CLIMATE VARIABILITY IN THE SUMMER OF 2020 IN SOUTH-WEST ROMANIA IN THE CONTEXT OF CLIMATE CHANGE

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Abstract: Climate variability in the summer of 2020 in south-west Romania in the context of climate change. Globally, 2020 ended the warmest decade since the beginning of the measurements (WMO), and the warmest year was 2016, marked by a strong and intense El Ñino. In Oltenia the warmest year was 2019 with the average for the whole region of 12.4°C and the deviation from normal of 2.5°C, followed by 2020 with the general average of 12.2°C and the deviation from normal of 2.3°C. After the 2019-2020 warm winter, which was the second Mediterranean winter in southern Romania, followed the normal thermal spring in which climatic anomalies were frequent. The summer of 2020 was warm and marked by great climate variability, given by the presence of a weak La Ñina climate process. Since June, the average temperature is normal and unstable, the climatic alternations and the progressive increase of the air temperature, determined that in August the weather will be the warmest during the summer and an intense heat wave occurred at the end of the month with the peak on 1.IX.2020.The paper analyses special climate variability in the summer of 2020, which is the continuation of an extensive series of works on climate variability and climate change in southwestern Romania (I. Marinică 2006, I. Marinică, Andreea Floriana, 2016, 2020). The paper is useful to all those interested in climate variability and climate change in this part of Romania.

Keywords: drought, heat, climate risks, heat waves.

1. INTRODUCTION

After *the second Mediterranean winter in southwestern Romania*, in the history of the climate in Romania (winter 2019-2020), in Oltenia, the average coming of spring index for the entire region was I = 452.1, and its percentage deviation from the normal was 66.6%, which means that spring in 2020 was very early (FTi). The average spring index in 2020 was the seventh highest (in the last 30 years), in descending order by years: 2016 (I = 543.3),

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2007 (I = 498.1), 2008 (I = 479.7); 2014 (I = 475.3); 2019 (I = 467.6); 2017 (I =464.4). In Oltenia the spring specific temperatures appeared very quickly, and the warming of the weather is so fast that in some years, summer temperatures come with hot values since the first decade of April (20 days after the spring equinox). The rapid rise in air temperature from one month to the next is closely linked to the increase in the length of the day. The variability of the Earth-Sun geometry shows that between the winter solstice (21.XII) and the summer solstice (21.VI), the length of the day increases for 6 months and between the summer and winter solstice the length of the day decreases. The day-to-day increases (or decreases) of the day are 0, 1, 2, 3 or 4 minutes. For any latitude on the face of the Earth, there are no variations in the length of the day, from one day to another, greater than 4 minutes (the rule of 4 minutes). For different latitudes. only the frequency with which they occur varies, and for the latitudes within the North Polar Circle the calculations show that there are increases (or decreases) of only 4 minutes, ie. 4 minutes / day x 6 months = 12hours, and so the length of the day becomes 24 hours and the Sun no longer sets (analogous in the case of the decline, only the length of the night is 24 hours and the Sun no longer rises). On 21.V, the length of the day reaches 15 hours (characteristic of summer days), and on 18.VI the first day is recorded with the maximum duration of the day of 15 hours and 32 minutes (I. Marinică, Andreea Marinică, 2019). *Early coming of spring⁴ is a particular climatic risk* because in such situations, spring is often accompanied by *climatic anomalies* consisting mainly of cold air waves, which produce cooling of the weather as a result of significant damage to agriculture. Spring 2020 was on average warm (CL) with a seasonal average temperature of 11.4°C and a deviation from normal of 0.9°C, but nevertheless climate anomalies were mainly recorded in the first two months (I. Marinică, Andreea Marinică, 2020). In the northern hemisphere, the beginning of the Greenland ice melting season was reported on 13.V.2020 - defined as the time when this phenomenon comprises at least 5% of the ice cap - according to the Danish Meteorological Institute (Danmarks Meteorologiske Institut - DMI). That is, "almost two weeks earlier", compared to the average date set after 40 years of monitoring (AFP, Martin Stendel, researcher at DMI). Also in May in western Siberia there was recorded a heat wave (according to DMI researchers). In May 2020, calculations showed that "the first quarter of 2020 ranked second among the warmest beginnings of the year since meteorological measurements, ie in the last 140 years, by 1.15°C above the average of the XXth century. Based on the anomalies observed from

⁴ *Coming of spring* is the climatic process of increasing the air temperature, which is registered starting with the last month of winter - February, this being the first month of the year, in which the monthly average air temperature registers the first inter-monthly increase. Spring indices = Σ of positive daily average temperatures in the range 1.II-10.IV.

the beginning of the year until May, experts from the American National Ocean and Atmospheric Administration (NOAA) estimated that there is a 99% chance that 2020 will be one of the warmest years ever recorded and 75% chances to become the warmest in the last 140 years, surpassing the record of 2016". *At the level of the Northern Hemisphere*, after the National Oceanic and Atmospheric Administration (NOAA), in the USA, June, July and August 2020 recorded temperatures by 1.17°C above the average of the twentieth century, thus exceeding the records of summers 2016 and 2019 (https://destepti.ro/vara-2020va-fi-cea-mai-calda-din-ultimii-100-of-years-the-summer-season-and-the-covidpandemic-19). *At the level of Oltenia*, the summer of 2020 was on average warm (C) with the average for the whole region of 21.8°C and the deviation from the normal of 1.1°C. Climate variability was particularly high during autumn 2020 and December 2020. Climate variability in the Northern Hemisphere was particularly high throughout 2020. We will further analyze the climate variability in the summer of 2020 in Oltenia.

