THE DRY AUTUMN OF 2018 IN SOUTHERN ROMANIA IN THE CONTEXT OF CLIMATE CHANGE

I. MARINICĂ[1], ANDREEA MARINICĂ[2]

Abstract. The dry autumn of 2018 in southern Romania in the context of climate change. The year 2018 in Romania has been the third warmest year since 1901, and globally the fourth warmest year on the planet since the beginning of the measurement. It was marked by early coming of spring with hot spring, hot summer (slightly warmer than normal after Hellmann's citation). The excessively dry and hot autumn followed in the first 77 days. The sharp cooling of the weather on the night of 18/19.XI.2018 has determined the end of the drought but also of the activity of setting up the autumn agricultural crops due to the abundant precipitations and the appearance of the snow layer. The paper analyses the aspects of climate variability from autumn 2018 in the southwest of Romania and analyses the synoptic conditions that determined the end of the hot weather and the early installation of the specific winter thermal regime. The paper is part of an extensive series of studies on climate variability and climate risk phenomena in the southwest of the country (Oltenia) and is useful to all those interested in climate change and the aspects of their manifestations at regional level in southwest Romania.

Key-words: dry autumn, early snowfall, snow cover, climate change

1. INTRODUCTION

Global warming also continued in 2018 which, globally, was the fourth warmest year in the history of meteorological recordings (according to the Copernicus Program, the European Union Climate Change Service, quoted by Reuters (7.I.2019). In 2018, the average temperature recorded on the Earth's surface was 14.7°C, with 0.2°C below the 2016 average, according to data collected throughout the year. The 2016 temperatures were amplified by the El Nino climate process which determined the rise of water temperature on the surface of the Pacific Ocean. "In 2018, we again witnessed a very hot year, the fourth recorded so far". "Dramatic climate events such as the hot and dry summer that affected large areas of Europe or rising temperatures in the Arctic region are alarming signals for each of us" (press release - Jean-Noël Thépaut, direct role of the Copernicus service on climate change). The years 2017 and 2015 were slightly warmer compared to the data recorded in 2018 (Copernicus). In December 2018, at the United Nations conference on global warming, UN Secretary-General Antonio Guterres said that

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humanity has "major problems due to climate change". "For many people, regions or even countries, it is already a matter of life and death" (200 countries participating in the annual meeting, COP24 - Katowice 2.XII.2018). The Copernicus report confirmed the forecasts published in November 2018 by the O.M.M., according to which 2018 will be the fourth warmest year in history. ***In Romania***, the year "2018" was the third warmest year from 1901 to the present (14.I.2019). The average annual air temperature in 2018 was 11.57°C, being the third highest value from 1901 to date, according to the records from the meteorological stations with long observations of the National Meteorological Administration. "The average air temperature in 2018 exceeded by 1.35°C the multiannual climatological average calculated for the period 1981-2010 (Vice Prime Minister and Minister of the Environment, Grațiela Gavrilescu - 14.I.2019). For the period 1900–2018, nine of the ten warmest years were recorded in the period 2000–2018 (except 1994, which ranked 5th in descending order of annual temperature thousands). These were: 2015 with an average of 11.72°C and a deviation of 1.73°C; 2007 with an average of 11.67°C and a deviation of 1.69°C; 2018 with an average of 11.57°C and a deviation of 1.58°C; 2014 with an average of 11.36°C and a deviation of 1.38°C; 2009 with an average of 11.28°C and a deviation of 1.29°C; 2013 with an average of 11.23°C and a deviation of 1,254°C; 2012 with an average of 11.23°C and a deviation of 1,253°C; 2008 with an average of 11.23°C and a deviation of 1.24°C and 2000 with an average of 11.21°C and a deviation of 1.22°C; At regional level ***in Oltenia*** the average temperature in 2018 was 11.76°C and the deviation from the average of the last century of 1.93°C. The winter 2017-2018 was warm, the burial was a little early, the warm spring with the exceptionally warm April (after the monthly averages and deviations from the average of the last century) and exceptionally dry, the summer was warm with the first two rainy months. August was an extremely dry heat in the Oltenia Plain. The hot and excessively dry weather extended until 16.XI when the autumn rains started and that on the night of 18/19.XI they turned into snow and snow, causing the early snow layer to appear. We will continue to analyze the climatic characteristics of this droughty autumn in Oltenia in the context of climate change.

2. DATA AND METHODS

For the accomplishment of the paper we used the data from the ANM archive and those from the international bases, the existing synoptic maps on the Internet from the international weather forecast centres, the ANM website, the satellite information, the information published in the print media and the results of the processing carried out by us.

3. RESULTS AND DISCUTIONS

3.1. Climate characteristics of September 2018

The average monthly temperatures in September 2018 were between 13.2°C at Voineasa and 20.0°C at Dr. Tr. Severin, and their deviations from the average of the last century were between -0.2°C (the only negative deviation) in the hilly area at Tg. Logrești and 2.0°C at Caracal in the Romanați Plain. According to the Hellmann criterion, these deviations show that September was warm in most of Oltenia (Table 1).

Table 1. *Air temperature regime in Oltenia and minimum and maximum temperature values at the soil surface in September 2018, for the area with altitude ≤ 600 m (NIX = average temperature values in September, for the period 1901-1990, MIX`18 = temperature averages in September 2018, Δ = MN = temperature deviation, CH = Hellmann criterion). (Source: data processed after ANM Archive)*

