire period until 2014 is 668.0 l/m^2, indicating a significant increase with 46.6 l/m^2. The annual average rainfall values, calculated for the entire region, for the period 2001 – 2014 is 748.0 l/m^2, which shows a dramatic increase with 127.6 l/m^2, compared to the last century.

The general average variation graph for the entire region, from this common compact period at all the meteorological stations shows a strong upward trend of the growth coefficient of 3.6468 (Figure 1).

In 2014, there were registered 14 annual rainfall values over 1000.0 l/m^2, meaning 4 values more than in 2005. The year 2005 was the first year when a meteorological station in the Oltenia Plain – Craiova, exceeded 1000.0 l/m^2, exceeding the absolute maximum of the last century, of 792.4 l/m^2 recorded in 1972, higher with 289.9 l/m^2, meaning 36.58 %, while in 2014, this record exceeded 354.8 l/m^2, higher with 44.77 %.

In 2014, three meteorological stations in the plain area recorded annual values of over 1000.0 l/m^2: Dr. Tr. Severin, Bailesti and Craiova and two stations in the Getic Piedmont: Slatina and Bâcles.

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[4] *The absolute annual maximum rainfall in Oltenia* (both for the meteorological stations and rainfall record stations) is of 1733.9 l / m2, registered in 1912 in the Valcea county, at Pesceana Cueni rainfall record station, on the river with the same name (Marinica I., 2006 pp. 6 si 357).

[5] The Slatina meteorological station has compact observations since 1977, thus the whole period of compact observations for the whole region is 1977 - 2014. In Slatina, the meteorological station has operated since 1893, but with interruptions, and old data rows are interrupted. Officially, 1977 is considered the year of establishment for the Slatina meteorological station.

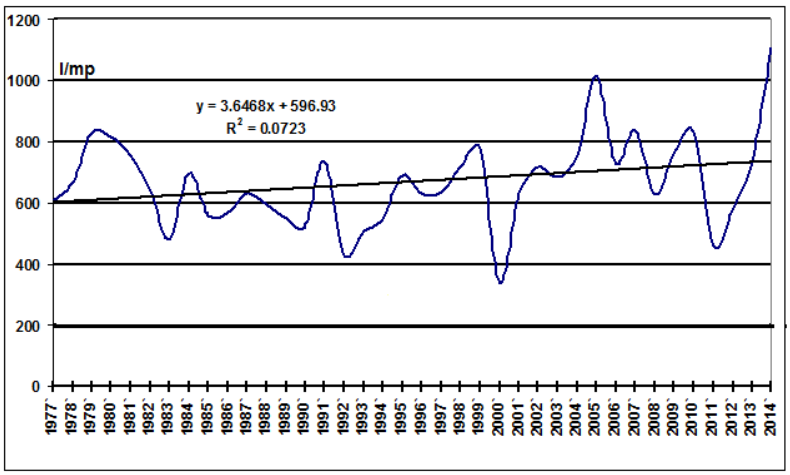

Figure 1. The annual average rainfall variation, calculated for the entire region of Oltenia, during the period 1977 – 2014

Processed data ANM – CMR Oltenia SMA Craiova

The analysis of monthly rainfall values and the results of applying the Hellmann criterion (Bogdan Octavia, Niculescu El., 1999; Marinica I., 2006) show that:

- in *January 2014*, the monthly rainfall amounts ranged from 50.5 l/m^2 at Bâcles, in the Mehedinti Hills to 101 l/m^2 at Apa Neagra, in the Sub-Carpathian Basin, while the deviations from the annual average, calculated for the period 1901-1990 were between 29.2 % at Calafat to 130.4 % at Ramnicu Valcea, designating an excessively rainy month in most of the region. *The monthly average for the entire region was 64.1* l/m^2, and its percentage deviation from normal was 46.0%, which means *a very rainy month, on average* for the entire region. January was marked by two very rainy periods: January 19 – 21, January 24 – 26, and the latter were heavy rainfalls. *The maximum amount of rainfall recorded in 24 hours was 46.8* l/m^2 *at Babeni and Berislavesti, in the Vâlcea County*, *on January 25, which was the wettest day in January, with the average for the region of 18.9 l / m2.*

- *February 2014* was excessively dry, being interruped by a rainy period, with a general average of 16.0 l/m^2.