2. DATA AND METHODS

To carry out the paper we used the existing synoptic maps on the Internet from the international weather forecasting centres, the NMA website, the satellite information as well as the information published in the written press.

3. RESULTS AND DISCUTIONS

3.1. Climatic characteristics of June 2020

The thermal regime of June 2020. The monthly averages of the air temperature were between 16.7°C in Voineasa and 21.9°C in Calafat, and their deviations from normal were between 0.0°C in Slatina in Getic Piedmont and 2.7°C to Apa Neagră in the Subcarpathian depressions. According to the Hellmann criterion, June 2020 was thermally normal (N) in most of Oltenia and warm (CL) on restricted areas in the extreme west at Dr. Tr. Severin, in the Olt River Corridor at Drăgășani, Rm. Vâlcea and Voineasa and warm (C) to Apa Neagră. In the mountain area at Ob Lotrului it was warm (CL) (Table 1). The monthly average air temperature, calculated for the entire Oltenia region was 20.2°C, and its deviation from normal was 0.8°C, which shows that the June was thermally normal on average for the entire Oltenia region. The monthly minima of the air temperature were registered in the first pentad of the monthl (most on 3.VI, with one exception) and were between 1.3°C in the Voineasa Intracarpathian Depression and 10.2°C at Calafat, and their average for the whole region was 5.6°C. The monthly maximum air temperatures were recorded

on the penultimate day of the month and were between 29.8°C in Polovragi and 35.5°C in Calafat in the southwest of the region. *The summer days5* were registered starting with 4.VI.2020, and the tropical days starting with 5.VI.2020. *The scorching heat days* were recorded in isolation between 25-30.VI.2020, the phenomenon of heat being insignificant.

Table 1. Oltenia air temperature regime and minimum and maximum ground surface temperature values in June 2020 (Hm= weather station altitude, Δ =M-N = deviation from average temperature in June, CH= Hellmann criterion, NVI= temperature averages in June calculated for the period 1901-1990 - normal; MVI= temperature averages in June 2020).

Meteorological						Tma	ıx air	Tmi	n air	Tma	x soil	Tmi	n soil
Station	Hm	NVI	MVI	$\Delta = M-N$	CH	(°C)	Date	(°C)	Date	(°C)	Date	(°C)	Date
Dr. Tr													
.Severin	77	20,7	21,8	1,1	CL	34,8	29	6,6	3	64,4	29	3,6	3
Calafat	66	21,0	21,9	0,9	Ν	35,5	29	10,2	3	54,8	29	12,8	1
Bechet	65	21,3	21,5	0,2	Ν	34,9	29	5,1	3	43,1	29	9,3	3
Băilești	56	21,1	21,2	0,1	Ν	34,8	29	8,6	3	41,9	29	8,3	3
Caracal	112	20,8	21,2	0,4	N	34,4	29	6,9	3	46,4	29	11,0	3
Craiova	190	20,6	20,9	0,3	Ν	32,7	29	6,9	3	61,7	29	5,1	3
Slatina	165	20,5	20,5	0	N	33,6	29	6,5	3	36,7	29	8,9	3
Bâcleș	309	19,0	19,7	0,7	N	32,6	29	6,4	3	-	-	-	-
Tg. Logrești	262	18,8	19,3	0,5	N	32,0	29	3,8	1	59,8	29	4,2	1
Drăgășani	280	19,4	20,5	1,1	CL	32,3	29	6,6	3	40,4	30	9,5	3
Apa Neagră	250	16,6	19,3	2,7	С	31,6	29	2,2	3	35,8	8	6,2	3
Tg. Jiu	210	19,4	20,3	0,9	Ν	32,5	29	5,1	3	54,2	3	3,1	3
Polovragi	546	17,7	18,5	0,8	N	<i>29</i> ,8	29	2,9	3	52,1	29	1,3	3
Rm. Vâlcea	243	19,0	20,4	1,4	CL	32,5	29	5,4	3	57,3	29	4,3	3
Voineasa	587	15,3	16,7	1,4	CL	30,2	29	1,3	3	-	-	-	-
Parâng	1585	-	-	-	-	22,7	29	-	-	-	-	-	-
Average													
Oltenia	-	<mark>19,4</mark>	<mark>20,2</mark>	<mark>0,8</mark>	N	<mark>32,3</mark>	-	<mark>5,6</mark>	-	<mark>48,5</mark>	<mark>29</mark>	<mark>6,7</mark>	-
Ob. Lotrului	1404	10,8	12,0	1,2	CL	23,7	29	-0,6	3	-	-	-	-

(Source: data processed from the ANM archive)

<u>5</u> Summer day is the day when Tmax $\geq 25.0^{\circ}$ C. Tropical day is the day when Tmax $\geq 30.0^{\circ}$ C. The scorching heat day is the day when Tmax $\geq 32.0^{\circ}$ C. The hot day is the day when the Tmax $\geq 35.0^{\circ}$ C.



Fig. 1. Variation of air temperature averages, daily maximums, daily averages and daily minimums calculated for the entire Oltenia region in June 2020. (Source: data processed from the ANM Archive).