Meteorological station	Hm	NIX	MIX`18	Δ=M-N	CH	Tmin air (°C)	Data	Tmax air (°C)	Data	Tmin soil (°C)	Data	Tmax soil (°C)	Data
Dr. Tr. Severin	77	18.4	20.0	1.6	CL	1.6	26	33.5	2	1.0	27	55.8	12
Calafat	66	18.4	19.7	1.3	CL	1.6	27	35.9	2	1.0	28	42.2	2
Bechet	65	17.7	18.2	0.5	N	-1.7	27	34.6	2	2.8	27	49.2	2
Băilești	56	17.7	18.6	0.9	N	-0.5	27	34.1	2	0.3	27	45.2	16
Caracal	112	17.8	19.8	2.0	C	3.0	27	34.6	2	8.5	27	35.2	2
Craiova	190	17.7	18.8	1.1	CL	1.7	26	33.0	2	2.0	27	54.4	12
Slatina	165	17.9	18.9	1.0	CL	0.9	27	34.2	2	3.8	27	37.2	2
Bâcleș	309	16.6	17.8	1.2	CL	2.9	27	31.1	2	-	-	-	-
Tg. Logrești	262	15.9	15.7	-0.2	N	-1.7	26	31.8	2	-1.2	27	51.0	2
Drăgășani	280	17.6	19.1	1.5	CL	3.6	27	33.0	2	5.6	27	46.1	2
Apa Neagră	250	15.9	15.9	0.0	N	-4.2	26	30.1	2	1.0	26;27	37.2	1
Tg. Jiu	210	16.6	17.7	1.1	CL	-0.3	27	32.3	2	-0.5	27	47.0	23
Polovragi	546	15.6	16.6	1.0	CL	-0.3	27	30.1	2	-2.5	26	51.4	2
Rm. Vâlcea	243	16.4	18.2	1.8	CL	1.7	27	33.3	2	2.5	27	50.8	1
Voineasa	587	12.3	13.2	0.9	N	-2.7	27	28.4	2	-	-	-	-
Parâng	1585	-	-	-	-	-2.6	26	20.7	2	-	-	-	-
Media Oltenia	-	16.8	17.9	1.1	CL	0.2	-	31.9	-	1.9	-	46.4	-
Ob. Lotrului	1404	8.0	9.0	1.0	CL	-5.1	27	23.5	2	-	-	-	-

The monthly average temperature calculated for the whole region was 17.9°C, and its deviation from the average of the last century was 1.1°C, confirming that September was warm for the entire Oltenia region. *The monthly average temperature decrease* from August to September was 5.1°C, making it the first major inter-montly temperature drop in 2018. The *monthly minimums of air temperature* were recorded in the last peak of the month on the 26th and 27.IX and were between -4.2°C at Apa Neagră and 3.6°C in Drăgășani, and their average for the whole region was 0.2°C. ***The monthly maximums of air temperature*** were recorded on 2.IX and ranged between 28.4°C in Voineasa and 35.9°C in Calafat. This has resulted in the translation of the summer season into autumn. The average monthly temperature maximum for the entire region was 31.9°C. The warm weather with summer temperatures extended until 24.IX. *At the soil surface*, the

minimum temperatures were mostly recorded on 27.IX and ranged between -2.5°C in Polovragi and 8.5°C in Caracal, and their average for the entire region was 1.9°C. As a result of the strong weather cooling from the last peak of September, in the mornings of 26 and 27.IX there was haze on relatively large areas and locally frozen in the air. *The maximum temperature* at the soil surface were recorded in the data of 1, 2, 12, 16 and 23.IX and were between 35.2°C in Caracal and 55.8°C in Dr. Tr. Severin. *The variation graphs* of the parameters that characterize the air temperature in September (daily averages of the minimum temperature, daily averages and daily maximums calculated for the whole Oltenia region) had linear decreasing trends, and of these the fastest decrease had an average daily maximum temperatures with the decrease coefficient of -0.3708 (Fig. 1)
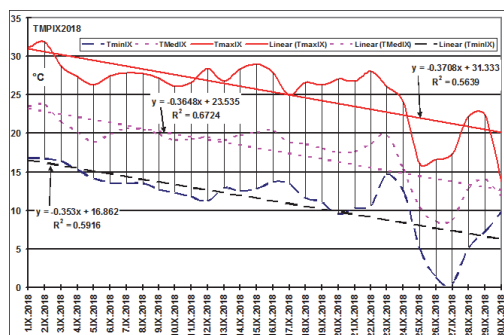

Fig. 1. *Variation of the parameters that characterize the air temperature in September in Oltenia (daily averages of minimum temperatures, daily averages and daily maxima calculated for the entire Oltenia region)* (Source: data processed after ANM Archive).

The rainfall regime for September 2018

The monthly precipitation quantities were between 2.6 l/m^2 at Slatina in the Getic Piedmont and 28.9 l/m^2 in Băilești in the Oltenia Plain, and their percentage deviations from the normal monthly averages were between -93.2% in Slatina and 12.8% in Băilești (the only positive deviation) which shows that the month of September was slightly rainy (PP) in a restricted area in Băilești and exceptionally dry (ES) in most of Oltenia (Table 2).

The average monthly precipitation quantities calculated for the whole region was 20.9 l/m^2, and its percentage deviation from the normal one was -55.8%, ie in September it was excessively dry for the whole region. As a result of this drought on September 28, 2018, the moisture content in the soil layer 0-20 cm (field) fell within low limits (moderate pedological drought) and particularly low (severe and extreme pedological drought), on most agricultural areas.

Table 2. *Monthly precipitation quantities recorded in autumn 2018 (Σ) (l/m²) compared to normal values (N); Δ% = percentage deviation from normal (the norms are calculated for the period 1901-1990), CH = Hellmann's criterion.*
(Source: data processed after ANM Archive)