- in *March 2014*, the monthly rainfall amounts ranged from 62.4 l/m^2 at Dragasani to 97.1 l/m^2 at Craiova, and the deviations of the annual average percentage ranged from 32.9 % at Caracal, in the Romanati Plain to 124.4 % at Bâcles, designating an excessively rainy month in most of Oltenia. *The monthly average rainfall for the region was 73.6* l/m^2, and the percentage deviation from the annual average of 75.5 % confirmed that *March was excessively rainy*, in average for the whole region. In March, there was a single five – day excessively rainy interval, March 2 – 6. *The maximum amount of rainfall in 24 hours was 41.4* l/m^2 *at Gabru, in the Dolj County, recorded on March 6, which was the wettest day in March, with an average of 19.1* l/m^2 for the entire region. During this month, there were recorded the first floods of 2014, in some areas of Oltenia.

- in *April 2014*, the monthly rainfall amounts ranged from 99.5 l/m^2 at Bailesti in the Oltenia Plain to 197.4 l/m^2 at Apa Neagra, while the deviations from the annual average percentage ranged from 50.5 % at Bailesti to 111.3 % at Dragasani, in the Olt Valley, designating *an excessively rainy month* throughout Oltenia. The monthly average rainfall for the whole region was 135.8 l/m^2, and its percentage deviation from the annual average was 135.8 %, confirming that April was an excessively rainy month, in average for the region. In April, there have been recorded two excessively rainy periods: April 15 – 19 and Aprilie 23 – 24, summing up 7 days, while *the maximum rainfall amount in 24 hours was 56.2* l/m^2 *at Filiasi, in the Dolj county,* on April 16, being the wettest day in April 2014, with an average for the whole region of 28.8 l/m^2. During this month, there have been registered floods in some areas of Oltenia, including Craiova. The amount of 197.4 l/m^2 registered at Apa Neagra is *the rainfall record* for this meteorological station, being the largest in the last 59 years (during the periodl 1956 – 2014).

- in *May 2014*, the monthly rainfall amounts ranged from 86.2 l/m^2 at Bailesti in the Oltenia Plain to 211.2 l/m^2 at Apa Neagra, and the deviations from the annual average percentage ranged from 16.5 % at Tg. Jiu to 157.4 % at Dragasani, in the Olt Valley, designating *an excessively rainy month* in most part of Oltenia. *The monthly average rainfall for the whole region* was 141.7 l/m^2, and its percentage deviation from the annual average of 77.9 % confirmed that May was excessively rainy, being over the average for this region. In May, there were registered three excessively rainy periods: May 2 – 5, May 12 – 15 and May 29 – 30, summing up 10 days, while *the maximum amount of rainfall in 24 hours was 86.0 l/m^2 at Spineni in the Olt County*. On 14th of May, it was the wettest day in May 2014, with a value of 53.7 l/m^2 over the average of the region. During this month, there were recorded floods on large areas of Oltenia, including

Craiova. The amount of 211.2 l/m^2 registered at Apa Neagra, is the fifth value over 200.0 l/m^2, in descending order, registered at this meteorological station, the largest after 1987, for the last 28 years, between 1987 – 2014.

