VERIFICATION OF THE SEECOF–21 SUMMER 2019 CLIMATE OUTLOOK AND SEASONAL BULLETIN FOR SERBIA

Belgrade, 3 October 2019

Republic Hydrometeorological Service of Serbia
Division for Climate Monitoring and Climate Forecast
Department of National Center for Climate Change, Climate Model Development and Disaster Risk Assessment
web: http://www.hidmet.gov.rs
mail: k.c@hidmet.gov.rs

Temperature

The SEECOF-21 outlook for the summer of 2019 in Serbia indicated warmer than normal temperature in Serbia with 50% probability relative to the 1981–2010 climatological base period (*Figure* A).
Climatological monitoring showed that the summer of 2019 was warm in entire Serbia, with above-normal temperature based on the tercile method (*Figure* B). The outlook for a warm summer was correct in entire Serbia.

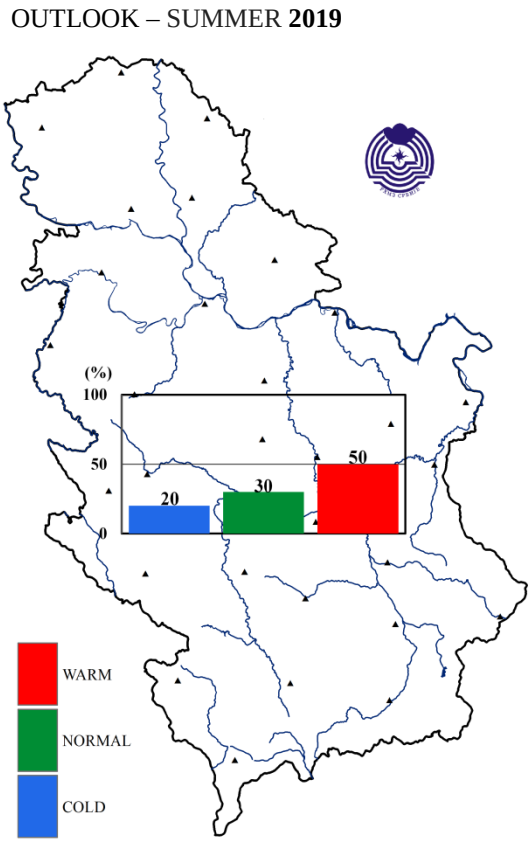

Figure A. SEECOF-21 - summer temperature outlook

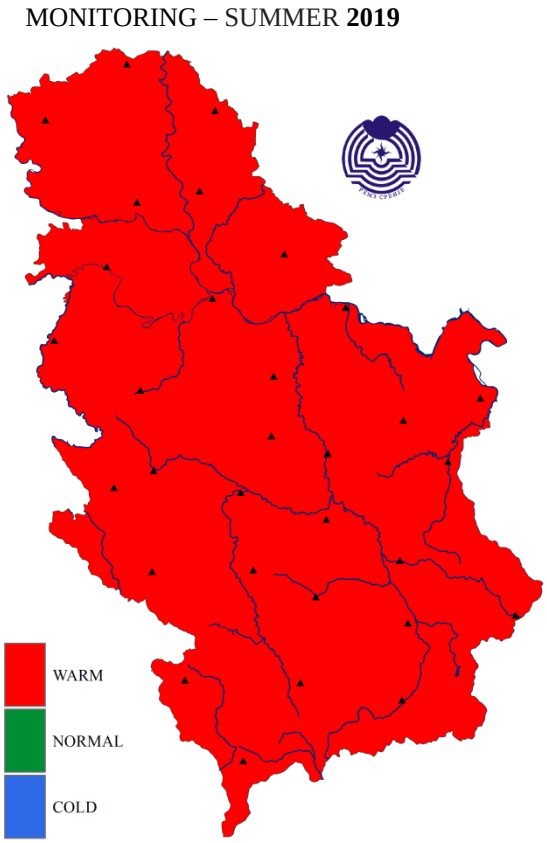

Figure B. Monitoring of the 2019 summer temperature using tercile method compared to the 1981-2010 base period

Precipitation

The SEECOF–21 climate outlook for the summer of 2019 indicated no predictive signal. Therefore, average precipitation sums were forecasted in most of Serbia, except in the northern part where dry conditions with the probability of 45% were forecasted (*Figure* C). Monitoring of precipitation showed average summer conditions in most of Serbia, except in certain scattered locations (*Figure* D). The outlook was correct for most of Serbia.

OUTLOOK – SUMMER **2019**

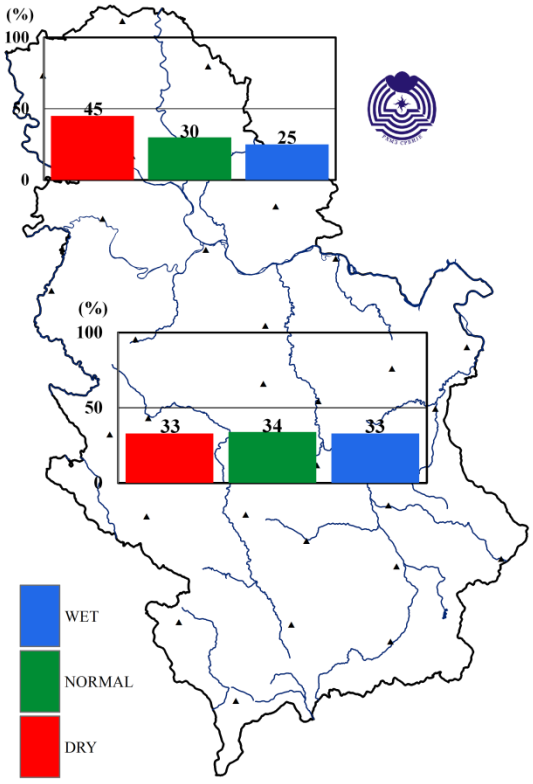

Figure C. SEECOF-21 - summer precipitation outlook

MONITORING – SUMMER **2019**

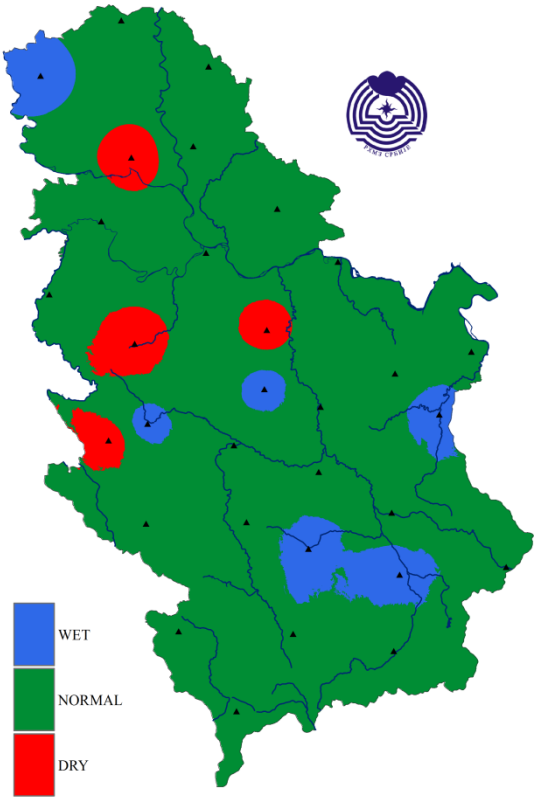

Figure D. Monitoring of the 2019 summer precipitation using tercile method relative to the 1981-2010 base period