Meteorological Station	Hm	September 2018				October 2018				November 2018			
		ΣIX	N	Δ%	CH	ΣX	N	Δ%	CH	ΣXI	N	Δ%	CH
Dr. Tr. Severin	77	4.2	48.4	-91.3	ES	4.4	66.4	-93.4	ES	76.9	71.5	7.6	N
Calafat	66	9.0	38.7	-76.7	ES	1.0	48.9	-98.0	ES	72.3	54.2	33.4	FP
Bechet	65	23.0	42.8	-46.3	ES	3.2	42.6	-92.5	ES	43.3	49.3	-12.2	PS
Băileşti	56	38.9	34.5	12.8	PP	1.4	46.2	-97.0	ES	73.8	57.2	29.0	P
Caracal	112	6.6	35.1	-81.2	ES	3.8	39.8	-90.5	ES	69.1	48.5	42.5	FP
Craiova	190	17.2	36.1	-52.4	ES	4.8	41.3	-88.4	ES	63.8	44.7	42.7	FP
Slatina	165	2.6	38.4	-93.2	ES	16.4	46.3	-64.6	ES	61.1	47.5	28.6	P
Bâcleş*	309	27.7	39.2	-29.3	S	0.5	57.1	-99.1	ES	16.9	47.9	-64.7	ES
Tg. Logreşti	262	28.2	38.4	-26.6	S	12.4	47.5	-73.9	ES	69.1	49.8	38.8	FP
Drăgăşani	280	31.6	50.3	-37.2	FS	10.6	50.3	-78.9	ES	51.4	52.6	-2.3	N
Apa Neagră	250	16.3	60.5	-73.1	ES	16.1	66.7	-75.9	ES	83.7	87.1	-3.9	N
Tg. Jiu	210	36.2	51.5	-29.7	S	22.4	66.3	-66.2	ES	78.9	62.3	26.6	P
Polovragi	546	22.2	61.7	-64.0	ES	38.6	68.6	-43.7	FS	67.2	78.7	-14.6	PS
Rm. Vâlcea	243	16.6	53.2	-68.8	ES	15.8	48.6	-67.5	ES	56.7	55.0	3.1	N
Voineasa*1	587	21.8	55.1	-60.4	ES	18.9	56.1	-66.3	ES	7.5	53.3	-85.9	ES
Parâng	1585	32.0	72.5	-55.9	ES	55.9	69.7	-19.8	PS	16.2	55.7	-70.9	ES
Average Oltenia	-	20.9	47.3	-55.8	ES	14.1	53.9	-73.8	ES	51.7	65.4	-20.9	S
Ob. Lotrului	1404	37.9	-	-	-	43.4	-	-	-	24.3	-	-	-

3.2. Climatic characteristics of October 2018

Monthly averages of air temperature were between 9.2°C in Voineasa and 14.5°C in Dr. Severin and Drăgăşani, and their deviations from the multinational averages of the last century were between 0.5°C in Tg. Logresti and 2.8°C in Drăgăşani, which according to the Hellmann criterion shows that October 2018 was warm (C) in most of the region (Table 3). The average monthly air temperature calculated for the entire Oltenia region was 12.8°C, and its deviation from the normal was 2.0°C, confirming that October was an average warm month for the entire Oltenia region.

The decrease of the monthly air temperature average from September to October was 5.1°C (equal to the inter-monthly decrease from August to September), being the second big decrease of the average temperature during the year 2018. *The monthly air temperature minima* were recorded the most in the latter part of the month and ranged between -1.6°C at the Apa Neagră and 4.9°C at Dr. Tr. Severin, and their average for the whole region was 1.1°C. *The monthly maxima* of air temperature were atypical

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[1] The Voineasa and Bâlceș weather stations are autonomous (automatic without personnel) and have the precipitation sensor covered in the cold season, as a result the precipitation quantities are not exact. The table values for November are not considered as indicative.

during the last three days of the month (with one exception) and ranged between 23.3°C in Voineasa and 28.0°C in Bechet, and their average for the entire region was 25.5°C.

Table 3. *Air temperature regime in Oltenia and minimum and maximum temperature values at the ground surface in October 2018, for the area with altitude ≤ 600 m (NX = average temperature values in October, for the period 1901-1990, MX`18 = temperature averages in October 2018, Δ = MN = temperature deviation, CH = Hellmann criterion).* (S*ource: data processed from ANM Archive*)

| Meteorolog ical station	Hm	NX	MX`1 8	Δ=M-N	CH	Tmin air		Tmax air		Tmin soil		Tmax soil	
						(°C)	Date	(°C)	Date	(°C)	Date	(°C)	Date
Dr. Tr. Severin	77	12.2	14.5	2.3	C	4.9	16	25.8	30	0.7	25	45.6	8
Calafat	66	11.9	14.0	2.1	C	3.2	23	26.9	31	3.4	14	29.8	10
Bechet	65	11.3	12.4	1.1	CL	-0.1	5	28.0	29	3.5	14	37.5	8
Băileşti	56	11.2	13.3	2.1	C	2.8	23	26.6	29	2.0	26	40.5	8
Caracal	112	11.5	14.0	2.5	C	2.7	25	26.8	31	5.9	25	26.8	31
Craiova	190	11.4	14.0	2.6	C	2.3	25	26.3	29	0.6	25	43.5	8
Slatina	165	11.2	13.3	2.1	C	2.7	15;25	26.1	30;31	1.6	25	26.2	8
Bâcleş	309	10.9	13.1	2.2	C	1.7	25	24.1	30;31	-	-	-	-
Tg. Logreşti	262	10.1	10.6	0.5	N	-0.7	15	26.1	30	-0.3	15	37.2	8
Drăgăşani	280	11.7	14.5	2.8	C	2.7	25	26.3	31	2.3	25	34.0	8
Apa Neagră	250	10.2	11.1	0.9	N	-1.6	15	24.5	31	0.0	25;26	33.7	8
Tg. Jiu	210	10.6	12.2	1.6	CL	1.8	6;15	26.9	30	0.7	15	36.9	12
Polovragi	546	10.2	12.3	2.1	C	-1	25	24.8	30	-3.2	25	40.4	8
Rm. Vâlcea	243	10.6	13.2	2.6	C	2.2	25	27.5	30	0.2	25	35.5	7
Voineasa	587	7.2	9.2	2.0	C	-0.9	5;15	23.3	10	-	-	-	-
Parâng	1585	4.7	-	-	-	-5.8	25	17.9	30	-	-	-	-
Average Oltenia	-	10.8	12.8	2.0	C	1.1	-	25.5	-	1.3	-	36.0	-
Ob. Lotrului	1404	4.1	5.0	0.9	N	-4.7	5	19.2	30	-	-	-	-
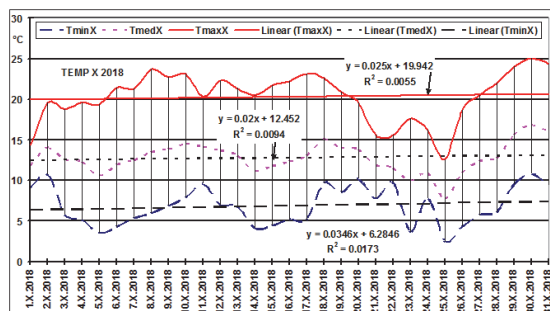
Fig. 2. *Variation of the parameters that characterize the air temperature in October in Oltenia (daily averages of minimum temperature, daily averages and daily maxima calculated for the entire Oltenia region)* (*data source processed from ANM Archive*).