- in *June 2014*, the monthly rainfall amounts ranged from 72.6 l/m^2 at Calafat, in the Oltenia Plain to 187.2 l/m^2 at Tg. Logresti in the Hills of Oltenia, while deviations from the annual average percentage ranged from 19.5 % at Polovragi to 158.9 % at Tg. Logresti, designating *a very rainy and excessively rainy month* in most parts of Oltenia. *The monthly average rainfall for the whole region was 115.6* l/m^2, and its percentage deviation from the annual average was 37.0 %, confirming that June was very rainy, on average, for the region. In June, there were registered four excessively rainy periods June 2 – 4, June 15 – 20, June 24 – 26 and June 30, summing up 13 days, while *the maximum amount of rainfall in 24 hours was 65.0* l/m^2 *at Craiova, in the Dolj County*, on June 18, being *the wettest day in June 2014, with an average of 18.6* l/m^2 *for the whole region*. During this month, there were recorded floods on the large areas of Oltenia, including Craiova. *The amount of 187.2* l/m^2 registered at Tg. Logresti is the second value, in descending order, registered at this meteorological station, being the largest after 1975, for the past 40 years in the period 1975 – 2014.

- in *July 2014*, the monthly rainfall amounts ranged from 58.5 l/m^2 at Caracal in the Romanati Plain to 290.4 l/m^2 at Polovragi, in the SubCarpathian Basin, while the annual average percentage deviations were between 8.7 % at Caracal and 336.8 % at Tg. Logresti, designating *an excessively rainy month* in most of Oltenia, except for a small area, at Caracal, where rainfalls were normal. *The monthly average rainfall for the whole region was 175.1* l/m^2, while the percentage deviation from the annual average was 169.5 %, confirming that July was *exceptionally rainy,* in average for the whole region. In July, there were recorded five excessively rainy periods July 3, July 8 – 11, July 14 – 19, July 21 – 23, July 25 – 31, summing up 21 days, while *the maximum amount of rainfalls in 24 hours was 112.6 was* l/m^2 *at Sadu, in the Gorj county*, on July 27, *the rainiest day of July 2014, with the average for the region of 36.1* l/m^2. During this month, there were registered floods in large areas of Oltenia, particularly intense on 27th, 28th, including Craiova. *The amount of 290.4* l/m^2 registered at Polovragi is the second value, in descending order, registered at this meteorological station, the largest after 1991, for the last 24 years, in the period 1991 – 2014. July was the wettest month of 2014.

- A*ugust* was the hottest month of the year 2014 and with normal rainfall values, in average for the whole region, with the general average of 55.5 l/m^2.

- in *September 2014*, the monthly rainfall amounts ranged from 28.4 l/m^2 at Râmnicu Vâlcea in the Olt Valley to 230.6 l/m^2 at Dr. Tr. Severin, while the deviations from the annual average percentage ranged from – 46.6 % at Râmnicu Vâlcea to 497.4 % at Bailesti, designating a month with rainfall characteristics from very dry to the restricted area of Râmnicu Vâlcea to excessively rainy in most parts of Oltenia. *The monthly average rainfall values for the whole region were 110.6* l/m^2, and its percentage deviation from the annual average was 134.0 %, confirming that September was *exceptionally rainy*, in average for the region. In September, there were recorded three excessively rainy periods September 3 – 6, September 14 – 16, September 22 – 23, summing up nine days, *while the maximum amount of rainfall in 24 hours was 102* l/m^2 *at Dr. Tr. Severin,* in the Mehedinti county, on September 14, being one of *the wettest days of September 2014 with an average for the whole region of 16.1* l/m^2*.* During this month, there have been severe flooding on large areas of Oltenia, both in the western and

eastern parts, particularly intense on September 5 and 14, including Caracal, on September 5 and then in the western part, in the area Orsova and Dr. Tr. Severin, on September 14. The amount of 230.6 l/m^2 recorded at Dr. Tr. Severin, is *an absolute rainfall record* for this meteorological station, being the largest in September, within all stream values, exceeding with 91.1 l/m^2, higher with 65.3 % than the old record rainfall in 1972 of 139.5 l/m^2, for the period 1956 – 2014.