Summer 2019			Air Temperature (°C)			
Station	Rank*	Rank**	33	50	66	Observed value
Beograd (1888-2019)	4	4	21.6	22.0	22.9	24.9
Palić (1945-2019)	3	3	20.9	21.3	21.9	23.5
Sombor (1942-2019)	4	4	20.6	21.0	21.3	23.0
Novi Sad (1948-2019)	4	4	20.8	21.0	21.6	23.6
Zrenjanin (1946-2019)	6	5	21.0	21.2	21.7	23.6
Kikinda (1948-2019)	5	5	20.8	21.3	21.7	23.4
Banatski Karlovac (1986-2019)	7	7	20.9	21.3	21.8	22.9
Loznica (1952-2019)	4	4	20.7	21.0	21.7	23.2
Sremska Mitrovica (1925-2019)	7	4	20.5	20.8	21.2	22.8
Valjevo (1926-2019)	5	4	20.5	20.9	21.6	23.4
Kragujevac (1925-2019)	11	6	20.6	21.2	21.6	22.8
Smederevska Palanka (1939-2019)	7	6	20.8	21.3	21.8	23.3
Veliko Gradište (1926-2019)	7	6	20.4	21.1	21.4	23.1
Crni Vrh (1967-2019)	4	4	15.9	16.3	16.6	18.4
Negotin (1927-2019)	10	6	22.0	22.7	23.1	24.4
Zlatibor (1950-2019)	5	5	16.3	16.8	17.3	18.9
Sjenica (1946-2019)	6	5	15.3	15.9	16.2	17.3
Pozega (1952-2019)	6	6	18.9	19.4	19.5	20.7
Kraljevo (1926-2019)	9	5	20.6	21.0	21.5	23.0
Kopaonik (1950-2019)	4	4	11.5	12.1	12.5	14.1
Kursumlija (1952-2019)	6	5	19.0	19.4	19.9	20.9
Krusevac (1927-2019)	11	6	20.7	21.1	21.5	22.8

Cuprija (1948-2019)	4	3	20.3	21.0	21.3	23.1
Nis (1925-2019)	9	5	21.2	21.9	22.2	23.6
Leskovac (1948-2019)	7	5	20.4	20.9	21.1	22.6
Zajecar (1929-2019)	22	15	20.9	21.8	22.0	22.0
Dimitrovgrad (1945-2019)	9	5	18.8	19.4	19.7	20.9
Vranje (1926-2019)	13	7	20.3	21.1	21.3	22.5

*Rank – period of stations work (warmest season)
**Rank – 1981-2019 period (warmest season)

Summer 2019			Precipitation sums (mm)			
Station	Rank*	Rank**	33	50	66	Observed Value
Beograd (1888-2019)	55	19	169.3	222.8	264.1	221.4
Palić (1945-2019)	41	20	161.4	197.6	219.0	178.0
Sombor (1942-2019)	14	7	180.2	187.8	215.1	276.1
Novi Sad (1948-2019)	49	27	174.5	187.8	236.8	163.8
Zrenjanin (1946-2019)	44	18	155.3	175.6	222.8	178.9
Kikinda (1948-2019)	52	15	152.4	174.9	205.7	156.8
Banatski Karlovac (1946-2019)	24	15	146.6	198.6	246.0	238.4
Loznica (1926-2019)	47	22	237.8	256.5	309.0	246.8
Sremska Mitrovica (1925-2019)	44	16	173.9	189.4	226.1	194.1
Valjevo (1926-2019)	66	27	214.0	233.9	286.7	178.6
Kragujevac (1925-2019)	27	11	154.8	195.4	230.6	234.5
Smederevska Palanka (1939-2019)	56	25	168.2	201.5	231.6	161.1
Veliko Gradište (1926-2019)	48	20	129.4	173.9	238.6	177.0

Crni Vrh (1967-2019)	33	20	169.4	196.9	249.3	198.1
Negotin (1927-2019)	36	18	105.8	138.2	188.9	141.5
Zlatibor (1950-2019)	54	30	230.7	288.4	313.0	207.7
Sjenica (1946-2019)	33	16	191.2	213.6	229.3	225.2
Pozega (1952-2019)	30	12	178.0	218.5	238.1	259.3
Kraljevo (1926-2019)	38	19	209.6	244.4	272.7	238.8
Kopaonik (1950-2019)	21	14	224.1	279.6	323.8	321.8
Kursumlija (1952-2019)	19	8	129.2	175.7	208.0	236.6
Krusevac (1927-2019)	36	15	137.0	172.5	209.9	198.2
Cuprija (1948-2019)	36	18	143.8	185.8	204.9	198.0
Nis (1925-2019)	48	20	125.9	150.2	178.7	143.9
Leskovac (1948-2019)	19	10	126.2	150.3	179.6	212.9
Zajecar (1929-2019)	18	7	115.7	156.2	172.8	223.4
Dimitrovgrad (1945-2019)	43	16	150.2	175.7	203.5	181.9
Vranje (1926-2019)	37	16	112.0	144.3	179.9	156.3

*Rank – period of stations work (highest seasonal precipitation)

**Rank – 1981-2019 period (highest seasonal precipitation)

Country	Seasonal temperature JJA		Seasonal precipitation JJA		High Impact Events
	Observed	SEECOF-21 climate outlook for temperature	Observed	SEECOF-21 climate outlook for precipitation	
Serbia (1)	Above normal in entire Serbia	**Above-normal** (20, 30, 50) in entire Serbia	Normal in most of Serbia	**Below-normal** (45, 35 20) in northern Serbia **No predictive signal normal** (33, 34, 33)	* **Summer 2019** The 5th warmest summer for Serbia, the 3rd warmest for Palic (northern Serbia). The 2nd warmest summer for Serbia based on the minimum air temperature. There were 73 days with the "feels like" temperature (THI) above 30 degrees, which is 6 days above the summer of 2017 that ranks as the 2nd warmest in the period from 1951 up to now. A heat wave was registered in the period from August 23rd to September 2nd in most of Serbia. * **June** The warmest June for Serbia based on the minimum air temperature. The 3rd warmest June for Serbia based on the mean air temperature. The 6th wettest June for Sombor (northern Serbia). Record-breaking precipitation sums for Pozega (southwestern Serbia). A heat wave was registered on Zlatibor (southwestern Serbia), lasting for 5 days.