The minimum temperatures on the soil surface were recorded, mostly, in the dates of 25 and 26.X and were between -3.2°C in Polovragi and 5.9°C in Caracal, and their average for the whole region was 1.3°C.

The maximum temperatures at the soil surface were mostly recorded in the first decade and ranged between 26.2°C in Slatina and 45.6°C at Dr. Tr. Severin, and their average for the entire region was 36.0°C.

The variation graphs of the parameters that characterize the air temperature in October (daily averages of the minimum temperature, daily averages and daily maxima calculated for the entire Oltenia region) had insignificantly increasing linear trends (Fig. 2), which means maintaining the warm weather throughout the month of October.

The rainfall regime for October 2018

In October 2018, the monthly precipitation quantities were between 0.5 l/m^2 in Bâcleș and 38.6 l/m^2 in Polovragi, and their percentage deviations from the normal multiannual averages were between -99.1% in Bâcleș and -43.7% at Polovragi, which, according to the Hellmann criterion, leads to the conclusion that October was excessively dry (ES) in most of Oltenia (Table 2). *The monthly average* of the precipitation quantities calculated for the whole Oltenia region was 14.1 l/m^2, and its percentage deviation from the normal one was -73.8%, confirming that October was an average of an excessively dry (ES) month for the entire Oltenia region.

3.3. Climate characteristics of November 2018

The monthly average temperatures in November 2018 were between 3.9°C at Voineasa and 6.9°C at Dr. Tr. Severin, and their deviations from the average of the last century were between -0.9°C at Bechet and 1.7°C at Voineasa, and according to the Hellmann criterion, these deviations lead to the classification of normal thermal month in most of Oltenia (Table 4).

The monthly average air temperature calculated for the entire Oltenia region was 5.3°C, and its deviation from the normal was 0.1°C, which confirms that November was on average thermally normal for the entire Oltenia region. *The monthly average temperature decrease* from October to November was 7.3°C, being ***the largest inter-monthly decrease in temperature throughout 2018***, which means an intense weather cooling compared to the first two months of autumn, cooling as it occurred. starting with 16.XI. *Monthly air temperature minima* were recorded on 30.XI and ranged between -13.6°C at Bechet and -4.8°C at Dr. Tr. Severin, and their average for the whole region was -8.3°C. *The maximum air temperatures* were recorded between 1 and 4.XI and ranged between 17.4°C in Bâcleș and 21.6°C in Tg. Jiu, and their average for the whole region was 19.5°C. *On the soil surface*, *the minimum temperatures* were recorded mostly on 30.XI and ranged between -14.0°C in Calafat and -1.8°C in Rm. Valcea, and their average for the entire region was - 7.7 ° C. The maximum temperatures on the surface of the soil were mostly recorded in the interval 1-4.XI and ranged between 18.8°C in Slatina (on the date of 3.XI) and 32.8°C on Dr. Tr. Severin (on the date 4.XI), and their average for the whole region was 26.2°C.

Table 4. *Air temperature regime in Oltenia and minimum and maximum temperature values at the soil surface in **November 2018**, for the area with altitude ≤ 600 m (*NX = normal monthly average temperatures (average temperature values for November, for the period 1901-1990), MX `18 = temperature averages in November 2018, Δ = MN = temperature deviation, CH = Hellmann criterion).
(Source: data processed from ANM Archive)

Meteorologi cal station	Hm	NX	MX`18	Δ=M-N	CH	Tmin air		Tmax air		Tmin soil		Tmax soil	
						(°C)	Date	(°C)	Date	(°C)	Date	(°C)	Date
Dr. Tr. Severin	77	6.4	**6.9**	0.5	N	-4.8	30	21.3	3	-3.5	30	**32.8**	4
Calafat	66	6.0	5.5	-0.5	N	-12.2	30	18.9	1	*-14.0*	30	21.5	3
Bechet	65	5.6	4.7	*-0.9*	N	*-13.6*	30	20.9	1	-13.0	30	25.7	4
Băileşti	56	5.5	5.5	0.0	N	-7.6	30	19.3	3	-12.8	30	29.7	15
Caracal	112	5.5	5.5	0.0	N	-9.5	30	18.7	3	-10.8	30	21.5	3
Craiova	190	5.5	5.4	-0.1	N	-7.7	30	18.1	4	-8.8	30	28.5	4
Slatina	165	5.6	5.3	-0.3	N	-7.5	30	17.5	4	-7.6	30	*18.8*	3
Bâcleş	309	4.8	4.9	0.1	N	-9.3	30	*17.4*	3	-	-	-	-
Tg. Logreşti	262	4.8	4.6	-0.2	N	-6.3	30	19.5	3	-5.0	30	28.6	3
Drăgăşani	280	5.6	5.6	0.0	N	-7.0	30	18.5	4	-8.7	30	23.1	4
Apa Neagră	250	4.8	4.5	-0.3	N	-7.1	20	20.5	1	-2.1	15;16	23.8	4
Tg. Jiu	210	5.1	5.7	0.6	N	-5.9	30	**21.6**	3	-5.5	30	28.8	1
Polovragi	546	4.8	4.7	-0.1	N	-8.2	30	20.8	1	-6.8	30	28.0	1
Rm. Vâlcea	243	5.2	6.2	1.0	N	-5.6	30	21.1	4	**-1.8**	30	30.0	1
Voineasa	587	2.2	*3.9*	**1.7**	CL	-6.0	30	20.9	2	-	-	-	-
Parâng	1585	0.4	-	-	-	-15.0	30	17.3	3	-	-	-	-
Average Oltenia	-	5.2	5.3	0.1	N	-8.3		19.5	-	-7.7	-	26.2	-
Ob. Lotrului	1404	-1.0	0.7	1.7	CL	-13.4	30	19.2	3	-	-	-	-