At Dr. Tr. Severin, *the value of 230.6* l/m^2 *in September 2014 is an absolute climate record for this station, being the highest monthly value of the last 53 years and the first value greater than 200* l/m^2, while the amount of 102.0 l/m^2 recorded in 24 hours, on September 14, 2014, is the second maximum amount of rainfalls in 24 hours after the 171.7 l/m^2 registered on July 30, 1969. The value of 175.2 l/m^2 is *a climatic record for September* at the Caracal meteorological station, being 1.5 times higher than the previous record of 114.2 l/m^2 in September 2005. *Other climate rainfall records in this month were: 124.6* l/m^2 *at Bechet, 206.1* l/m^2 *at Bailesti (the first value over 200* l/m^2 *in September at this station), 175.2* l/m^2 *at Caracal, 160.6* l/m^2 *at Craiova and 172.8* l/m^2 *at Bâcles*. These records have far exceeded the old monthly rainfall records registered at these stations during the last century. The value of 127.4 l/m^2 at Calafat is the second value in September from all stream data of this station, after that of of 147.1 l/m^2 on September 1, 1996.

- in *October 2014*, the monthly rainfall amounts ranged from 25.4 l/m^2 at Bâcles, in the Hills of Mehedinti to 152.8 l/m^2 at Apa Neagra, while the deviations from the annual average percentage ranged from – 55.5 % at Bâcles to 129.1 % at Apa Neagra, designating a month with rainfall characteristics from excessively dry in an restricted area at Bâcles to *excessively rainy* in the Subcarpathian area and the mountains. *The monthly average rainfall value for the entire region was 69.1* l/m^2, and its percentage deviation, compared to the annual average was 28.2 %, thus considering October *the rainy month*, on average for the whole region. In October, there was only one excessively rainy interval, October 22 – 24, summing up 3 days, while *the maximum amount of rainfall in 24 hours was 116.4* l/m^2 *at Sadu, in the Gorj county*, on October 23, which was *the wettest day in October 2014, with the average for the region of 26.3* l/m^2. This month, there were floods in large areas of the Oltenia Subcarpathians, on October 23.

- *November 2014* was very dry, interrupting again, the rainy period, with an average of 34.3 l/m^2.

- in *December 2014*, the monthly rainfall amounts ranged from 96.8 l/m^2 at Bechet, in the extreme south of the region to 218.0 l/m^2 at Apa Neagra, while the percentage deviations from the annual average were between 89.5 % at Polovragi to 289.0 % Polovragi at Slatina, designating an *excessively rainy month* in most of Oltenia, excepting the mountain area where it was rainy. *The monthly average rainfall value for the whole region was 129.3* l/m^2, and its percentage deviation from the annual average was 163.1 %, confirming that December was *exceptionally rainy*, in average for the whole region. In December, there were three excessively rainy periods: December 1 – 2, December 6 – 10, December 26 – 28, summing up 10 days, while *the maximum amount of rainfall in 24 hours was 69.8* l/m^2 *at Sadu, in the Gorj county*, on December 9, being *one of the wettest days of December 2014 with the average for the whole region of 27.4* l/m^2. During this month, there were registered floods on large areas of Oltenia, on December 6 and 9. The amount of 218.0 l/m^2 registered at Apa Neagra, is the third value in descending order, for this meteorological station, being the largest in December from all the stream values recorded after 1990.

As a result, in 2014, in the south-west of Romania, there were registered 23 excessively rainy intervals, which summed up 84 excessively rainy days, representing 23.0 % of the year, in which the rains also had a torrential character. The rainy period had a space-time expansion of 70.7 %, the normal one of 6.4 % and the dry one of 22.9 %. *The highest rainfall amount in 24 hours was 116.4 was* l/m^2 *at Sadu, in the Gorj county*, on October 23. The rainy day in 2014 was registered on July 27, with an average for the whole region of 36.1 l/m^2. There were 21 rainfall records throughout the year and 23 intervals with floods on different areas of Oltenia. Thus, the year 2014 is appreciated 'the year of rainfall records'.