SEASONAL BULLETIN FOR SERBIA - SUMMER 2019

Warm and averagely rainy summer. 5th warmest summer for Serbia, 3rd warmest for Palic. 2nd warmest summer for Serbia based on the minimum air temperature. There were 73 days with the "feels like" temperature above 30 degrees, which is 6 days above the summer 2017 that ranks as the 2nd warmest in the period from 1951 up to now. Heat wave was registered in the period from August 23rd to September 2nd in most of Serbia.

Analysis of the 2019 summer season relative to the 1981-2010 base period

Temperature

Mean air temperature in summer ranged from 20.7°C in Pozega to 24.9°C in Belgrade, and on the mountains from 14.1°C at Kopaonik to 18.9°C at Zlatibor (*Figure 1*).

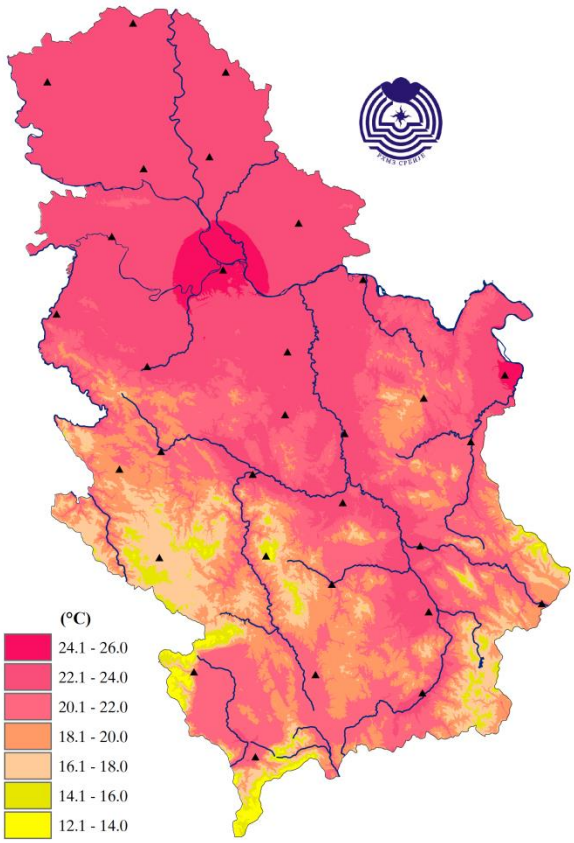

Figure 1. Spatial distribution of mean sasonal air temperature during summer

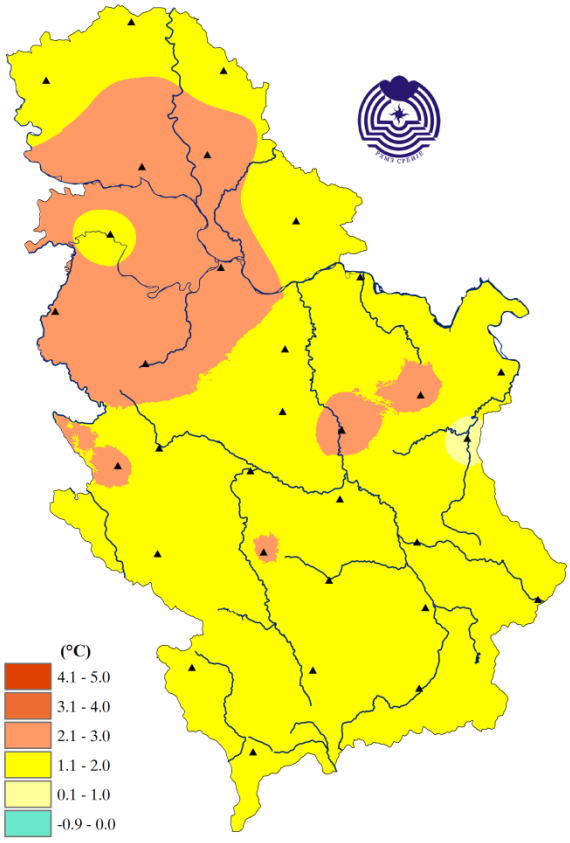

Figure 2. Mean seasonal air temperature anomaly during summer compared to the 1981-2010 normal

Departure of the summer mean air temperature from the normal[1] for the 1981–2010 base period ranged from 0.5ºC in Zajecar to 2.6ºC in Belgrade, and in the upland from 1.5°C in Sjenica to 2.2°C at Crni Vrh (*Figure 2*).

Based on the percentile method[2], mean air temperature in summer was in the extremely warm category in certain northern, western and central parts of the country and very warm category elsewhere, apart from Zajecar where it was within the average (*Figure 3*).

Based on the tercile method, mean air temperature during summer was in the warm category in entire Serbia (*Figure 4)*.

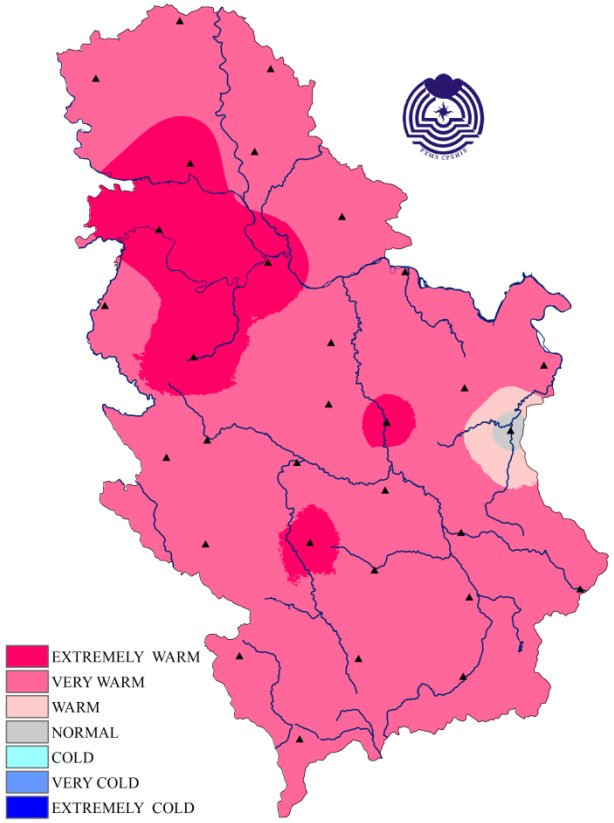

Figure 3. Spatial distribution of mean seasonal air temperature according to the percentile method