The heat wave phenomenon was insignificant, thermal maximums \geq 35.0°C, registering in one day at a single meteorological station (Calafat 29.VI.2020). The average monthly maximum air temperature for the entire region was 32.3°C. The graphs of the variation of the parameters that characterize the air temperature in June (daily highs, daily averages and daily lows) had increasing linear trends, and the daily lows had the fastest growth, with a growth coefficient of 0.2314 (Fig. 1). There were **three intervals of increase in air temperature**: 1-10.VI.2020 (10 days), 13-20.VI (8 days), 22-30.VI (9 days) totalling 27 days. At the soil surface, the monthly minimum temperatures were recorded in the range 1-3.VI.2020 and were between 1.3°C in Polovragi and 12.8°C in Calafat, and their average for the entire region was of 6.7°C. The monthly maximums of the temperature at the soil surface were registered, most of them, on 29.VI and were between 35.8°C at Apa Neagră and 64.4°C at Dr. Tr. Severin, and the average their temperature for the whole region was 48.5°C.

Rainfall in June

The monthly precipitation amounts were between 36.0 l/m^2 at Dr. Tr. Severin and 179.6 l/m^2 at Apa Neagră, and their percentage deviations from normal were between -50.3% at Dr. Tr. Severin and 98.2% in Bâcleş (Table 2). According to the Hellmann criterion, the deficient precipitations were registered in the extreme west of Oltenia (ES at Dr. Tr. Severin) and southwest (FS at

Calafat), generally in the Oltenia Plain (FS at Băilesti) and on a small area in the Corridor. Oltului to Drăgăsani (PS). Excessive rainfall was recorded in most of the region, being exceptionally rainy (EP) in the area of the hills, in the Subcarpathians and in the mountains (Table 2). The average amount of precipitation calculated for the entire region was 116.8 l/m^2 , and its percentage deviation from normal was 38.7%, and according to the Hellmann Criterion. June was very rainy (FP) on average for the whole of Oltenia. There were 2 rainy intervals: 9-18.VI.2020 (10 days) and 22-23.VI.2020 (2 days), totalling 12 days. Of these, we note the data of 9, 10, 15-17 and 23.VI.2020 in which the average of the quantities calculated for the entire region was $\geq 10.0 \text{ l/m}^2$. The rains in June were unevenly distributed, and after the excessively dry April (ES) and the rainier month (P), the precipitation deficit and the atmospheric and *pedological drought* remained in the Oltenia Plain and the extreme west. In June 2020 there were torrential rains throughout Romania. Between 20-25.VI there were floods in Caras-Severin, Bistrita-Năsăud, Timis, Botosani (Oroftiana locality and others). In Ukraine, three dams broke on the Prut and some localities in Romania were evacuated in front of the flood wave (Source Romania TV). High floods were on the Jiu River, south of Hunedoara, broken roads, demolished bridges, rainfall of 200 l/m² in a short time, etc. The Lupeni mine was flooded and the workers were trapped underground.

Meteorologica		June 2020					J	uly 2020		August 2020					
l					С				С	ΣVII			С		
Station	Hm	ΣVI	Ν	$\Delta\%$	Н	ΣVII	Ν	$\Delta\%$	Н	I	Ν	$\Delta\%$	Н		
Dr. Tr.						111,		125,			38,				
Severin	77	36,0	72,5	-50,3	ES	2	49,3	6	EP	43,3	2	13,4	PP		
											35,				
Calafat	66	40,4	65,6	-38,4	FS	45,2	45,6	-0,9	Ν	66,2	6	86,0	EP		
											37,				
Bechet	65	72,0	62,3	15,6	PP	53,0	46,6	13,7	PP	50,0	9	31,9	FP		
											39,				
Băilești	56	46,3	66,5	-30,5	FS	67,2	45,0	49,3	FP	34,6	0	-11,3	PS		
											39,				
Caracal	112	89,4	73,7	21,3	P	30,4	53,8	-43,5	FS	44,8	9	12,3	PP		
											42,				
Craiova	190	90,0	71,2	26,5	P	59,3	51,4	15,4	PP	29,2	1	-30,6	FS		
		128,									46,				
Slatina	165	4	80,6	59,3	EP	30,9	57,5	-46,3	FS	21,8	8	-53,4	ES		
		142,									33,				
Bâcleș	309	7	72,0	98,2	EP	85,7	47,1	82,0	EP	44,7	4	33,8	FP		
Tg.		116,									43,	154,			
Logrești	262	6	72,3	61,3	EP	85,2	49,5	72,1	EP	111,0	6	6	EP		
											46,				
Drăgăsani	280	76.5	87.6	-12.7	PS	39.7	51.6	-23.1	S	31.0	4	-33.2	FS		

Table 2. Precipitation quantities recorded in summer 2020 (Σ), compared to normal values (N for the period 1901-1990), deviation (Δ %) and the type of rainfall according to the Hellmann criterion (CH).

Apa		179,				133,					60,		
Neagră	250	6	99,2	81,0	EP	5	72,7	83,6	EP	40,8	1	-32,1	FS
		144,				100,					64,		
Tg. Jiu	210	9	93,0	55,8	EP	4	61,9	62,2	EP	36,1	3	-43,9	FS
		125,	112,			158,					76,		
Polovragi	546	6	3	11,8	PP	6	88,9	78,5	EP	71,4	5	-6,7	Ν
Rm.											69,		
Vâlcea	243	93,5	86,9	7,6	Ν	36,4	98,0	-62,9	ES	29,3	4	-57,8	ES
		172,	106,			217,		145,			72,		
Voineasa	587	9	7	62,0	EP	6	88,6	6	EP	56,0	8	-23,1	S
	158	313,	124,	152,		135,	132,				90,		
Parâng	5	4	1	5	EP	8	1	2,8	Ν	62,4	6	-31,1	FS
Average		<mark>116,</mark>									<mark>52,</mark>		
Oltenia	-	<mark>8</mark>	<mark>84,2</mark>	<mark>38,7</mark>	FP	<mark>86,9</mark>	<mark>65,0</mark>	<mark>33,7</mark>	FP	<mark>48,3</mark>	<mark>3</mark>	<mark>-7,7</mark>	N
Ob.	140	201,				210,							
Lotrului	4	4				2				79,9			