The graphs of variation of the parameters that characterize the air temperature in November (daily averages of the minimum temperature, daily averages and daily maxima calculated for the whole Oltenia region) had strongly decreasing linear trends, and of these the fastest decrease was the daily average of the maximum temperatures with the coefficient of decrease of -0.6636 (Fig. 3).
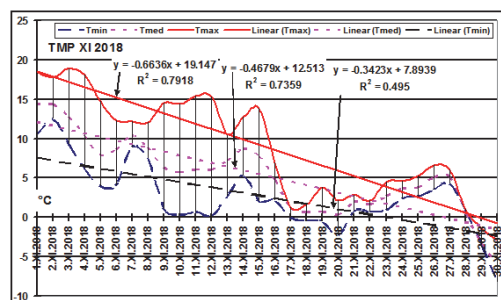

Fig. 3. *Variation of the parameters that characterize the air temperature in November in Oltenia (daily averages of minimum temperature, daily averages and daily maxima calculated for the entire Oltenia region)* (data source processed from ANM Archive).

The rainfall regime for November 2018

The monthly precipitation amounts ranged from 43.3 l/m^2 at Bechet to 83.7 l/m^2 at Apa Neagră, and their percentage deviations from normal were between -14.6% in Polovragi and 42.7% in Craiova. According to the Hellmann criterion we conclude that in November 2018 the rainfall types were from slightly dry (PS) in restricted areas like Bechet and Polovragi to very rainy (FP) in Calafat, Caracal, Craiova and Tg. Logresti, in much of Oltenia ending the excessive drought of the first two autumn months. In the Parang mountain area, the percentage deviation from the normal was -70.9% which shows that in this area, November was excessively dry (ES). *The average monthly rainfall* for the entire Oltenia was 51.7 l/m^2, and the percentage deviation of its normal was -20.9%, which shows that on average, for the entire Oltenia region, November was dry (S) (Table 2). The significant rainfall of autumn 2018 started slowly on 16.XI with light rain, and on the night of 18/19.XI they turned into sleet and snow and formed a snow layer with thicknesses between 2 cm at Tg. Jiu and 17 cm in Băilești and Craiova. There were two significant rainfall intervals: 16-22.XI and 25-28.XI. The first snow layer melted in the range 20-23.XI. And in the second precipitation interval there were snowfall in the afternoon of 28.XI, on the night of 28/29.XI and isolated and 29.XI, which deposited a layer of snow, with thicknesses between 2 cm at Rm. Vâlcea and 18 cm at Bechet. The second layer of snow melted in the range 2-5.XII. Significant rainfall in the second half of November, the snow layer and the significant cooling of the weather interrupted the seasonal agricultural work. As a result, due to the excessive drought, the setting up of autumn agricultural crops was very difficult and delayed. The agricultural crops in some areas could not be financed, and the rape did not rise uniformly with large gaps, and in some areas the crop had to be abolished.

3.4. Seasonal climate characteristics of autumn 2018

The seasonal averages of air temperature were between 10.3°C at Tg. Logresti and 13.8°C at Dr. Tr. Severin, and their deviations from normal were between 0.0°C at Tg. Logresti and 1.5°C at Dr. Tr. Severin, Drăgășani and Caracal deviations which according to the Hellmann criterion show that autumn 2018 as a whole was warm (C) (Table 5). The average annual air temperature calculated for the entire region was 12.0°C, and its deviation from normal was 1.1°C, which confirms that the average autumn 2018 has been warm (C) throughout Oltenia. The annual precipitation amounts were between 69.5 l/m^2 at Bechet and 137.5 l/m^2 at Tg. Jiu, and their percentage deviations from the normal ones were between -54.1% at Dr. Tr. Severin and 17.3% at Băilești, which according to Hellmann's criterion shows that autumn 2018 was rainfall deficient in all Oltenia, and the characterizations of the types of rainfall time were from slightly dry (PS) in Băilești and excessively dry (ES) to Dr. Tr. Severin, Bechet and Apa Neagră.

Table 5. *Overall thermal and rainfall regime of autumn 2018 (*Hm = altitude of the weather station, T2018 = average of temperature values in autumn 2018 (°C), NtT = normal values of seasonal average of autumn temperature (calculated for the period 1901-1990) (°C), Δ = TN = deviations from normal (°C), ST2018 = sum of precipitation in autumn 2018 (l/m²), NT = normal values of precipitation in autumn (l/m²), Δ = SN = deviations from normal (l/m²), Δ% = percentage deviations from normal, CrH = Hellmann criterion). (Source: data processed from ANM Archive)