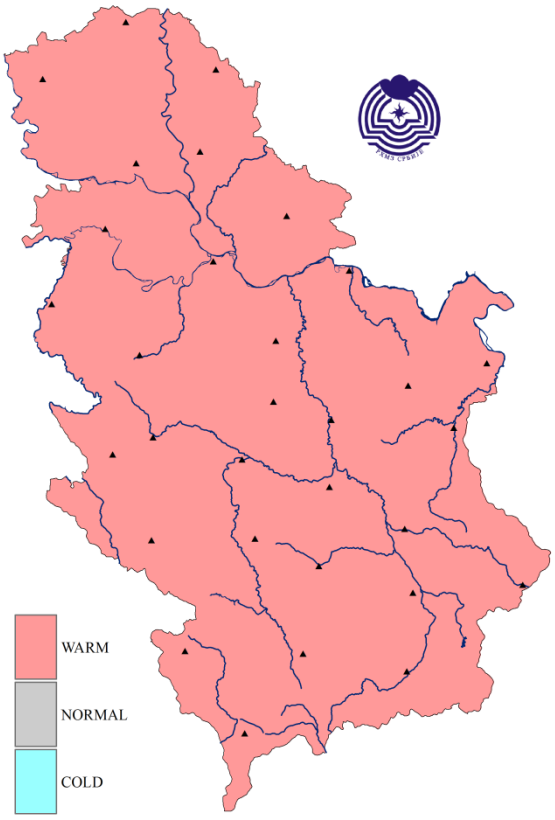

Figure 4. Spatial distribution of mean seasonal air temperature according to the tercile method

Summer 2019 ranks as the 5th warmest for Serbia with the mean air temperature of 22.1°C. The warmest summer in Serbia was the summer of 2012 with the air temperature of 23.3°C (*Figure 5*). With the air temperature of 24.9°C, Belgrade experienced its 4thwarmest summer since 1888, whereas the summer of 2012 ranks as the warmest on record for Belgrade with the mean seasonal air temperature of 26.0°C. Summer 2019 was the 3rd warmest for Palic, and 4th warmest for Novi Sad, Sombor, Loznica, Ćuprija, Kopaonik and Crnom Vrh.

[1] Term normal refers to climatological standard normal, that is, the average value of a particular climate event, calculated for the period from January1, 1981 to December 31, 2010

[2] **n**th percentile of a variable refers to the value of the observed variable below which there is n percent of data previously arranged in an ascending order

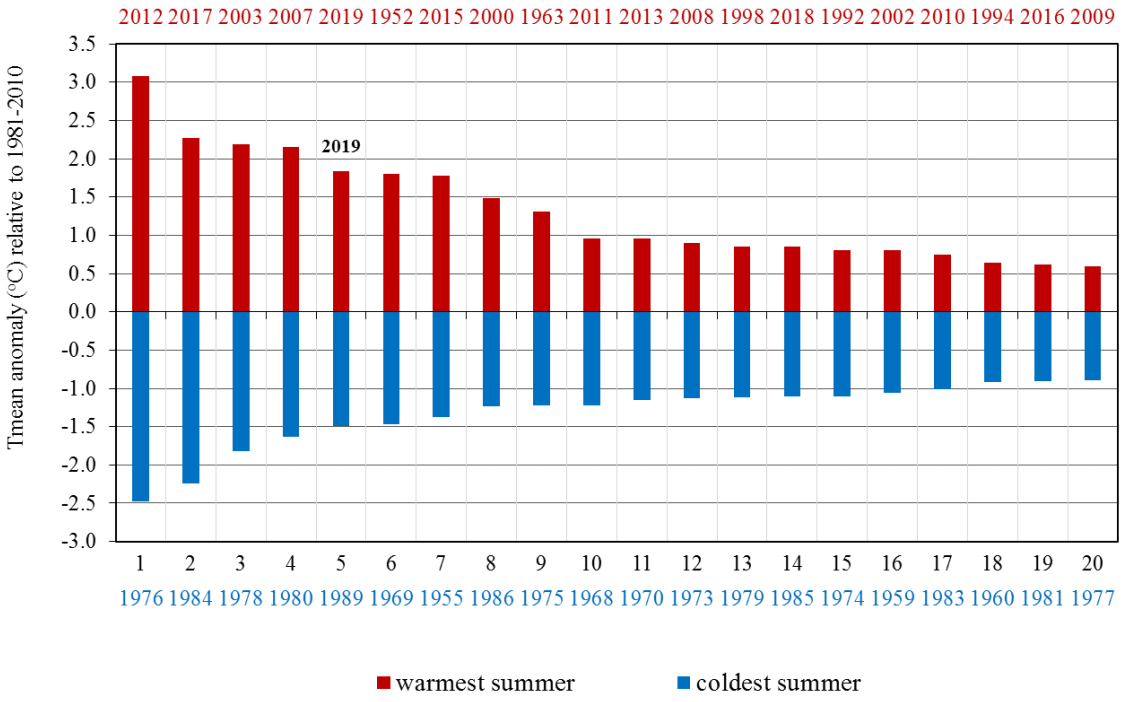

Figure 5. Rank of the warmest and coldest summer seasons for Serbia for the 1951-2019 period, compared to the 1981-2010 normal

