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CONSIDERATIONS ON THE CLIMATE VARIABILITY IN THE SOUTH-WESTERN ROMANIA IN 2017

Ion MARINICĂ[1], Dana Maria (OPREA) CONSTANTIN[2], Andreea Floriana MARINICĂ[3], Elena GRIGORE[2]

[1]University of Craiova, Faculty of Science, 13 A.I. Cuza Street, 200585, Craiova, Romania, *ionmarinica@yahoo.com*

[2]University of Bucharest, Faculty of Geography, Blvd. Nicolae Bălcescu no. 1, 010041, District 1, Bucharest, Romania, Phone: +4021 314 3508, *danamartines@yahoo.com*, *elazigzag@gmail.com*

[3]Bachelor of Sciences, Klimacampus, Hamburg, Germany, *marinica.andreea@gmail.com*

Abstract

2017 was the second warmest year in the Earth history since the beginning of the air temperature measurement (NASA, 2018). The average land and the ocean surface temperature in 2017 was 0.87°C above the 20th century average and below the record of 0.99 °C in 2016. Worldwide, September 2017 was the fourth warmest month recorded so far (NASA, 2018). 2017 was the warmest year of the record history without the El Nino phenomenon (NASA, 2018). According to the World Meteorological Organization, 2017 was the year of meteorological extremes (WMO, 2018). At regional level, in the South-Western Romania, the climatic variability was exceptional, marked by rapid changes from a dry weather to a rainy weather, from a cold and rainy weather to a particularly hot and droughty weather. Climate alternations were recorded each month of the year. After a cold January, with an average of the entire region of -5.1°C, being the fifth coldest month of January in the last 57 years, a warmer month than the normal winter followed, while the frost disappeared starting with February 2nd 2017. The spring was warm with drought in March throughout Oltenia, and in April and May in the Oltenia Plain. The summer was extremely hot and drought-free, with 11 absolute thermic records in August. The autumn thermic regime was installed in the South-Western Romania in the last decade of September. The summer was extended until September 19th, and the summer heat in some areas of the plain until September 17th. The autumn of 2017 was warm and overwhelming. In December, on 25th, the highest temperature values (between 12.7°C at Voineasa and 18.9°C at Calafat) were recorded, so the warm weather also marked this month. During the whole year, 8 months of rain and 2 rainy months or significant rainfall from agriculture and 2 normal rainfall months were recorded. The most rainy month of the year was July with a monthly average for the entire region of 99.8 l/m^2, and the driest month was June with an average of 25.2 l/m^2. As a result, water flows and water rates on the rivers have had significant variations, affecting the drought periods, with a lack of drinking water and problems for navigation on the Danube.

Keywords: heat wave, excedent precipitations, climate variability, 2017, South -Western Romania.