Meteorological Station	Hm	Thermal regime (°C)				Pluviometric regime (l/m²)				
		NtT	T2018	Δ=T-N	CrH	ST2018	NT	Δ=S-N	Δ%	CrH
Dr. Tr. Severin	77	12.3	13.8	1.5	C	85.5	186.3	*-100.8*	*-54.1*	ES
Calafat	66	12.1	13.1	1.0	CL	82.3	141.8	-59.5	-42.0	FS
Bechet	65	11.5	11.8	0.3	N	*69.5*	134.7	-65.2	-48.4	ES
Băileşti	56	11.5	12.5	1.0	CL	114.1	137.9	*-23.8*	*-17.3*	PS
Caracal	112	11.6	13.1	1.5	C	79.5	123.4	-43.9	-35.6	FS
Craiova	190	11.5	12.7	1.2	C	85.8	122.1	-36.3	-29.7	FS
Slatina	165	11.6	12.5	0.9	CL	80.1	132.2	-52.1	-39.4	FS
Bâcleş[*]	309	10.8	11.9	1.1	C	-	-	-	-	-
Tg. Logreşti	262	10.3	*10.3*	*0.0*	N	109.7	135.7	-26.0	-19.2	S
Drăgăşani	280	11.6	13.1	1.5	C	93.6	153.2	-59.6	-38.9	FS
Apa Neagră	250	10.3	10.5	0.2	N	116.1	214.3	-98.2	-45.8	ES
Tg. Jiu	210	10.8	11.9	1.1	C	137.5	180.1	-42.6	-23.7	S
Polovragi	546	10.2	11.2	1.0	CL	128.0	209.0	-81.0	-38.8	FS
Rm. Vâlcea	243	10.7	12.5	1.8	C	89.1	156.8	-67.7	-43.2	FS
Voineasa[*]	587	7.2	8.8	1.6	C	--	-	-	-	-
Parâng	1585	-	-	-	-	104.1	197.9	-93.8	-47.4	ES
Average Oltenia	-	10.9	12.0	1.1	C	98.2	159.0	-60.8	-38.2	FS
Ob. Lotrului	1404	3.7	4.9	1.2	C	105.6	-	105.6	-	-
Petroşani	607	8.2	-	-	-	79.7	181.5	-101.8	-56.1	ES

The average of the seasonally calculated quantities for the whole Oltenia region was 98.2 l/m², and its percentage deviation from the normal one was 38.2%, which, according to the Hellmann criterion, we conclude that autumn 2018 was on average very dry (FS) for the whole region Oltenia. In September, in the data of 1, 2, 8, 11-14.IX, 16-23.IX, 26-28.IX, for 18 days, no rain drop was reported in Oltenia, and the humidity deficit from the soil it was excessive (excessive pedological drought) and the air temperature was higher than normal. In October, the situation of excessive drought continued to be recorded for 18 days without a drop of rain, including 15 consecutive (3-18.X, 26, 27 and 31.X). The excessive atmospheric and pedological drought also continued in the first 17 days of November. Thus, in November there were 10 days without a drop of rain in the data of: 2-5.XI, 8-12.X and 14.XI. In the interval 1.IX-30.XI there were a total of 46 days without a drop of rain (50.5% of the autumn days) (most of them located in the interval 1.IX -17.XI), and on the other days of the latter interval rainfall was isolated and insignificant. Significant rainfall for agriculture, in some areas were recorded in September between 3-5.IX and in November in the intervals: 16-22.XI, 25-28.XI totalling 14 days (15.4% of autumn days).

In November, it makes the real transition from the autumn thermal regime to the winter thermal regime, and the normal decrease of the average monthly

temperature for the entire Oltenia region (calculated for the last century) is -5.5°C. The normal decrease of the monthly average temperature for the entire Oltenia region from November to December is -4.9°C being the last major decrease of the average monthly air temperature during the year.

In most years the decrease of the average temperatures to those characteristic of December is made in the last peak of the month and as a result it is true the popular observation that the day of 30.XI is "the end of winter". For the period 1961-2018 (the last 58 years) the statistical analysis of the monthly temperature averages in November at the weather station in Craiova (located in the central part of Oltenia) shows that the share of cold weather was 32.8%, of the normal thermal temperature of 31.0%, and of the hot weather of 36.2% (Table 6) which shows a predominance of the warm months. Only two very cold November months (FR) were recorded, the coldest being in 1988 with the average of -0.4°C (the lowest monthly average for the last 58 years), and the coldest month was in the year 1993. In the symmetrical class of the very hot months no month was recorded, and in the class of the warm months (C) according to the Hellmann criterion 11 months were recorded, most after 1990 (7 months). The warmest November after the monthly average temperature was in 2010 with an average of 9.7°C.

Table 6. *Thermal classification of November in Craiova, during the last 58 years* (T med = average temperature of November in Craiova (°C), Type = thermal classification of the month according to Hellmann criterion, T-cold (cold time) = no. months colder than normal and percentage, TN (normal thermal time) = number of normal months and percentage, T-warm (hot time) = number of months warmer than normal and their percentage, Hellmann classes: ER = exceptionally cold, FR = very cold, R = cold, RC = cool, N = normal, CL = warm, C = hot, FC = very hot, EC = exceptionally hot, normal monthly average (5.5°C).

YEAR	Tmed	TYPE	YEAR	Tmed	TYPE	YEAR	Tmed	TYPE	YEAR	Tmed	TYPE
1961	7.8	C	1977	7.1	CL	1993	-0.1	FR	2009	7.7	C
1962	7.8	C	1978	2.5	R	1994	5.3	N	2010	9.7	C
1963	8.6	C	1979	5.6	N	1995	1.4	R	2011	3.0	R
1964	6.6	CL	1980	4.5	RC	1996	7.6	C	2012	7.3	CL
1965	3.9	RC	1981	4.7	N	1997	5.3	N	2013	7.9	C
1966	5.8	N	1982	3.2	R	1998	2.5	R	2014	5.2	N
1967	6.3	N	1983	2.1	R	1999	4.4	RC	2015	8.2	C
1968	6.0	N	1984	4.9	N	2000	8.4	C	2016	5.1	N
1969	8.3	C	1985	4.1	RC	2001	4.7	N	2017	6.3	N
1970	7.0	CL	1986	4.0	RC	2002	6.8	CL	2018	5.4	N
1971	4.7	N	1987	6.7	CL	2003	6.7	CL	Media	5.4	N
1972	5.8	N	1988	-0.4	FR	2004	6.5	CL	T-rece	19	32.8%
1973	2.8	R	1989	4.1	RC	2005	4.2	RC	TN	18	31.0%
1974	3.9	RC	1990	7.4	CL	2006	7.5	C	T-cald	21	36.2%
1975	2.4	R	1991	5.0	N	2007	2.7	R			
1976	5.8	N	1992	6.7	CL	2008	6.1	N			

The graph of the monthly average temperature variation in Craiova indicates an increasing linear trend (Fig. 4). After the summer of 2018, when the first two months were excessively rainy, and the heat June and July normal heat and August hot and excessively dry in the Oltenia Plain, the excessively dry and warm autumn followed in most of it. The cooling of the weather triggered in Oltenia on 16.XI increased rapidly, so that the rains at the beginning weak (on the 16th and 17th dates) turned into sleet and snow on the 18th and at night between 18 and 19.XI.