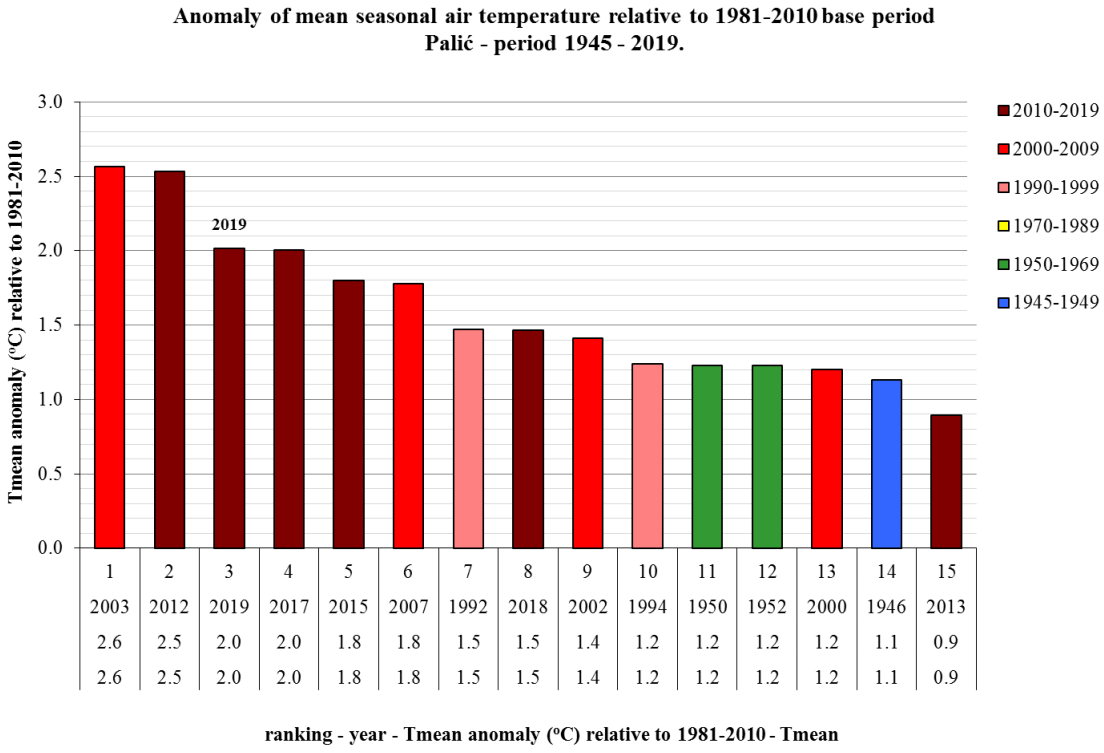

Figure 6. Rank of the warmest summer seasons in Palic for the 1945-2019 period

Number of summer days[3] ranged from 75 days in Pozega to 87 days in Negotin, which is 12 days above the average. On the mountains, number of summer days ranged from 1 at Kopaonik to 53 in Sijenica and Zlatibor, which is 21 and 25 days above the average in Sjenica and Zlatibor, respectively. Belgrade observed 84 summer days, which is 16 days above the average (*Figure 7).*

Number of tropical days[4] ranged from 47 in Pozega, Kursumlija and Kragujevac to 61 days in Negotin, which is 21 days above the average. In the upland, at Kopaonik there weren't any tropical days, whereas Zlatibor observed total of 10 tropical days. Belgrade recorded 55 tropical days, which is 23 days above the average (*Figure 8*).

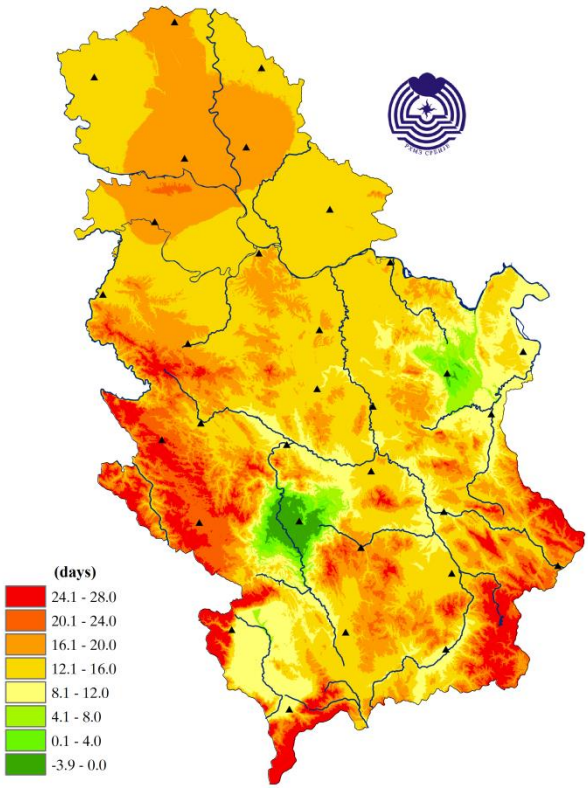

Figure 7. Deviation of the number of summer days during summer compared to the 1981-2010 normal

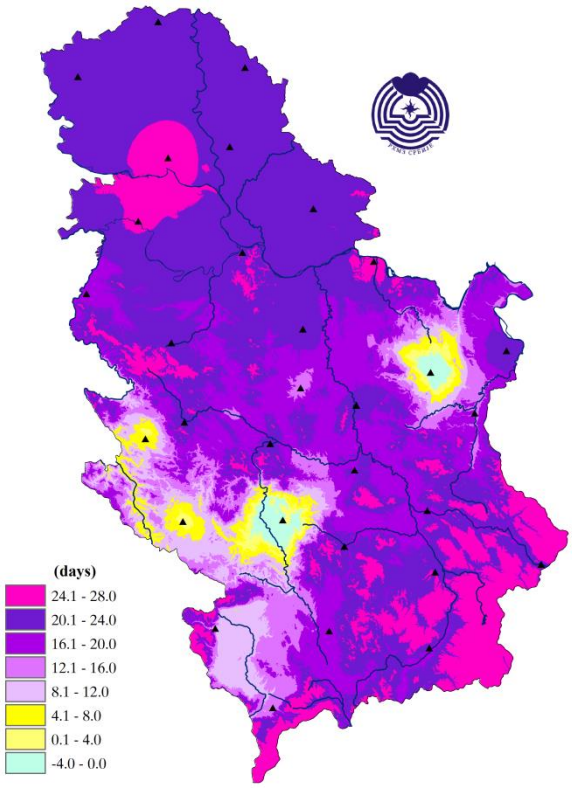

Figure 8. Deviation of the number of tropical days during summer compared to the 1981-2010 normal

The highest number of tropical nights[5], total of 46 nights, was recorded in Belgrade which is 30 days above the average, Negotin observed 14, Zrenjanin recorded 13 tropical nights which is 7 days above the average for these stations. Elsewhere, there were up to 11 tropical nights, while in Požega, Kuršumlija, Leskovac, Zajecar and Vranje as well as on the mountains there were none, apart from Crni Vrh where 4 tropical nights were registered.

[3] Summer day is defined as the day with the maximum air temperature of 25°C and above

[4] Tropical day is defined as the day with the maximum air temperature of 30°C and above

[5] Tropical night is defined as the day with the daily air temperature of 20°C and above

The highest summer daily air temperature of 38.1°C was measured in Leskovac on August 12.

The lowest summer air temperature of 2.8°C was measured at Kopaonik on July 11.

Most of the summer season, mean, maximum and minimum air temperature were above the multiannual average. Warm periods were registered at the end of mid-June, in the period between June and July, and third decade of July and most of August. Colder periods were recorded at the very beginning of June, mid-July as well as at the beginning and middle of August (*Figure 9*).