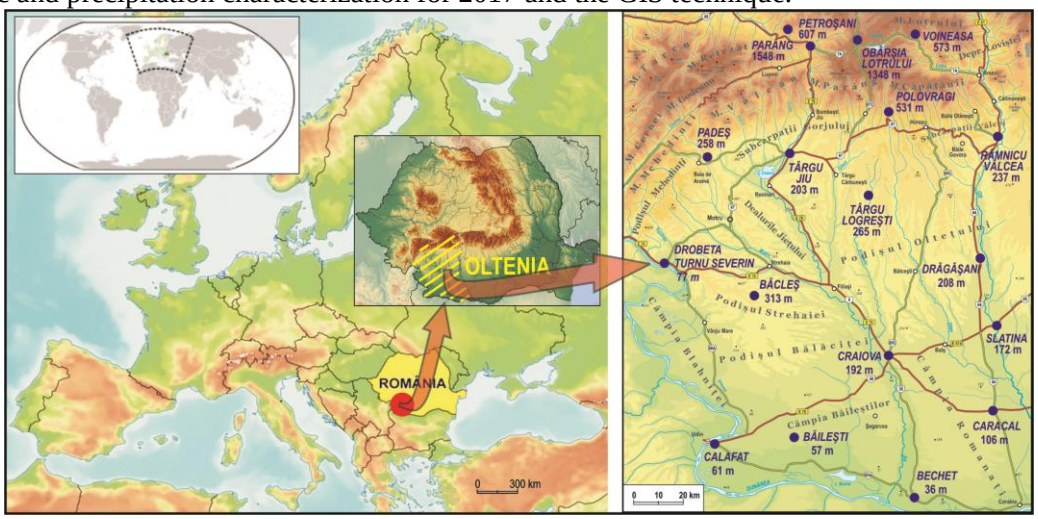
1. INTRODUCTION

During 2017, the warm weather prevailed over extended periods of time, with the exception of January, April and May in the South-Western of Romania. The study area, also known as Oltenia, represents 12% of Romania, and rises at an altitude of 20 meters in the Danube Plain to 2519 m in the Parâng Mountains (Figure 1). January 2017 was a cold month according to the Hellmann criterion, and the average temperature calculated for the whole region (-5.1°C) was the fifth cold month January, in the last 57 years, in descending order of the average temperature after January 1963: in 1963 (-8.4°C), in 1985 (-6.9°C), in 1969 (-5.9°C), in 1964 (-5.3°C). However, the temperature data analysis of January, in the period 1961-2017 indicates an increasing trend (Figure 2), which confirms the continued warming of the climate at regional level in January (Marinică and Marinică, 2016). April and May were normal, then the warm weather returned and prevailed until the end of the year. The degraded rainfall regime was recorded especially in the first 8 months of the year, then in the autumn there was a pluviometric excess, and in December, the degraded rainwater regime was returned. The climate alternations from one month to the next causing a climate variability in the South-West of Romania for (Marinică et al., 2014; Marinică et al., 2016).

2. METHODS

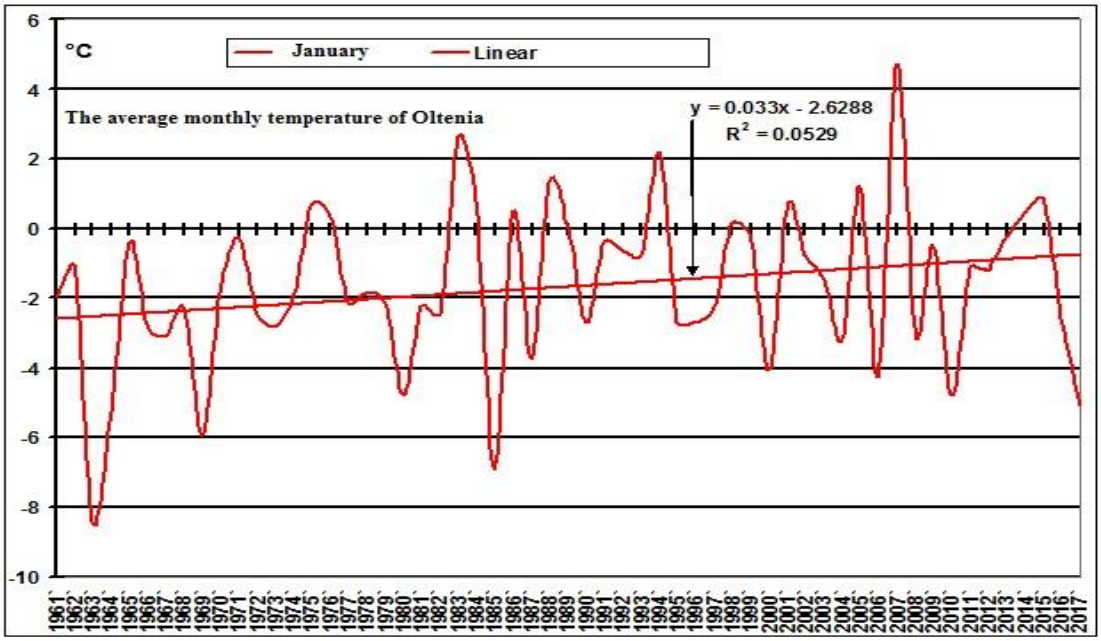
For the study, there have been used the synoptic maps from the international weather forecasting centers, the meteorological data from the archives of the National Meteorological Administration (NMA)

from the 16 meteorological stations located in the South-Western Romania (Figure 1, right), the satellite imagery and the specialized literature. There have also been used the Sprint index, the Helmann criterion for the thermic and precipitation characterization for 2017 and the GIS technique.