Summer of 2018 has been warm throughout the northern hemisphere including in the Arctic region. This strong and massive atmosphere warming weakened the intensity of the Polar Vortex, which caused that, with the increased cooling of the air in the northern hemisphere, cold Arctic continental air (CA) masses were successively detached from the polar Vortex and moved to the southern latitudes[1] (Fig. 5). Situations of this type were repeated throughout the winter of 2018-2019, which made the first winter month to be thermally normal, January warm (CL) and February warm (C).
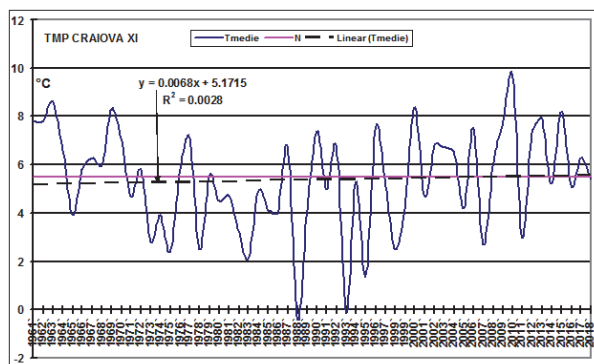

Fig. 4. *Variation of the average monthly air temperature in November in Craiova between 1961-2018* (Source: data processed from ANM Archive).

In the northern hemisphere the intense cooling started in the first part of November, and at Oymiacon in Siberia on 8.XI.2018, when the thermal minimum recorded was -41.0°C (Report: Yakutia.com). The first victim of the cold season in Romania was registered in the morning of 9.XI.2018, when at Miercurea Ciuc after the cold night, a man died in the city park and the second one suffered hypothermic shock. The intense cooling began in Romania and Oltenia on 18.XI.2018 during an evening with rain, sleet and snow associated with wind intensifications (the first Mediterranean Cyclone in autumn 2018), for which the ANM issued a yellow code. At the level of the northern hemisphere in this period has produced exceptional weather events in many areas, thus on 15.XI.2018, massive floods occurred in the

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[1] This remark explains the popular observation that "the hotter the summer, the colder the winter."

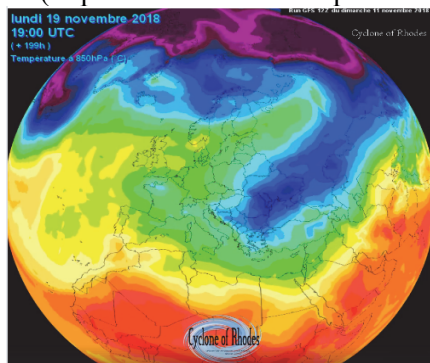Arabian Desert (Saudi Arabia and Kuwait) where the water layer exceeded 1m thick (https: //evz.ro/inundatii-puternice-in-arabia-saudita-877567.html).

Fig. 5. *Adequacy of cold air from the Polar Vortex to South-East Europe, situation from 19.XI.2018, 00 UTC (situation calculated as of 11.XI.2018, Source: Cyclone of Rhodes ; https://twitter.com/cycloneorhodes)*

We will continue to analyze ***the sharp cooling of the air in Oltenia from 16-18.XI***, which determined the installation of specific thermal regime in the first part of December, 14 days earlier. The initiation of the process over Eastern Europe including Romania, was made on the 14.XI, and the maximum phase of this first cooling was registered on the 19.XI.2018, at 00 UTC (ie exactly as the calculations indicated). At this time, the air circulation over Europe was blocked (the 552 damgp isohypse had the form of the letter "Ω"). *The position of the baric centres on the surface of the earth at this time*, shows the strong Scandinavian Anticyclone developed above the Scandinavian Peninsula and Great Britain with atmospheric pressure values of over 1040 hPa (Fig. 6). Initially it was part of the backbone of the Azoric Anticyclone extended to northern Europe. The strongly developed Icelandic Cyclone (with very low centre atmospheric pressure below 980 hPa) is located south of Greenland, and in its thalweg we find the central Mediterranean Cyclone west of the Iberian Peninsula (1006 hPa closed isohypse). To the east is located the East-European Anticyclone united with the Scandinavian one. *At altitude at the level of 500 hPa* is located the thalweg that preceded the atmospheric blockade, in which to the west of Romania is positioned a low geopotential nucleus with values at the centre below 544 hPa. At altitude the air circulation over Romania was ultra-polar, and the arctic cold air mass (A) reached west of Romania and then the western part of Romania. The advection of the cold air mass is highlighted by the air temperature field at the level of 850 hPa (Fig. 7). At this time (00 UTC) it is observed the penetration of cold air mass (the isotherm of -5°C) up to the coast of the Adriatic Sea.
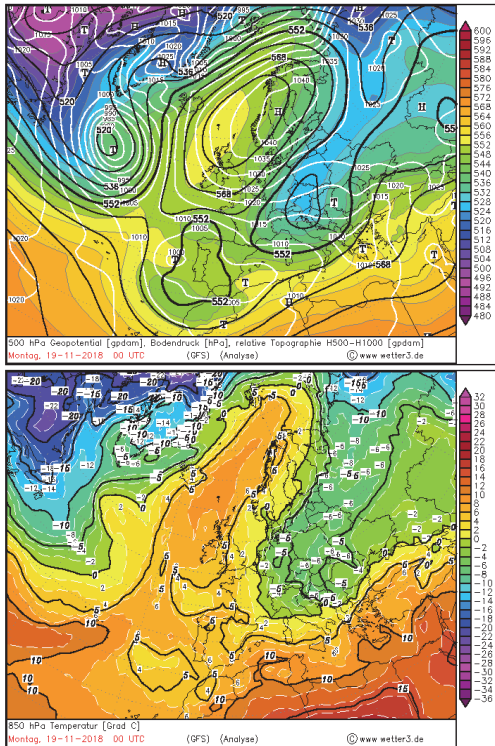
Fig. 6. *The synoptic situation on the ground (the atmospheric pressure field at the ground surface level) superimposed with the geopotential field from altitude at the isobaric level of 500 hPa and the relative barographic topography TR 500/1000 on 19.XI.2018 UTC time (after www.wetter3.de).*
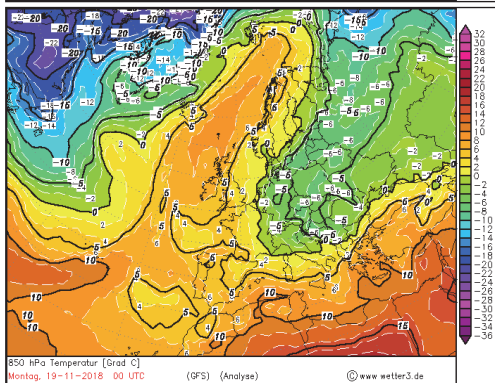