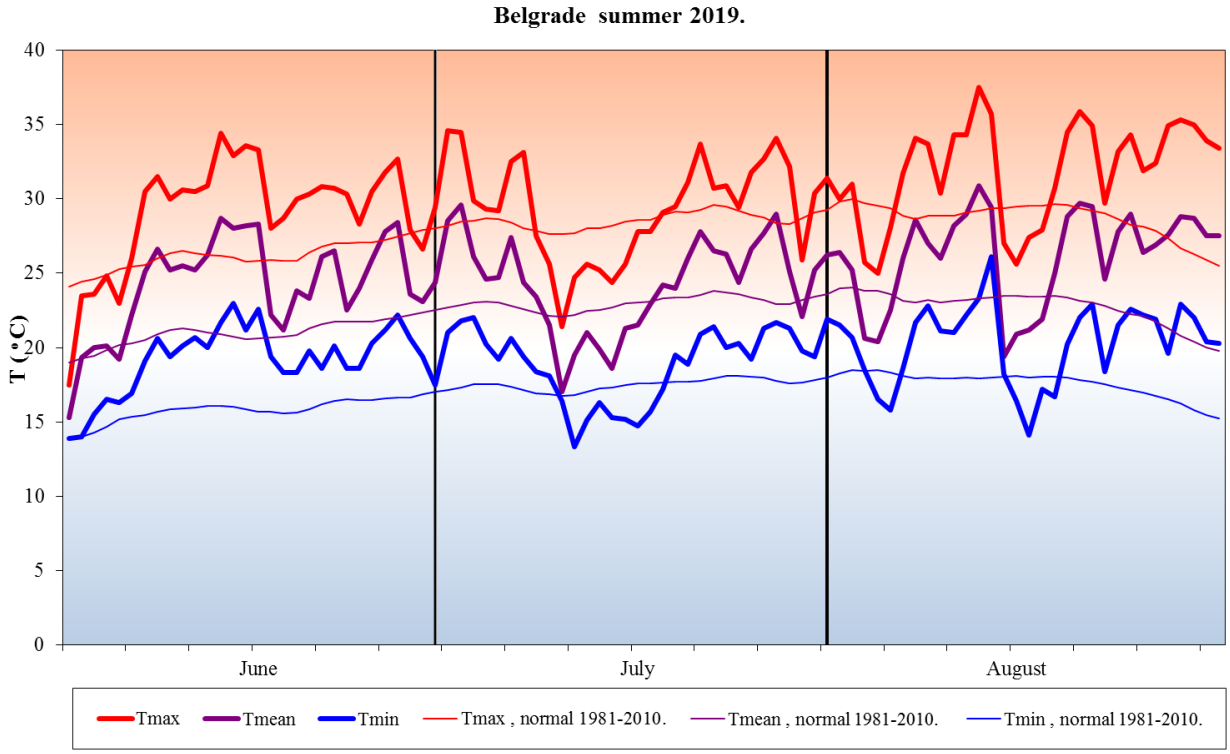

Figure 9. Three – month course of the mean, maximum and minimum air temperature in Belgrade

Figures 10 and 11 show three-month course of the daily air temperature in Belgrade and Kopaonik in summer 2019 and 2012.