Source: OpenGis processed data, 2018

Figure 1. The geographic localization of the study area (left) and of the meteorological stations (right)



Source: processed data from the NMA archive, 2018

Figure 2. The monthy temperature variation in January in the South-Western Romania, for the period 1961-2017

3. RESULTS AND DISCUSSION

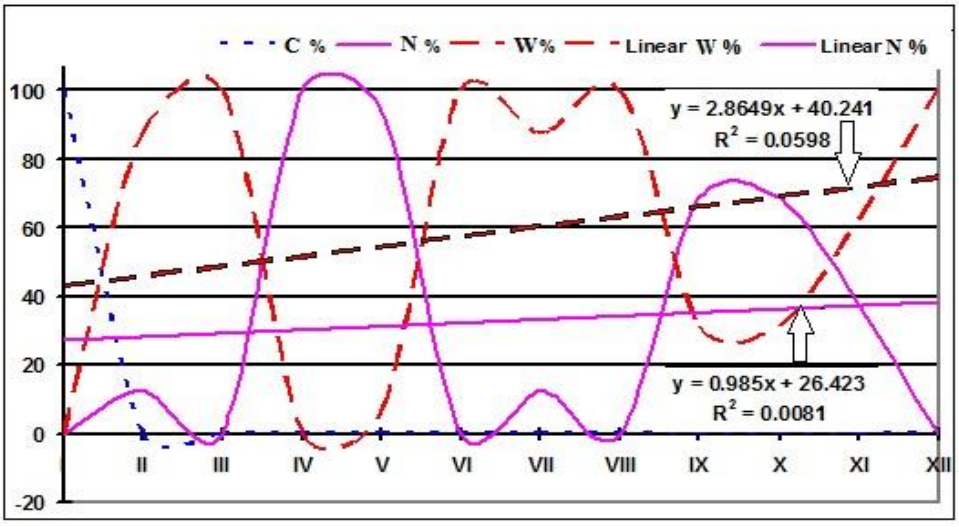
Starting the morning of February 2nd, the cold weather ended suddenly, followed by a warming up and quickly disappearance of the snow layer, so that the cold weather was recorded only during January (Table 1). The scattering indexes were between 313.9°C at Voineasa and 542.2°C at Dr. Tr. Severin and their average for the whole region was 464.4°C, being the fourth value in descending order of the whole climate data, after the 520.3°C recorded in 2016, 499.4°C recorded in 2002 and 471.4°C recorded in 2007. Figure 3 shows that the warm time (W) type had a linearly increasing trend with a significantly growth factor of 2.8649. The normal thermic time (N) had a growing trend, and the growth rate was 0.985. For the whole year, the warm time (W) had a space-time extension of 58.9%, the cold time (C) of 8.3% and the normal time of 32.8%.

The hottest months, were the summer months. In June, the monthly average temperatures ranged between 17.9°C at Voineasa and 24.8°C at Dr. Tr. Severin, many of which were slightly higher than those of July. The deviations of the monthly averages from the normals calculated for the period 1901-1990 were between 2.2°C at Bechet and Băileşti and 5.2°C at the Black Water (Padeş, district of Gorj), which according to Hellmann criterion shows that June was warm for all the relief forms of Oltenia (Table 1). The monthly thermic peaks were recorded mostly on June 29th and ranged between 32.5°C at Polovragi and Voineasa and 39.9°C at Calafat (which is also the thermic maximum, for the whole country for June 2017) and their average for the entire region was 36.2°C (Table 2). Among these, the value of 38.8°C at Craiova was the highest absolute temperature for this station, being the highest in the history of the observations for June. There were also recorded four other high values in second place, in descending order of the data strings at the respective stations: 39.4°C at Băilești; 39.7°C at Bechet; 39.5°C to 38.9°C at Slatina. As a result, June 2017 for the Slatina meteorological station was the warmest of the last 106 years, and for Craiova station the warmest since the meteorological observations were made.