Fig. 7. *The altitude temperature field at the isobaric level of 850 hPa on 19.XI.2018 at 00 UTC (after www.wetter3.de).*

This type of synoptic situation is particularly important for Europe because it has the property of persistence and repetition and can cause significant weather cooling in Romania (and in Eastern Europe) and precipitation in any season. Thus, during the first two months of summer 2018, this type of synoptic situation determined in June a normal thermal weather (N), and in warm July (CL) that is slightly warmer than normal (after Hellmann's Criterion), and the precipitation recorded in the whole country was excessively large compared to normal. ***Similar synoptic situations through persistence and repetition have determined in the past, in the year 1813, an excessively cold year considered to be "the year without summer[2]"*** (Pfister 1999) quoted by Elena Teodoreanu (p. 273). The occurrence of such a synoptic situation is determined by the positioning of Europe with the Atlantic Ocean and the Gulfstream in the west, whose action favours the advance

[2] *In fact, the true year without summer* is considered the year 1816. The profound causes of the occurrence between 1812 and 1816 of *the years with cold summers* (years without summer) were the volcanic eruptions over a period of several years, culminating with the one the most powerful eruption known in history, that of the Tambora volcano (April 1815). These eruptions from 1812 to 1815, caused the accumulation in the atmosphere of large quantities of volcanic ash and dust. An historical minimum of solar activity (**the Dalton minimum**) further accentuated the cooling of the summer weather of 1816 (Source: Elena Teodoreanu (2017, p. 274)

of the Azoric Anticyclone ridge to northern Europe over the Scandinavian Peninsula (which limits its extension), thus initiating the blockage and advection of cold (continental polar (cP) or arctic (A)) air over Eastern Europe. This type of synoptic situation is particularly important for Europe because it makes the natural connection between the North Atlantic Oscillation and the Arctic Oscillation. Such situations have been repeated throughout the winter of 2018-2019. Therefore, this type of synoptic situation has a great potential for climate risk. Climate warming has diminished its frequency of occurrence. For Europe, this type of atmospheric circulation will remain one of the main causes of the accelerated and rapid weather cooling. The subsequent evolution of the atmospheric blockade and the action of the Coriolis force determines the advance of cold air over much of Europe. Atmospheric circulations of this type are more frequent during periods of minimal solar activity and when natural or human phenomena decrease the intensity of solar radiation. The presence of the Scandinavian Peninsula, its shape and positioning are of great importance in the formation, development and evolution of this type of atmospheric circulation. In most of Europe, the autumn of 2018 was hot, and it was estimated in February 2019 that: "We had an unusual late summer this autumn, and now the spring begins earlier (26.II.2019). This is associated with global warming which greatly increases the likelihood of such warming " (Dim Coumou from the Potsdam Institute for Environmental Impact Research (PIK)).

4. CONCLUSIONS

The autumn of 2018 was atypical, excessively dry and hot in the first 77 days. The excessive drought was a continuation of the drought installed during August and caused serious problems for the beginning of the 2018-2019 agricultural year, by delaying the establishment of agricultural crops, compromising those already planted, and performing superficial agricultural works due to the hardened soil that did not allowed to make autumn plows. Significant precipitations were recorded very late between 18-22.XI.2018, initially as rain and then sleet and snow, which caused the formation of the snow layer. The air circulation jam situation was repeated at the end of November between 28-30.XI, which meant that on the 30.XI the monthly minimums of November and of the autumn season were recorded. The colds of the latter part of November are often severe and cause the December temperatures to set in, sometimes even earlier. Not coincidentally, the feast of St. Andrew (with a fixed date of 30.XI) is popularly called *the head of winter*, with the meaning of the beginning of winter. The weather cooling from the last days of November was prolonged during the first 3 days of December 2018, determining the registration of the most monthly minimums of December in the interval 1-3.XII. *The minimum rainfall* of the year 2018 was recorded during the autumn, and the secondary rainfall maximum greatly diminished can be considered to have been recorded between 18.XI-31.XII.2018.

REFERENCES

1. Marinică, I., Marinică, Andreea Floriana (2016), *Variabilitatea climatica în Oltenia şi schimbari climatice*, Universitaria Publishing House, Craiova, 308 p.
2. Pfister, Chr. (1999), *Wetternachhersage, 500 jahre Klimavariationen und Naturcatastrophen (1496-1995)*, Verlag Paul Haupt, Bern, Stuttgart, Wien.
3. Teodoreanu, Elena (2017), *În căutarea timpului trecut. Schiță de climatologie istorică,* Paideia Publishing House, București.
4. *** https://jurnalul.antena3.ro/stiri/observator/anul-2018-a-fost-al-patrulea-cel-mai-calduros-din-istorie-796335.html
5. ***https://www.green-report.ro/2018-al-patrulea-cel-mai-calduros-an-inregistrat-vreodata/