At continental level, large-scale floods were recorded in different months in the Western Balkans, France, Italy etc. and the so-called Mediterranean Cyclones that hit some areas of the continent were rated as having 'the force comparable to the tropical Cyclones', because of the devastating effects of the floods and wind intensification associated with them.

The graphs of the monthly rainfall variation, for the entire period of observations have a strong linear ascending trend at all the meteorological stations in Oltenia, confirming the increase in precipitation.

The synoptic causes of heavy and torrential rains in 2014

The rains were produced by very strong Mediterranean Cyclones, whose frontal systems were very well developed and affected large areas of Europe. The high frequency of the Mediterranean Cyclones, during this year, was correlated with the negative phase of the North Atlantic oscillation. During this year, some of the strongest floods were caused by Mediterranean Cyclones (with an evolution most of their time at intermediate levels of altitude, with no correspondence to the earth surface), thus producing some problems in the forecasting activities for the people with limited work experience. However, the forecasts were very well done, firstly due to the experience of the staff in the field. There will be further analyzed examples of synoptic causes for the heavy rains during the intervals September 3 – 5, 2014, September 14 – 16, 2014.

The synoptic causes of the heavy rains during the interval of September 3 – 5, were produced by a powerful Mediterranean Cyclone with intermediate levels of development in the atmosphere, with no correspondent at ground level, for most of the period, as shown in Figure 2. Its trend was trans-Balkanic and within September 5, at 6 o'clock UTC and September 5, at 12 o'clock UTC, it had a poor correspondent at the Earth's surface. This type of cyclone formed at the southern periphery of the Central European AntiCyclone with a Scandinavian dorsal is particularly strong, usually having a triple supply of hot and humid air from above the Mediterranean Sea (mT), with some cool and humid air from above the Black Sea (MP) and cool air, even cold (mP + cP) from above the North Sea, with an advection at the periphery of the antiCyclone.

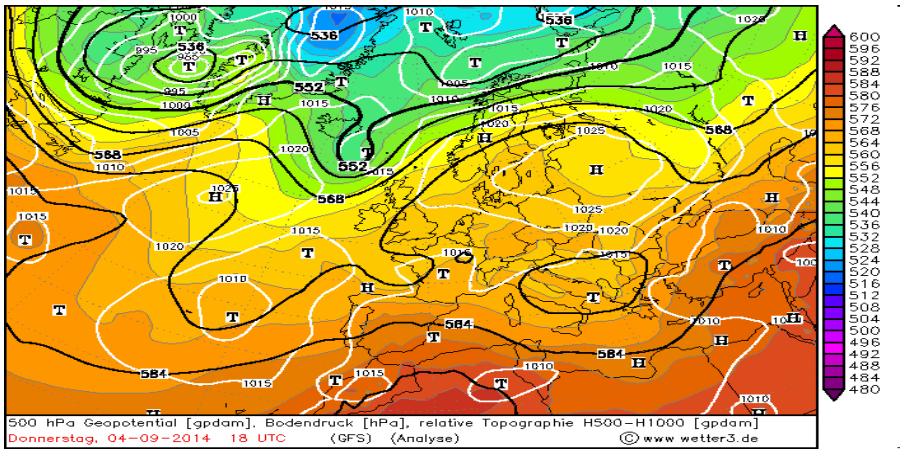

Figure 2. The synoptical situation on the ground and altitude at 500hPa level, superimposed over the TA 500/1000 relative topography, on September 4, 2014, at 18 o'clock UTC
Source: www.wetter3.de

This rich humid air supply causes an intense precipitation of the cloud systems and their interaction with the relief forms increases precipitations in certain areas [6].