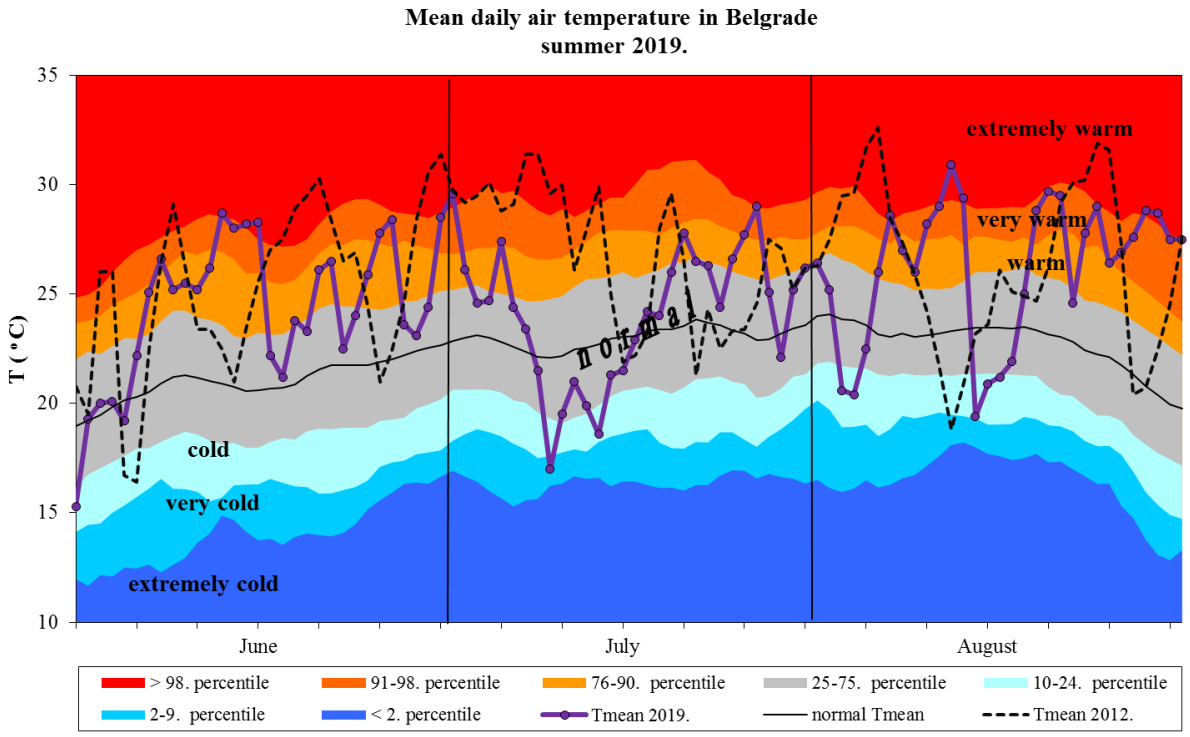

Figure 10. Three – month course of the mean daily air temperature in Belgrade

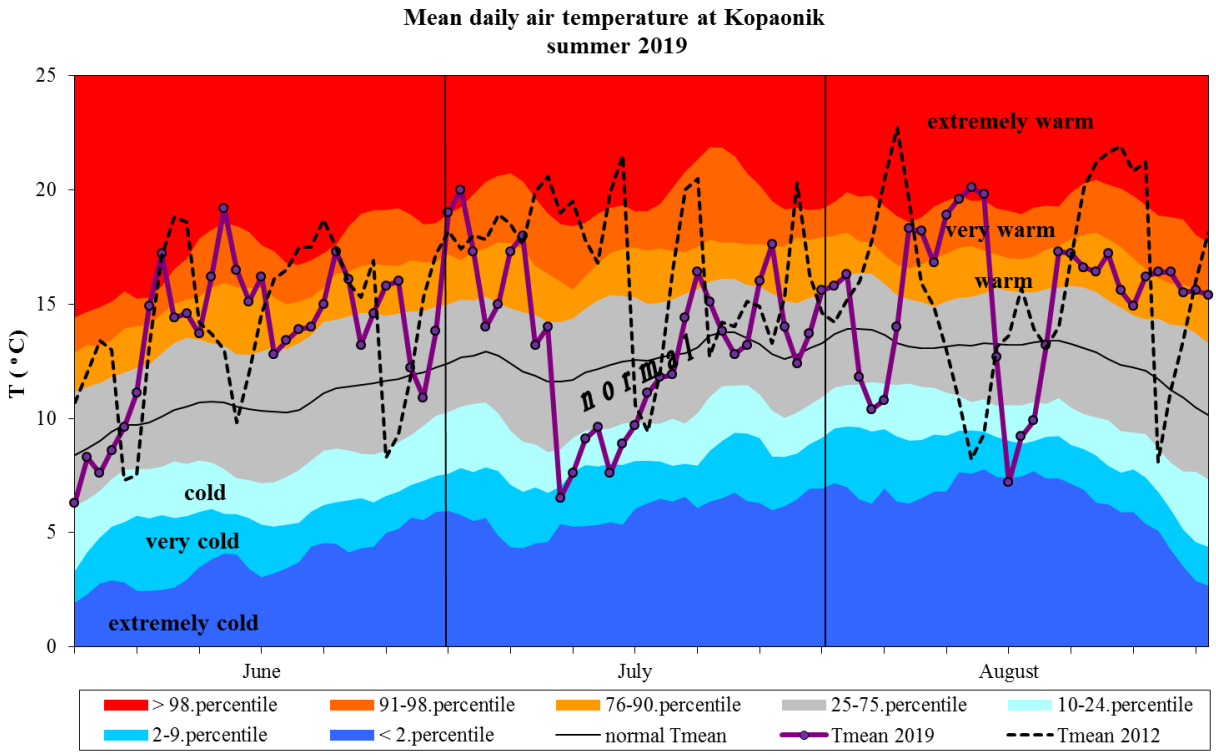

Figure 11. Three – month course of the mean daily air temperature at Kopaonik

Figure 12 shows the assessment of the mean air temperature and precipitation sums for Serbia for the summer season (June, July and August) based on the tercile distribution relative to the 1981-2010 base period. Summer of 2019 was characterized by warm and averagely rainy conditions, that is, air temperature in the upper tercile and precipitation sums within the average. Based on the minimum air temperature, this summer ranks as the second warmest on record, and based on the maximum air temperature it was 6th warmest (*Figure 13*).

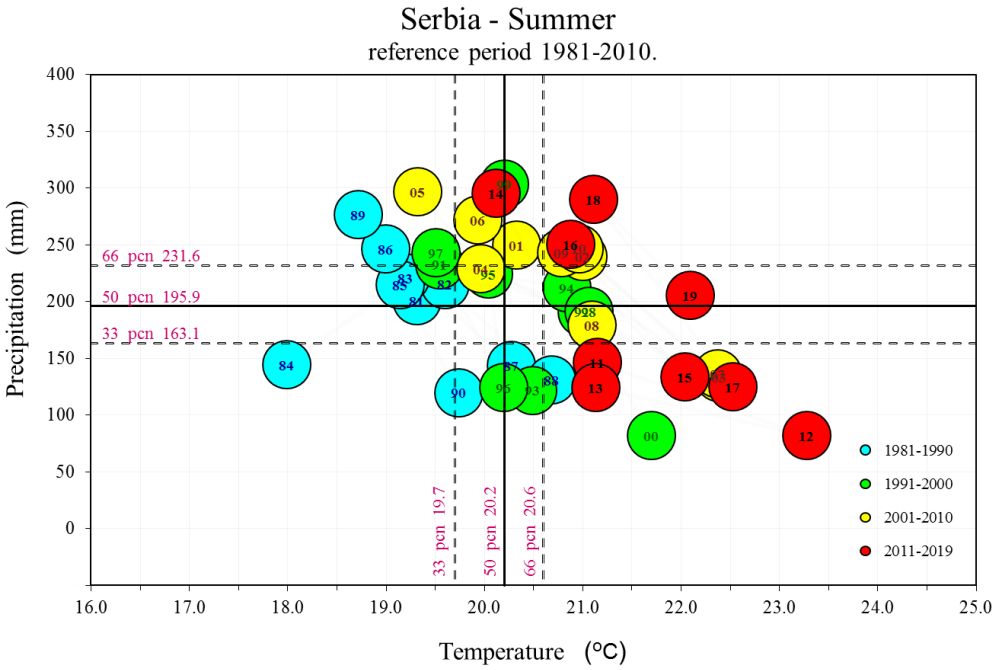

Figure 12. Assessment of **mean** air temperature and precipitation sums for summer in Serbia with the accompanying terciles compared to the 1981-2010 normal

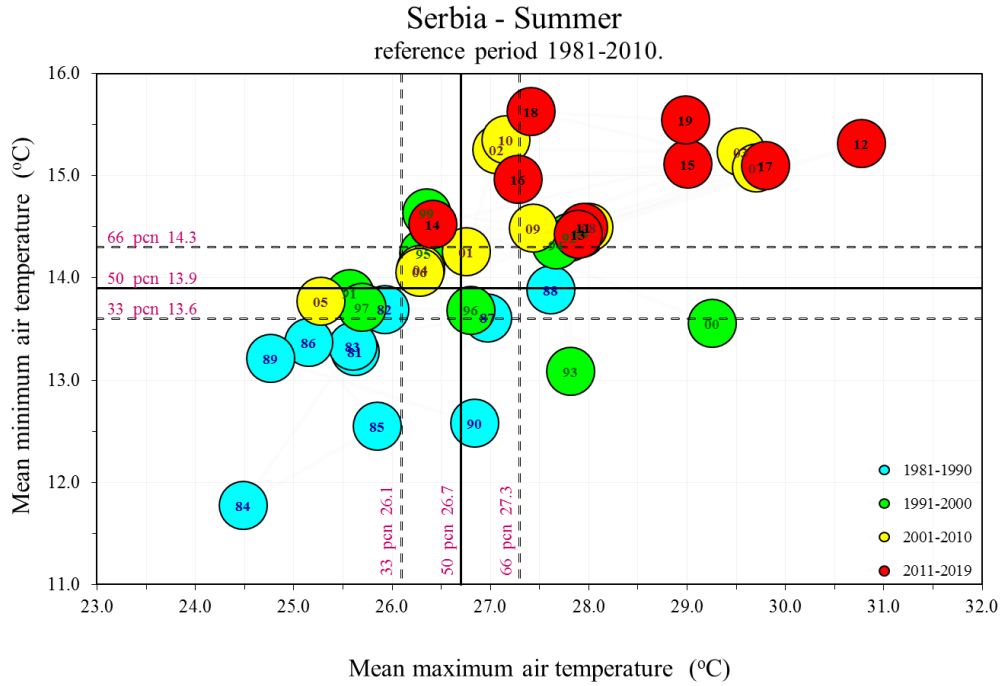

Figure 13. Assessment of **maximum** and **minimum** air temperature for summer in Serbia with the accompanying terciles compared to the 1981-2010 normal