Tabel 1. The matrix of the thermic time types recorded in the South-Western Romania in 2017, after Helmann Criterion (C = cold, COT = cool, N = normal, W = warm, HT = hot, VHT = very hot, EHT = extremely hot)

The meteorological station	Months of the year											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dr. Tr. Severin	C	HT	HT	N	N	HT	HT	HT	W	W	W	HT
Calafat	C	W	HT	N	N	HT	W	HT	N	W	W	HT
Bechet	C	N	HT	N	N	HT	W	W	N	N	W	HT
Băilești	C	N	HT	N	N	HT	W	HT	N	N	N	HT
Caracal	C	W	HT	N	N	HT	W	HT	W	N	W	HT
Craiova	C	W	HT	N	N	HT	W	HT	W	W	N	HT
Slatina	C	W	HT	N	N	HT	W	HT	N	N	N	HT
Bâcleș	C	HT	HT	N	N	HT	W	HT	N	W	W	HT
Tg. Logrești	C	W	HT	N	N	HT	N	W	N	N	N	HT
Drăgășani	COT	HT	VH	N	N	HT	W	HT	W	W	N	HT
Apa Neagră	C	HT	HT	N	N	EHT	W	HT	N	N	W	W
Tg. Jiu	COT	HT	HT	N	N	HT	W	HT	N	N	W	W
Polovragi	COT	HT	VH	N	N	HT	W	HT	N	N	N	HT
Rm.Vâlcea	COT	HT	HT	N	W	HT	W	HT	W	N	W	HT
Voineasa	COT	HT	HT	N	N	HT	N	HT	N	N	W	HT
Average of Oltenia	C	HT	HT	N	N	HT	W	HT	N	N	W	HT
Ob. Lotrului	C	HT	HT	N	W	HT	W	HT	N	N	W	W

Suorce: processed data from the MNA archive, 2018



Source: processed data from the MNA archive, 2018

Figure 3. The spatial-temporal extend variability (%) of the thermic types, after the Hellmann criterion, and their alternation in the South-Western Romania, in 2017

In June, there was only one heat wave of 11 days that began on June 21st, reaching the maximum intensity point on June 29th, and continued until July 2nd when it reached its second point intensity, being recorded the most of the maximum thermic peaks of July. The most surface temperature peaks were recorded on June 29th and 30th, generally slightly higher than those in July, ranging from 43.7°C at Drăgăşani to 67.3°C at Dr. Tr. Severin, with the average for the whole region of 55.1°C, higher than in July (Table 2).

Table 2. The extreme air and ground surface temperatures (°C), recorded in the months of June, July and August 2017, in South-Western Romania

The meteorological station	Tmax air VI		Tmax ground surface VI		Tmax air VII		Tmax ground surface VII		Tmax air VIII		Tmax ground surface VIII	
	(°C)	Data	(°C)	Data	(°C)	Data	(°C)	Data	(°C)	Data	(°C)	Data
Dr. Tr. Severin	38.7	29	67.3	30	38.4	22	66.6	11	41.3	5	69.0	4
Calafat	39.9	29	54.5	20	38.7	22	48.9	24	42.2	6	53.0	5
Bechet	39.7	29	53.9	30	37.8	1	51.5	30	40.4	5	56.3	6
Băileşti	39.4	29	46.2	29	37.7	1	46.4	23	40.0	5	49.9	5
Caracal	39.5	29	55.1	23	39.1	1	44.7	11	39.3	6	41.7	6
Craiova	38.8	29	63.4	29	38.9	1	63.4	22	40.8	6	65.6	4
Slatina	38.9	29	44.4	29	38.2	1	43.0	1	39.3	5	45.0	6
Bâcleş	36.7	29	-	-	35.7	11	-	-	38.3	5	-	-
Tg. Logreşti	35.4	29	59.4	30	34.8	1	55.6	11	38.3	5	64.5	6
Drăgăşani	36.6	29	43.7	30	36.4	1	41.5	1	38.7	4;5	44.5	6
Apa Neagră	35.3	29	47.7	22	34.7	22	48.0	11	38.7	5	48.6	4
Tg. Jiu	36.6	29	59.8	29	35.7	1	57.2	10	39.6	5	63.3	5
Polovragi	32.5	29	58.5	29	32.5	1	54.7	13	35.1	5	56.5	5
Rm. Vâlcea	35.4	29	62.4	24	36.2	1	60.1	10	38.6	5	63.6	6
Voineasa	32.5	30	-	-	33.0	1	-	-	33.8	5	-	-
Parâng	22.8	29	-	-	24.5	22	-	-	28.3	5	-	-
Average of Oltenia	36.2		55.1		35.8		52.4		38.3		55.5	
Ob. Lotrului	25.4	29	-	-	26.7	11	-	-	29.2	5	-	-