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(Source: data processed from the ANM Archive)

As a result on 28.VI the Mintia thermal power plant was shut down due to lack of coal and Hunedoara was left without electricity. On June 30, 2020, the water reserve in the soil layer 0-100 cm, in *the autumn wheat crop*, had satisfactory values up to close to optimal and optimal, on large agricultural areas in Oltenia. *The soil moisture content* was within low limits (moderate pedological drought) on a small area in southern Oltenia. The water supply on the soil depth 0-100 cm, in *the non-irrigated maize crop*, was within satisfactory limits, close to optimal and optimal, in Oltenia (according to ANM).

3.2. Climate characteristics of July 2020

The thermal regime of July 2020

The monthly averages of the air temperature were between 17.3°C at Voineasa and 24.2°C at Calafat, and their deviations from normal were between 0.2°C at Apa Neagră and Voineasa and 1.6°C in Drăgășani. According to the Hellmann criterion, July was thermally normal (N) in most of the region and warm (CL) in the extreme west and southwest of the region (Dr. Tr. Severin and Calafat), in the Romanați Plain and the Olt River Corridor (Caracal, Slatina Drăgășani and Rm. Vâlcea) (Table 3). *The overall average air temperature* calculated for the whole region was 22.3°C, and its deviation from normal was 0.8°C, which confirms that July was the average normal (N) for the whole of Oltenia. So in July the average air temperature increased by 2.1°C compared to the first month of summer. *The minimum monthly air temperatures* were recorded in the range 8-20.VII and were between 5.4°C at Apa Neagră (8.VII) and 13.5°C at Caracal (20.VII), and the average for the whole Oltenia region was 10.6°C.

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Table 3. Oltenia air temperature regime and minimum and maximum surface temperature values in July 2020 ($\Delta = MN =$ deviation from the average temperature in July, CH = Hellmann criterion, NVII = temperature averages for July calculated for the interval 1901-1990 - normal; MVII = average temperatures in July 2020, CH = Hellmann criterion)

Meteorological	Hm	NVII	MVII	Δ=M-	СН	Tma	x air	Tmi	n air	Tma	x soil	Tmi	n soil
Sation				Ν		(°C)	Date	(°C)	Date	(°C)	Date	(°C)	Date
Dr. Tr. Severin	77	23,0	24,0	1,0	CL	35,5	31	13,4	8	66,2	5	7,0	7
Calafat	66	23,2	24,2	1,0	CL	37,3	31	12,9	11	53,2	1	15,6	20
Bechet	65	23,0	23,4	0,4	N	37,4	30	12,0	9	45,3	2	14,0	9
Băilești	56	22,8	23,4	0,6	N	36,2	30	11,5	8	56,5	30	10,7	9
Caracal	112	22,9	24,0	1,1	CL	37,1	30	13,5	20	51,0	30	15,1	20
Craiova	190	22,3	23,0	0,7	N	35,9	31	12,3	20	61,8	6	11,5	20
Slatina	165	22,0	23,3	1,3	CL	36,1	31	11,3	20	40,7	31	13,7	20
Bâcleș	309	21,3	22,0	0,7	N	33,3	30,31	9,6	8	-	-	-	-
Tg. Logrești	262	20,7	21,0	0,3	N	33,0	30	10,0	8	60,3	1	10,6	8
Drăgășani	280	21,7	23,3	1,6	CL	35,5	31	12,1	20	46,8	30	13,8	20
Apa Neagră	250	20,5	20,7	0,2	N	33,5	31	5,4	8	42,8	11	8,2	8
Tg. Jiu	210	21,3	22,1	0,8	N	33,6	31	10,5	20	59,8	10	10,1	9
Polovragi	546	19,7	20,6	0,9	N	31,4	31	9,8	8	55,6	31	7,3	8
Rm. Vâlcea	243	21,2	22,5	1,3	CL	35,3	31	13,3	20	63,2	31	12	8
Voineasa	587	17,1	17,3	0,2	N	30,2	29	6,6	14	-	-	-	-
Parâng	1585	-	-	-	-	23,6	31	4,9	8	-	-	-	-
Average Oltenia	•	<mark>21,5</mark>	<mark>22,3</mark>	<mark>0,8</mark>	N	<mark>34,1</mark>		<mark>10,6</mark>	-	<mark>54,1</mark>	-	11,5	-
Ob. Lotrului	1404	12,5	12,9	0,4	N	26,0	30	1,3	14	-	-	-	-

(Source: data processed from the ANM Archive)

The maximum monthly air temperatures were recorded in the last two days of the month and were between 30.2°C in Voineasa and 37.4°C in Bechet, and their average for the entire region was 34.1°C. In Romania, the maximum temperature in the country in July 2020 was 38.4°C recorded in Oltenița on 30.VII.2020, equal to the maximum in August 38.4°C recorded in Zimnicea on 29 .VIII.2020. As a result, the hottest area in Romania in the summer of 2020 was in the southeast of the country. The excessively hot period was registered between 29.VII - 1.IX.2020. The heat was frequent, and the heat wave was registered only in the last two days of the month. The graphs that characterize the variation of the air temperature in July, in Oltenia (daily averages of minimums, averages and maximums calculated for the whole region) had frequent fluctuations registering 6 growth intervals 1-3.VII (3 days),

5 -6.VII (2 days), 9-11.VII (3 days), 15-17.VII (3 days), 21-25.VII (5 days) and 27-31.VII (5 days), totalling 21 days. The most significant cooling interval of the weather was registered in the interval 18-20.VII (3 days) when on 18.VII the average of the thermal maximums on the whole region was 18.4°C (Fig. 2). Linear trends were slightly increasing for highs and lows and very slightly decreasing for daily averages.