The heavy rainfalls during September 14 –15, 2014 produced floods in the west part of the region and in the Caras-Severin County. On the night of September 14 to September 15, 2014, there were torrential rainfalls. Between September 14, at 7 o'clock UTC – September 15, at 7 o'clock UTC, the maximum value in 24 hours was 102.0 l / m at Dr. Tr. Severin, of 50.1 l / m at Halânga and 24.1 l / m at Bâcles. The area most affected was the one between Dr. Tr. Severin and Orsova. The road was flooded and damaged by water leaks with mud, rocks and liquid soil (called in the regional language 'lavina' soil - word of German origin and used in Serbia, Germany, Austria etc. and actually designating a leak under form of an avalanche). The road was blocked by the cars caught in the avalanche and they were damaged or buried by mud and rocks. There has been a victim as a result of asphyxiation, the car being buried by the 'lavina'. Two other people, in the same car, have been resuscitated and saved.

In Dr. Tr. Severin area, the rain started on September 14, at 13 o'clock UTC and lasted, with some flashes, until September 15, at 20 o'clock UTC, showing that the duration of the rain was of 30 hours, during which the rainfalls summed up 170.4 l / m2, which means an average intensity of 5.7 l / m2 / hour, and which, according to the Hellman criterion for torrential rainfalls, indicates *an excessively torrential rain*.

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[6] This type of Mediterranean Cyclone formed at this junction, produces short time and heavy torrential rainfall on most parts of Europe, that is why the Romanian researchers (in the last century) have called it 'the European summer monsoon'. In the warm years, in the northern hemisphere, this Cyclone is also formed during autumn.

The synoptic situation from September 15, 2014 at 18 o'clock UTC is: at *ground level,* on September 14, 2014 at 18 o'clock UTC, the position of the barometric centers of atmospheric action above Europe was as it follows: the Azore AntiCyclone was positioned in the North Atlantic

having a value above 1025 hPa at the center, as shown in Figure 3. This was united by a high atmospheric pressure waist with the Scandinavian AntiCyclone, positioned over the Scandinavian Peninsula, having values above 1030 hPa at the center. On the Atlantic Ocean, a Cyclone of Icelandic origin was positioned at west of the Iberian Peninsula, being located in the elevated thalweg of the Icelandic Depression, with values below 995 hPa at the center.

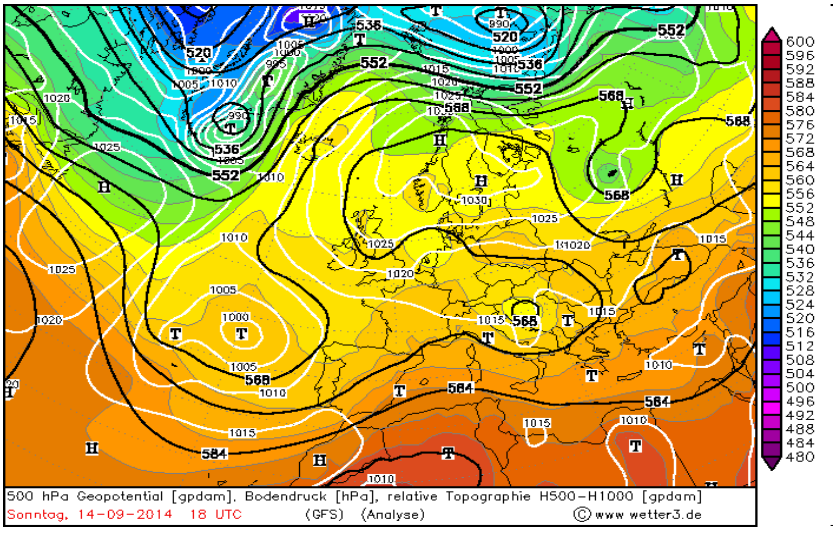

Figure 3. The synoptic situation on the ground and altitude at 500 hPa level, superimposed over the TA 500/1000 relative topography, on September 14, 2014, at 18 o'clock UTC
Source: www.wetter3.de

The Icelandic Cyclone was located at the west of Iceland, on the southwest coasts of Greenland. Another Cyclone of Icelandic origin was located at the east of Svalbard Archipelago, with a value below 990 hPa at the center. In the Minor Asia Peninsula, the Arabic Cyclone was present, partially stationary in the warm season of the year, with values under 1010 hPa in the center. Above the Mediterranean Sea, an extreamly low preassure field, almost uniform, was present, having values around 1015 hPa.