Source: processed data from the NMA archive, 2018

In July, the monthly air temperature averages were between 17.9°C at Voineasa and 25.8°C at Dr. Tr. Severin, and their deviations from the normals calculated for the period 1901-1990 were between 0.7°C at Craiova and 2.8°C at Dr. Tr. Severin, designating, according to Hellmann criterion, a warm month for most of Oltenia (Table 1). The most monthly air temperature peaks were recorded on July 1st and ranged from 32.5°C at Polovragi to 39.1°C at Caracal, and their average for Oltenia was 35.8°C. Although there were no absolute records, the warm weather prevailed most of the month (87.5% space-time extension). The second summer heat wave was recorded between July 7th - July 12th, for 6 days, followed by the third wave of heat in the period July 20th - July 24th and the fourth wave of heat, lasting 15 days, recorded in the period July 29th - August 12th. In Romania, on July 1st, there was the red code of high temperatures for more than half of the country (NMA, 2017). As a result of the drought, on a large part of the continent Europe (European Drought Observatory, 2017), the level of Danube at Bechet decreased with 6 cm on July 1st comparing to the previous day.

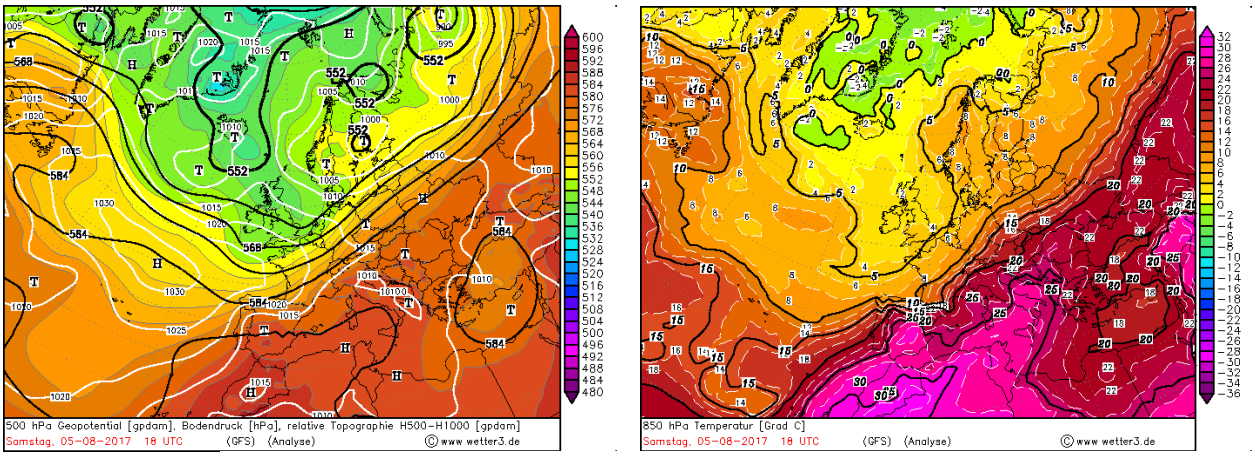
In August, the monthly average air temperatures ranged from 18.4°C at Voineasa to 26.1°C at Dr. Tr. Severin and their deviations from the multiannual averages were between 1.7°C at Tg. Logreşti and 3.9°C at Dr. Tr. Severin, leading to the classification of the hot thermic time (HT) types in most of the region (Table 1). The maximum air temperatures were recorded during the peak intensity phase of most intense heat wave in August (August 4th, 5th and 6th) and were between 33.8°C at Voineasa and 42.2°C at Calafat, with the average for the entire region of 38.3°C. During this heat wave in Oltenia, there were five absolute thermic records of 28.3°C at Parâng, 38.3°C at Tg. Logreşti, 39.6°C at Tg. Jiu, 41.3°C at Dr. Tr. Severin and 42.2°C at Calafat, the latter being the absolute thermic maximum of August 2017 for the whole Romania. In the whole country, in the period August 5th - August 6th 2017, there were 26 absolute thermic records. Also, four thermic peaks in August 2017 in Oltenia ranked second in descending order of the data strings at the respective meteorological stations: 40.8°C at Craiova is the second value after 41.0°C registered in 1922; 38.7°C at Drăgăşani is equal to the one registered in 2012; 38.7°C at Apa Neagră is the second value after 38.8°C recorded in 2015 and 29.2°C at Obârşia Lotrului is the second after 29.9°C recorded in 2012. For the