Fig. 2. Variation of air temperature averages, daily maximums, daily averages and daily minimums calculated for the entire Oltenia region in July 2020. (Source: data processed from the ANM Archive).

At the surface of the soil, the monthly minimum temperatures were recorded in the data of 7, 8, 9 and 20.VII and were between 7.3° C in Polovragi and 15.6° C in Calafat, and their average for the whole Oltenia region was 11.5° C. The monthly maximum surface temperatures were recorded in the data of 1, 2, 5, 6, 10, 30 and 31.VII and were between 40.7° C in Slatina and 66.2° C in Dr, Tr. Severin, the latter being the maximum soil surface temperature for the whole year 2020. The average monthly thermal maximums at the soil surface for the entire Oltenia was 54.1° C being the highest monthly average in 2020.

Pluviometric regime of July

The monthly precipitation amounts in July were between 30.4 l/m^2 in Caracal and 217.6 l/m^2 in Voineasa, and their percentage deviations from normal were between -62.9 in Rm. Vâlcea and 145,6% at Voineasa. According to the Hellmann criterion, July was excessively rainy (EP) in the extreme west

at Dr. Tr. Severin and in the area of the hills (Table 2); very rainy (FP) in the Oltenia Plain in Băilesti; slightly rainy (PP) in the extreme south at Bechet and in the central part of Oltenia at Craiova; dry (S) in the Olt Corridor at Drăgășani; very dry (FS) in Caracal and Slatina and excessively dry (ES) in Rm. Vâlcea. The average rainfall calculated for the entire Oltenia region was 86.9 $1/m^2$, and its percentage deviation from normal was 33.7% and so according to the Hellmann criterion, July was very rainy (FP) in average for the whole region. In July there were 2 rainy intervals: 17-19.VII (3 days) and 24-25.VII (2 days), totalling 5 days. Although, according to the precipitation statistics, the situation seems good, in reality, the strong increase in air temperature, starting with 24.VI was accompanied by the very dry interval 24.VI-16.VII (23 days) which caused stage forcing important to all crops and crop losses through damage. On July 31, 2020, the moisture reserve on the soil depth 0-100 cm, in the culture of non-irrigated corn, was within satisfactory limits and close to optimal in northern Oltenia. The water content of the soil had low and particularly low values (moderate, strong and extreme pedological drought), in most of Oltenia (ANM).

3.3. Climatic characteristics of August 2020

Thermal regime of August 2020

The monthly average temperatures were between 17.4°C at Voineasa and 24.7°C at Caracal, and their deviations from normal were between 0.6°C at Apa Neagră and 2.9°C at Rm Vâlcea (Table 4). According to the Hellmann criterion, August was hot (CL) in the Oltenia Plain, in the Mehedinti Hills at Bâcles, in the Subcarpathian Depressions in Gorj County (Tg. Jiu, Polovragi), in the Voineasa intramountain depression and in the mountain area (Ob. Lotrului) and warm (C) in the extreme west at Dr. Tr. Severin, in the Romanati Plain at Caracal, in the central part of Oltenia at Craiova and in the Olt Corridor at Drăgăsani and Slatina. The average monthly air temperature for the whole Oltenia region was 22.8°C, and its deviation from normal was 1.7°C, which shows that August was on average a warm month (CL) for the whole Oltenia region. The monthly average air temperature in August was the highest average temperature taken in 2020, which is a climate anomaly because, in August, the first average decrease in the average monthly temperature during the year is usually recorded. The monthly minimums of air temperature were recorded on 28.VIII and were between 7.0°C in Voineasa and 14.9°C in Drăgăsani, and their average for the entire Oltenia region was 11.0°C. The monthly maximum air temperatures were recorded, mostly, between 29-31.VIII and were between 30.5°C in Voineasa and 37.5°C in Bechet, and their average for the entire Oltenia region was of 34.3°C. In August there were 6 days with hot

temperatures (7, 14, 23, 29, 30 and 31.VIII). The most important cooling of the weather occurred on 16.VIII when the thermal maximums were between 19.2°C at Voineasa and 26.8°C at Bechet. *The most important heat wave of summer 2020* was registered between 21.VIII-1.IX.2020, during which, in Romania, the air temperature approached 0.7°C to the climatic threshold of 40.0°C.

Thus, on 1.IX.2020, in Romania, the maximum temperature in the country for 2020 was registered, which was 39.3°C registered in Zimnicea on 1.IX.2020. For the Zimnicea meteorological station, the value of 39.3°C is an absolute thermal record for September for the entire period of meteorological observations. On the same day, 1.IX.20 recorded 39.1°C in Giurgiu.

Table 4. Oltenia air temperature regime and minimum and maximum surface temperature values in August 2020 (Hm = altitude of the weather station, $\Delta = MN =$ temperature deviation, CH = Hellmann criterion, NVIII = temperature averages for August calculated for the period 1901- 1990 - normal; MVIII = average temperatures in August 2020).