In the lower troposphere, below 500 hPa, the air circulation for Oltenia was of north-eastern type, this air mass being advected at the periphery of the Scandinavian AntiCyclone, bringing an air riched in water vapor from above the North Sea and Black Sea.

At the level of 500 hPa, in the upper troposphere, the Western and Northeastern Europe was located in a low geopotential field, the value for the rainfall curves, characteristic for this date, being of 576 damgp. The South-East and North Europe were situated in the high geopotential dorsal. The shape of the rainfall curve of 576 damgp, similar to the letter 'Ω' shows that there was a traffic jam in altitudine.

At this level, three low geopotential cores can be noticed: one located on the south-eastern coasts of Greenland, over the Icelandic Cyclone and corresponding to its values of under 528 damgp center, a second one located above the Svalbard Archipelago with values below 520 damgp in the center and a third one, of interest to us, located above Serbia and Montenegro, on the Adriatic coast, with values below 568 damgp.

This third geopotential core explains the presence of an atmospheric disturbance of Mediterranean cyclonic type, with an evolution at the levels of altitude in the atmosphere, without any correspondence at ground level. It is actually the same type of Mediterranean Cyclone like the one that hit Oltenia between September 4 – 5, 2014.

For Oltenia, the air circulation, at 500 hPa level, was of south-west origin, feeding in altitudine, the south-western Mediterranean Cyclone with hot and humid air, riched in water vapor from above the Mediterranean Sea, but also from above the Atlantic Ocean.

As a result, this Mediterranean Cyclone, with an evolution at altitude levels, actually has a strong quadruple supply of water vapor which supported it.

The cloud systems have been highly developed and produced heavy rainfall in large parts of the continent (Figure 3). The torrential rains were continuous, with a duration of 24-36 hours in certain areas of the Caras-Severin and Mehedinti counties. The situation has evolved slowly over the three days of September 14, 15, 16.

Conclusions

The year 2014 was an exceptionally rainy year, when heavy rains were only interrupted in two months, February and November. At regional level, in the south-west of Romania, the year was marked by the development of 23 powerful Mediterranean Cyclones that caused heavy and torrential rains on extensive areas of Romania and Europe and, as a result, there have been registered 21 rainfall records.

It is the first year when the monthly rainfall values exceeded 1000.0 l / m2 on large areas of the Oltenia Plain, thus holding the annual absolute record.

In this article, there have been highlighted the increase of frequency in rainy intervals and of the exceptional rainfall quantities across the whole region, being underlined the increase of climatic variability.

The year 2014 was considered, in early December 2014, the warmest year since the beginning of the measurements, when each of the first nine months were recorded the warmest months of the onset temperature measurements (NOAA).

However, in Oltenia and even throughout Romania, 2014 was a year of normal heat, but excessively rainy, the annual rainfall value exceeding the values recorded in the wettest year 2005.

Like 2014, 2005 was a normal thermal year in Oltenia and Romania, but excessively rainy.

The rainfall amounts recorded in 2014 have exceeded, by far, those recorded in 2005, marking a new 'threshold' of rainfall regime in this part of the country.

However, the floods were not as catastrophic as those in 2005 due to the more uniform distribution of these rains throughout the year.

The main global cause of these heavy and torrential rainfalls is closely linked to global climatic warming because of which the warmer atmosphere contains a greater amount of water vapors and therefore, there are more intense precipitation processes and the cyclone intensity is higher. All these processes are very energetic (taking into account the thermodynamics of water vapor) and produce significant changes in the temperature field with effects on the modification of air currents in the atmosphere. An important consequence is the increasing of the air circulation and water cycle in nature, with all the effects of these processes.

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