period August 2nd - August 6th 2017, a red and orange code for the whole country was issued, being the first of its kind in the entire NMA activity, which is an absolute climatic record for the whole country and also a record for NMA activity (NMA, 2017). Between August 3rd - August 6th, the heat discomfort was widened across the country and the temperature – humidity index (THI) exceeded the critical threshold of 80 across the country except for the high mountain range, reaching the peak in this summer of 86.3 at Brăila (August 6th), and in Oltenia, the maximum value was 86.0 at Calafat, being the second value in the whole country in descending order. The heat wave from July 29th - August 12th was the most intense wave after August 10th 1951, the most intense in the last 66 years, and as a spatial-temporal extension was more extended and with the longest duration consisted of a record climatic not only for Romania but even for the entire because the advection of the hot air mass has overtaken Northwards the 70° North parallel, even touching the 80° North parallel Europe (Di Giuseppe et. al., 2017).

Between August 15th and 20th, the fifth wave of heat of the summer of 2017, with a duration of 6 days, was recorded. As a result, in the summer of 2017, five heat waves with a total duration of 43 days (47.3% of the summer) were observed. At the ground surface, the thermic peaks ranged from 41.7°C at Caracal to 69.0°C at Dr. Tr. Severin with the average for Oltenia of 55.5°C, being the highest in the summer (Table 2).

The most widespread and intense heat wave of August (July 29th - August 12th 2017) reached its peak on August 5th. At ground level, on August 5th 2017 at 18 UTC, the distribution of the main action areas of the pressure field was as it follows: the Azoric Anticyclone with values of the center pressure above 1030 hPa was centered on the Atlantic Ocean and its dorsal extended over Europe up to Austria and Western Hungary (the isobar of 1015 hPa, Figure 4 left). Also, in its backward with values below 1015 hPa is the territory of Romania. To the East and South-East of the Black Sea coast, there was a vast, low-pressure, atmospheric low pressure field, stationary in this area during the warm season. The Northern Europe was dominated by a series of cyclone fields of Icelandic origin (Icelandic Cyclones) with more cyclone nuclei. In the average troposphere, at 500 hPa, most of Europe was dominated by a vast geopopathic field, and in the North of the continent by a low geopotential field (below 552 damgp). Under these conditions, for more than half of the Southern Europe, the air traffic was from the Western and South-West tropical continental (cT) sector, advecting over much of Europe a very hot air from the Northern Africa. This type of atmospheric circulation has lasted for 15 days, which has greatly contributed to the increase of air and soil temperature and water. Above the Mediterranean Sea, a weak cyclonic field is observed, with values below 1010 hPa, which has contributed to the intensification of warm air admission to the South-Western and Southern Romania.

The heat field analysis at 850 hPa (about 1500 m altitude) indicates the true magnitude of the warm air in North Africa (Figure 4 right). Thus, on August 5th, the isotherm of 25.0°C crossed the Southern Italy, the coast of the Adriatic Sea, and advanced over Serbia, approaching Romania from the South-West. Also, one can observe the main directions of the warm air advection over Europe: one over Gibraltar in the Iberian Peninsula, the other over the Southern Italy and the Balkan Peninsula up above Romania, and the third from the Arabian Peninsula over the Eastern Turkey to the South-East and South of the Black Sea. The situation maintained, with some variations in the intensity of the advection, from July 29th until August 12th.