Meteorological	Hm	NVIII	MVIII	∆=M-N	СН	Tmax air		Tmin air		Tmax soil		Tmin soil	
Station						(°C)	Date	(°C)	Date	(°C)	Date	(°C)	Date
Dr. Tr. Severin	77	22,2	24,3	2,1	С	35,3	31	12,7	28	63,6	14	9,8	28
Calafat	66	22,7	24,6	1,9	CL	37,1	31	13,3	28	43,1	4	16,7	28
Bechet	65	22,4	23,8	1,4	CL	37,5	31	11,1	28	42,4	30;31	15,3	28
Băilești	56	22,5	24,1	1,6	CL	36,2	31	11,0	28	48,9	30	11,5	28
Caracal	112	22,4	24,7	2,3	С	36,2	29	14,4	28	49,9	23	14,8	28
Craiova	190	22,2	24,2	2,0	С	36,0	31	12,9	28	57,2	1	12,6	28
Slatina	165	22,2	24,2	2,0	С	35,9	29	11,9	28	46,2	29	12,0	28
Bâcleș	309	20,9	22,7	1,8	CL	34,0	31	13,1	28	-	-	-	-
Tg. Logrești	262	20,2	21,0	0,8	N	34,3	8	8,8	28	53,9	31	8,0	28
Drăgășani	280	21,5	24,3	2,8	С	35,9	31	14,9	28	47,5	31	14,9	28
Apa Neagră	250	20,1	20,7	0,6	N	33,8	8	6,8	28	51,8	8	8,2	28
Tg. Jiu	210	20,9	22,2	1,3	CL	33,9	31	10,1	28	55,2	31	7,2	28
Polovragi	546	19,4	21,0	1,6	CL	31,8	8	9,2	28	54,6	12	6,2	28
Rm.Vâlcea	243	20,5	23,4	2,9	С	36,4	8	10,9	28	61,4	7	8,2	28
Voineasa	587	16,3	17,4	1,1	CL	30,5	31	7,0	28	-	-	-	-
Parâng	1585	-	-	-	-	24,0	31	7,2	26	-	-	-	-
Average Oltenia	•	<mark>21,1</mark>	<mark>22,8</mark>	<mark>1,7</mark>	CL	<mark>34,3</mark>	-	<mark>11,0</mark>	-	52,0	-	11,2	-
Ob. Lotrului	1404	11,8	13,1	1,3	CL	27,9	31	3,5	28	-	-	-	-

(Source: data processed from the ANM Archive)



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Fig. 3. Variation of air temperature averages, daily maximums, daily averages and daily minimums calculated for the entire Oltenia region in August 2020. (Source: data processed from the ANM Archive).

The heat was frequent, and the heat wave was registered starting with the 7th of July. At the surface of the soil, the minimum temperatures were recorded on 28.VIII and were between $6.2^{\circ}C$ at Polovragi and $16.7^{\circ}C$ at Calafat, and their average for the whole Oltenia region was 11, 2°C. The maximum temperatures at the soil surface were recorded, most in the range 29-31.VIII, and were between 42.4°C at Bechet and 63.6°C at Dr. Tr. Severin, and their average for the whole Oltenia region was 52.0°C. The graphs that characterize the variation of the air temperature in August, in Oltenia (daily averages of minimums, averages and maximums calculated for the whole region) had frequent fluctuations registering 3 growth intervals 1-14.VIII (14 days), 18 -24.VIII (7 days) and 27-31.VIII (5 days), totalling 26 days. There were two short intervals of cooling of the weather 15-16.VIII and 25-26.VIII, and the most significant cooling of the weather was registered in the interval 15-16.VIII when on 15.VIII the average of the thermal maximums on the whole region was 22.4°C (Fig. 3). The linear trends were: slightly increasing for highs and decreasing for lows and daily averages. We note that the cooling of the weather around August 15⁶ occurs frequently because on 15VIII (or 16.VIII in some years) there is a 10-hour night and then exceeding it and increasing the

⁶ That is why it is said among the people that "*after St. Mary we take off our hats*", and on the 29th of VIII St. John's Day is celebrated in autumn and it is said that "*from this day the coolness of autumn begins to be felt*". This last aspect is due to the fact that on this date, *the duration of the night exceeds 10 hours and 30 minutes* and, as a rule, the thermal regime specific to the first part of September is already installed.

frequency of decreases in the duration of 3 minutes (from a day to another). As a result, the daily minimum air temperature decreases and therefore the daily averages normally decrease. Therefore, this *effect of gradual cooling of the nights and mornings is beneficial*, determining good conditions for people's night rest after the hot summer, and *for plants it induces important stages of development*, they perceive the coming of autumn.

Pluviometric regime of August

The monthly precipitation amounts in August were between 21.8 1/m² in Slatina and 111.0 l/m^2 in Tg. Logresti, and their percentage deviations from normal were between -57.8% in Rm. Vâlcea and 154.6% in Tg. Logresti. According to the Hellmann criterion, August was excessively dry (ES) in the Olt Corridor at Slatina and Rm. Vâlcea; very dry (FS) in Craiova, Drăgășani, Apa Neagră, Tg. Jiu and Parang; dry (S) in Voineasa and slightly dry (PS) in Băilesti; normal in Polovragi; slightly rainy (PP) at Dr. Tr. Severin and Caracal; very rainy (FP) at Bechet and Bâcles and excessively rainy (EP) at Calafat and Tg. Logresti. In the excess rainfall areas, the precipitations were given by intense rain showers on small areas, and the precipitation deficit was on large areas (Table 2). The average monthly rainfall calculated for the entire Oltenia region was 48.3 1/m², and its percentage deviation from normal was -7.7%, which according to the Hellmann criterion, shows that August was, on average, "normal rainfall" for the entire region, due to the compensation effect ("levelling") of the average. In August, only in one day (25.VIII with an average for the entire region of 12.8 l/m^2) there were significant precipitations but in the area of the hills, and in the area of the plain insignificant.