Source: http://www1.wetter3.de/Archive/, 2018

Figure 4. The ground pressure field, superimposed over the geopotential one at 500 hPa, and the relative bargraph topography TR500/1000 from August 5th 2017 at 18 hours UTC (left); The temperature field at 850 hPa from August 5th 2017 at 18 hours UTC (right)

The advection of the extremely hot air to the Northern Europe has reached the 80°North parallel (Figure 4 right), which shows the intensity and massiveness of the warm air over Europe, which is a climatic record for the entire continent of Europe. The Earth's thermic Equator during this heat wave was positioned in the Northern Africa and expanded into the Iberian Peninsula, Southern Italy, the Balkan Peninsula, Romania and the South-Eastern Turkey, which explains the achievement of these extremely high temperatures.

The hotter weather than normal continued throughout the year including in December, and the thermic maximums of this month were recorded on December 25th and ranged from 12.5°C at Voineasa to 18.9°C at Calafat.

The analysis of the pluviometric time types according to the Hellmann criteria, recorded during 2017, shows that the dry time prevailed in the first six months of August and December, and the rainfall time in July and autumn (though the significant rainfall in July were recorded within 36 hours on July 2nd and 3rd (Table 3).

Tabel 3. The matrix of the rainfall time types recorded in the South-Western Romania in 2017 (ER = exceptionally rainy, VR = very rainy, R = rainy, SR = slightly rainy, ED = exceptionally dry, VD = very dry, D = dry, SD = slightly dry, N = normal)

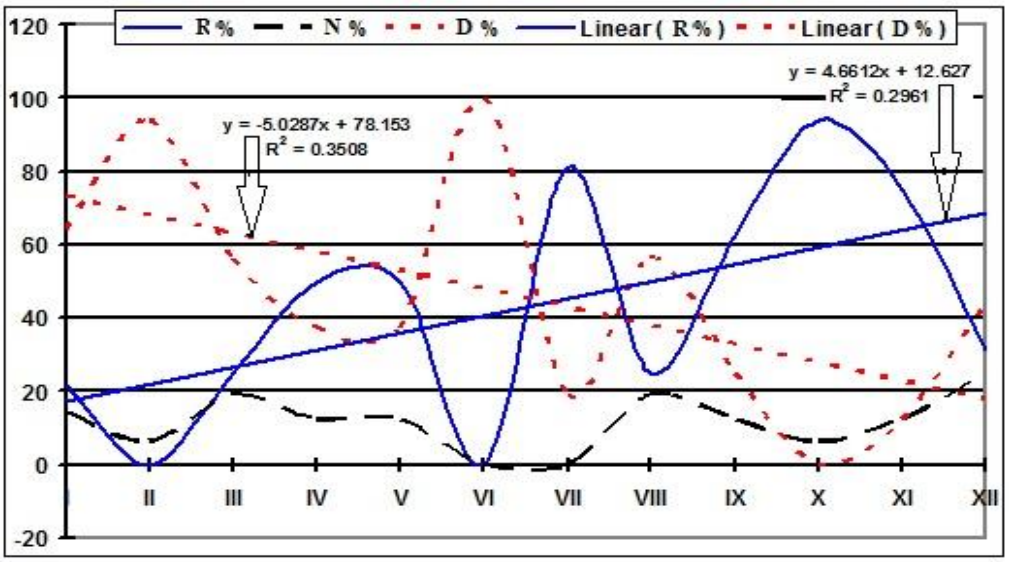
The meteorological station	Months of the year											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dr. Tr. Severin	ED	SD	ED	VR	VD	ED	VD	N	N	SR	SD	VD
Calafat	N	VD	R	SR	VR	ED	SD	R	VR	ER	N	VR
Bechet	R	ED	R	SD	N	ED	ER	ED	ER	ER	VR	VR
Băileşti	SR	VD	N	SD	VD	ED	SR	N	VR	ER	SR	SR
Caracal	VR	ED	R	D	SD	ED	ER	ED	ER	ER	VR	R
Craiova	SD	N	N	VR	N	ED	ER	ED	VR	ER	ER	SR
Slatina	N	ED	SR	N	D	ED	ER	ED	N	ER	ER	N
Bâcleş	-	ED	ED	VD	VD	ED	ER	SR	D	ER	N	VD
Tg. Logreşti	VD	D	VD	SR	ER	ED	ER	VD	R	ER	VR	SD
Drăgăşani	VD	VD	ED	ER	ER	ED	ER	VD	D	ER	VR	VD
Apa Neagră	ED	D	ED	SR	D	ED	R	ED	VD	VR	VR	VD
Tg. Jiu	ED	SD	ED	N	R	ED	ER	ED	SR	N	SR	D
Polovragi	ED	SD	ED	D	ER	ED	ER	D	SR	VR	SR	N
Rm. Vâlcea	ED	SD	ED	VR	ER	SD	VR	R	VD	ER	SR	N
Voineasa	ED	ED	ED	ED	VR	D	ER	ER	VR	SR	ED	VD
Parâng	ED	D	N	SR	VR	VD	D	N	VR	R	R	N
Average of Oltenia	VD	VD	VD	N	SR	ED	ER	D	SD	ER	SR	N

Source: processed data from the NMA archive, 2018

The statistical analysis of these time types shows that the dry time (D) had a spatial-temporal extension of 41.9%, normal (N) of 11.5% and rainy time (R) of 46.6%.

The graphic of the variation of the rainfall time types in figure 5 over the year 2017 shows that the rainy weather (R) had a linearly increasing trend with a growth rate of 4.6612 and showed three maxims: one in May with the average rainfall of 94.7 l/m^2 for the entire region, one in July with 99.8 l/m^2, and the third in October, with rainfall averages of 92.1 l/m^2. The dry time (D) had a linear downward trend with three maxims: one in the January-March period, when the monthly precipitation had average values for the whole region of: 25.6 l/m^2 and 26.9 l/m^2 in February and 26.7 l/m^2 in March, the second in June, when the average monthly rainfall was 25.2 l/m^2, being the smallest of the year and the third in August, with the average rainfall volume of 39.6 l/m^2. The intense drought of June constituted a special danger for the agriculture because in June, all the agricultural crops, the fruit trees, vineyards, vegetation carpet, forest, etc. are in advanced stages of vegetation, the water requirements being at maximum.

However, in 2017, the situation was very well rescued by the torrential rains arriving within a short 36-hour period from the afternoon of July 2nd to July 3rd, at 12 o'clock pm, in which the daily average rainfall was 33.1 l/m^2 and 24.8 l/m^2, respectively. The drought manifested itself on a large part of the European continent and affected the water sources, the river flows and the Danube River, creatingg problems for navigation (Figure 6).



Source: processed data from the NMA archive, 2018

Figure 5. The space-time extension of rainfall time types (%), after the Hellmann criterion, and their alternation during 2017 in the South-Western Romania

Source: after www.edelta.ro

Figure 6. The variation of the Danube waters quotas in the period January 17th 2017 - January 20th 2018 in the South-Western Romania

4. CONCLUSIONS

Although in 2017 the El Ninõ climatic process was absent, in the South-Western Romania (as well as across the country and the Northern Hemisphere), the weather was warm and the highest temperatures were recorded during the summer. During the summer, six absolute thermic climatic records were recorded in Oltenia, one of them in June and five in August. In the South-Western Romania, seven maximum temperature values were in the second place in descending order of the values in the whole data range. The climate warming continued not only globally but even at regional level in Romania, supported by the thermic records, the predominance of the hot time (HT) and the increasing trend of this type of time throughout the year. From a statistical point of view, the dry time (D = 41.9%) and rainy (R = 46.6%) seem to be close to the spatial-temporal expansion, but their rapid alternation and the predominance of the dry time during summer and spring has produced major problems to the agricultural crops and the navigation on the Danube.

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