3.4. Seasonal climatic characteristics of summer 2020

The seasonal temperature averages were between 17.1°C at Voineasa and 23.6°C at Calafat, and their deviations from normal were between 0.5°C at Tg. Logrești and 1.9°C at Rm. Vâlcea. According to the Hellmann Criterion, the summer of 2020 was hot (C) in most of Oltenia; warm (CL) in the Oltenia Plain in Băilești and Bechet and the Voineasa and normal (N) intramontane depression (N) on a restricted area at Tg. Logrești. **The average air temperature for the summer** season for the entire region was 21.8°C, and its deviation from normal was 1.1°C which confirms that the summer was warm (C) on average for the entire Oltenia region. (Table 5).

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Table 5. Overall thermal and pluviometric regime of summer 2020 (Hm = altitude of the weather station, V2020 = average temperature values in summer 2020 (°C), NtV = normal values of seasonal averages of summer temperature (°C), $\Delta = VN =$ deviations compared to normal (°C), SV = sum of precipitation in summer 2020 (1/m²), NV = normal values of precipitation in summer (1/m²), $\Delta = SN =$ deviations of precipitation amounts from normal (1/m²), $\Delta\%$ = percentage deviations from normal, CrH = Hellmann criterion).

Meteorological		Thermal regime (°C) Pluviometric regime (l/m ²								
Station	Hm	NtV	V 2020	∆=V-N	CrH	SV2020	NV	Δ=S-N	Δ%	CrH
Dr. Tr. Severin	77	22,0	23,4	1,4	С	190,5	160	30,5	19,1	Р
Calafat	66	22,3	23,6	1,3	С	151,8	146,8	5,0	3,4	N
Bechet	65	22,2	22,9	0,7	CL	175,0	146,8	28,2	19,2	Р
Băilești	56	22,1	22,9	0,8	CL	148,1	150,5	-2,4	-1,6	N
Caracal	112	22,0	23,3	1,3	С	164,6	167,4	-2,8	-1,7	N
Craiova	190	21,7	22,7	1,0	С	178,5	164,7	13,8	8,4	N
Slatina	165	21,6	22,7	1,1	С	181,1	184,9	-3,8	-2,1	N
Bâcleș	309	20,4	21,5	1,1	С	273,1	152,5	120,6	79,1	EP
Tg. Logrești	262	19,9	20,4	0,5	N	312,8	165,4	147,4	89,1	EP
Drăgășani	280	20,9	22,7	1,8	С	147,2	185,6	-38,4	-20,7	S
Apa Neagră	250	19,1	20,2	1,1	С	353,9	232	121,9	52,5	EP
Tg. Jiu	210	20,5	21,5	1,0	С	281,4	219,2	62,2	28,4	FP
Polovragi	546	18,9	20,0	1,1	С	355,6	277,7	77,9	28,1	FP
Rm. Vâlcea	243	20,2	22,1	1,9	С	159,2	254,3	-95,1	-37,4	FS
Voineasa	587	16,2	17,1	0,9	CL	446,5	268,1	178,4	66,5	EP
Parâng	1585	-	-	-	-	511,6	346,8	164,8	47,5	EP
Average Oltenia	-	<mark>20,7</mark>	<mark>21,8</mark>	<mark>1,1</mark>	C	<mark>251,9</mark>	<mark>201,4</mark>	<mark>50,5</mark>	<mark>25,1</mark>	
Ob. Lotrului	1404	11,7	12,7	1,0	С	491,5	-	-	-	-

(Source: data processed from the ANM Archive)

The seasonal rainfall amounts were between 147.2 1/m² in Drăgășani and 446.5 1/m² in Voineasa, and their percentage deviations from normal were between -37.4% in Rm. Vâlcea and 89, 1% to Tg. Logrești. According to the Hellmann criterion applied to these amounts of precipitation, the summer of 2020 was very dry (FS) at Rm. Vâlcea; dry (S) in Drăgășani; normal (N) on an extended area in the Oltenia Plain at Calafat, Băilești, Caracal, Craiova and in the Getic Piedmont at Slatina; rainy (P) in Dr. Tr. Severin and Bechet; very

rainy (FP) at Tg. Jiu and Polovragi and excessively rainy (EP) at Bâcleş, Tg. Logreşti, Apa Neagră, Voineasa and Parâng. *The average of the seasonal quantities* for the entire Oltenia was 251.9 l/m², and its percentage deviation from normal was 25.1%, which according to the Hellmann criterion, shows that the summer of 2020 was on average rainy (P). Although the situation, according to calculations, seems relatively good, in reality there were 62 excessively dry days in the intervals: 1-8.VI, 24.VI-16.VII, 19-24.VIII, 26.VII -31.VIII, in which high air and soil temperatures and low water supply, caused significant damage to all crops. In total, during the summer, 4 rainy intervals were registered: 9-18.VI (10 days), 22-23.VI (2 days), 17-19.VII (3 days); 24-25.VII (2 days), totalling 17 days, and the rainiest day of the summer was on 18.VII with the average for the whole Oltenia of 27.8 l/m².

3.5. The heat wave from the period 27.VIII-2.IX

In August the air temperature remained high throughout the month and throughout the country, the increase in heat intensity was like a continuous heat wave, with only three days in which the maximums fell below 30°C (15, 16 and 25.VIII). Between 27.VIII-2.IX, the increase in air temperature was rapid and intense, and the peak was recorded on 1.IX. We will analyze the synoptic causes and the process of formation and evolution of this heat wave.

At the level of the earth's surface, the distribution of the main baric centres above Europe was as follows: The Azoric anticyclone (with atmospheric pressure values at the centre > 1020 hPa) had an extended ridge to the northeast of the Kola Peninsula and the White Sea. An anticyclone nucleus (with atmospheric pressure values at the center > 1020 hPa) was positioned in the area of this ridge, above Great Britain and the southern half of the Scandinavian Peninsula (Fig. 4). To the north of this anticyclone field was positioned the vast field of the Icelandic Cyclone (with atmospheric pressure values at the centre < 995 hPa), and to the east a vast field of weak atmospheric pressure belonging to the Arab Cyclone (with pressure values at the centre < 1005 hPa). In these conditions at the level of the terrestrial surface, for Oltenia, the air circulation was from the northeastern sector, with warm air from Don Plain.



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Fig. 4. Geo-potential field at the level of 500 hPa and relative topography TR500 / 1000 superimposed with the field of atmospheric pressure at the level of the terrestrial surface on 1.IX.2020 at 12 UTC (the moment of reaching the peak of the heat wave) (after www.wetter3.de).



Fig. 5. *Temperature field at the level of 850 hPa on 1.IX.2020 at 12 UTC (the moment when the heat wave reaches its peak).* (after **www.wetter3.de**)

South of the Danube, on the territory of Bulgaria, was positioned a small cyclonic nucleus of thermal nature (with values at the centre < 1005 hPa) which contributed to the intensification of the hot air flow to the south of Romania. At the level of 500 hPa (about 5000 m altitude) the high geopotential field (with values \geq 552 damgp), was extended over most of Europe. In the area of this geopotential field, there was an individual geopotential dorsal that was extended over the Scandinavian Peninsula (558 damgp isohypsis), and in the eastern part of this ridge a geopotential potential extended to the south, to northern Italy (558 damgp), which shows that above most of Europe there was an atmospheric blocking circulation (the 588 damgp isohypsis has the shape of the letter " Ω "). Under these conditions for Romania, in the lower troposphere, the air circulation was from the southern sector (tropical circulation), and the advected air mass was tropical continental (cT) with hot air from North Africa advected over southern Italy and the Balkan Peninsula. The analysis of the temperature field at the level of 850 hPa (about 1500 m altitude) shows the strong advection of hot air over Europe, and south of Romania, positioned tangentially to the Danube, there is a very hot air core with values of 25°C, and in its centre above 30°C (exactly in the area of the thermal cyclone above Bulgaria). This position fully explains the intense advection of hot air in southern Romania. This type of warm advections with the "peak of the maximum" placed in the southeast of Romania (above Muntenia) occurred throughout the winter of 2020-2021.

4. Conclusions

The summer of 2020 was as a whole warm, marked by a warm August at the end of which there was an intense heat wave which on 1.IX.2020 determined the registration of two temperature values close to 40°C (39,3°C in Zimnicea - *climate record* and 39.1°C in Giurgiu). In Romania, on 29.VIII, monthly temperature records were recorded for August at 9 weather stations (source: ANM). The heat wave between 27.VIII-2.IX.2020 was the most intense in the last five years (2016-2020). Excess rainfall was recorded in the area of the hills, and in the Oltenia Plain the rainfall was generally normal but marked by long dry intervals, especially in August, when the air temperature was particularly high. Thus, 62 excessively dry days were recorded in the intervals: 1-8.VI, 24.VI-16.VII, 19-24.VIII, 26.VII-31.VIII, in which the high temperatures of air and soil and the reduced water supply, have caused significant damage to all crops. In total, during the summer, 4 rainy intervals were registered: 9-18.VI (10 days), 22-23.VI (2 days), 17-19.VII (3 days); 24-25.VII (2 days), totalling 17 days, and the rainiest day of the summer was on 18.VII with the average for the whole Oltenia of 27.8 l/m^2 . The climatic

variability was particularly high, since June very rainy and unstable with temperature values generally below 35.0°C, the increase of the air temperature was progressive, and in August although the total amounts of precipitation were on average, for the whole of Oltenia, normal, there was intense drought and heat waves (6-14.VIII; 18-24.VIII and 27.VIII-1.IX.2020). Thermal alternations were manifested by heating and cooling of the weather, so on 14.VII in Romania, there were 25 record minimum climatic temperatures for the temperature drop, for 14.VII (ANM). High summer temperatures are necessary to complete the maturation of agricultural crops, vegetables, trees and vines. Without the intense heat of summer, we would have almost nothing and people's food would be precarious. These climatic processes that led to great climate variability in the summer of 2020 occurred in the absence of the El Ñino climate process and even a slight La Ñina was recorded (which peaked at the end of December 2020 and January 2021, according to the WMO), and global air pollution was lower than in 2019, due to the restrictions imposed by the Covid Pandemic. The high climatic variability and intense heat wave contrast with the general observation that "the warmest years, with record temperatures, usually coincided with a strong El Nino event, as happened in 2016" (according to the WMO Secretary General, Prof. Taalas). The global average temperature in 2020 is about 1.2°C above the pre-industrial level (1850-1900) and in the near term, there is at least a one in five chance of exceeding 1.5°C by 2024 (WMO).

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