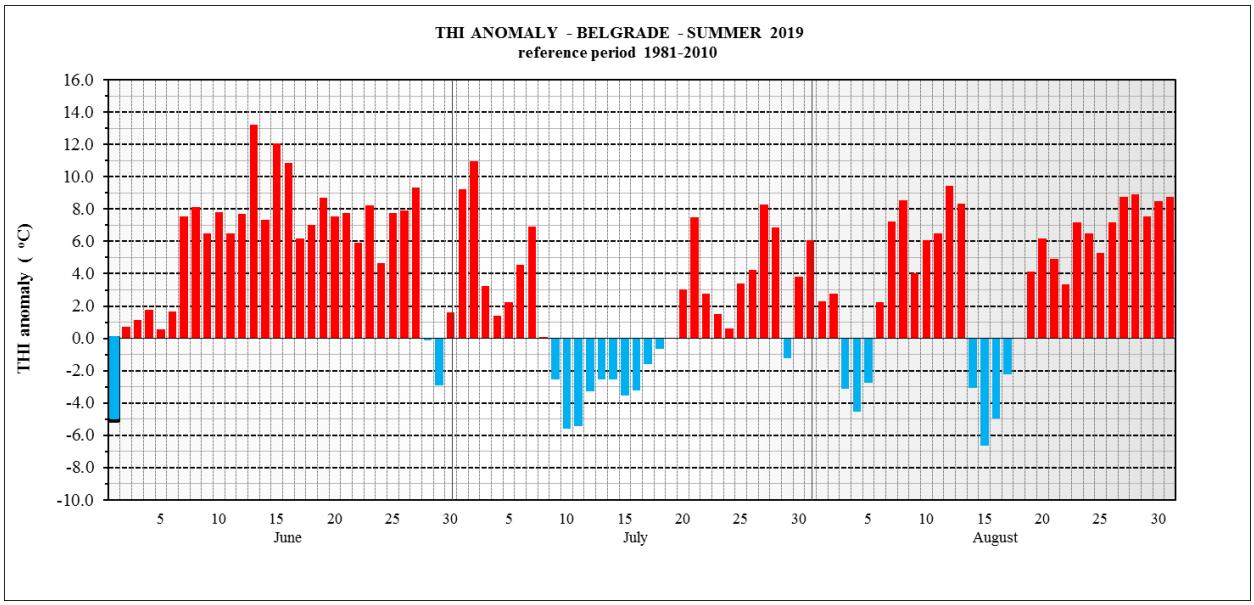

Figure 14.

Departure of the Temperature Humidity Index (THI)[6] was positive most of the summer (*Figure 14)*. The highest discrepancy between the feels like temperature and the maximum daily air temperature was recorded during the second half of June, at the beginning and end of July (*Figure* 15) amounting to 8.3°C. Even though the maximum air temperature that was measured that day was 34.5°C, the feels like temperature amounted to 42.8°C which was the maximum temperature for the 2019 summer.

There were 73 days with THI above 30°C, which is 6 days above the summer 2017 average, ranking as the warmest summer since 1951 up to date.

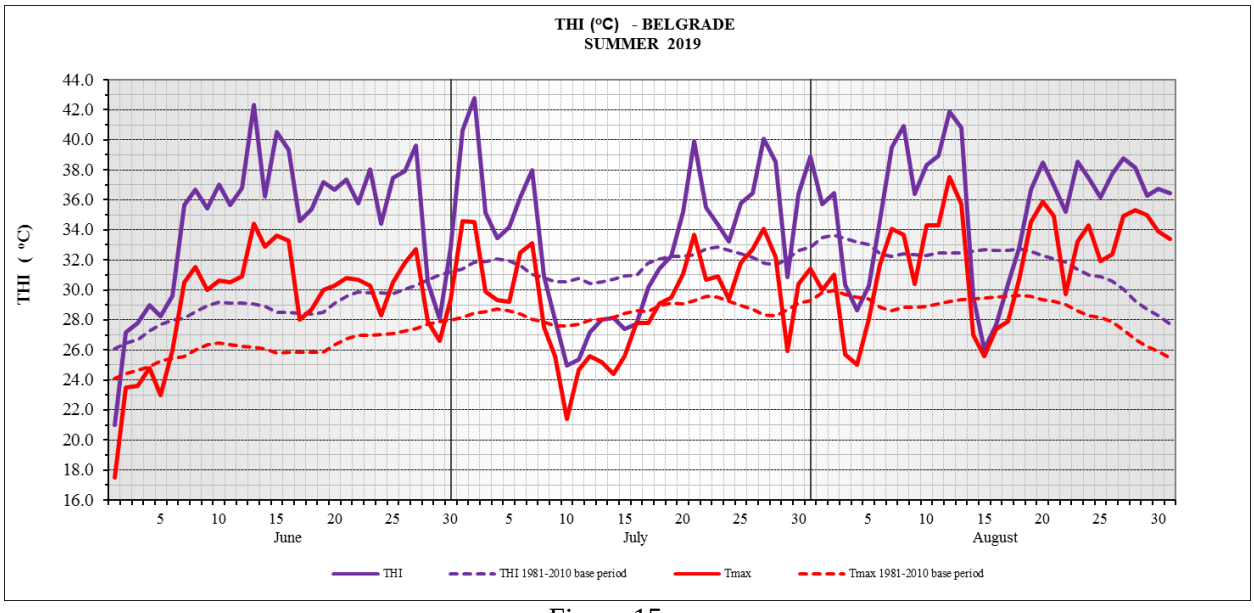

Figure 15.

[6] THI is defined as the unit of subjective sensation of warmth, that is, unit of relative discomfort due to the prolonged exposure to extremely warm and wet weather, indicating likelihood of heatstroke, sun stroke or other acute body stress symptoms

Heat waves during the summer of 2019

In summer 2019, three heat waves[7] (*Table* 1) were recorded at the territory of Serbia. The onset of the first heat wave was registered at Zlatibor, lasting from 12 to 16 June, the second heat wave was observed in the period from 7 to 13 August in Pozega, Vranje, Dimitrovgrad, Leskovac, Sjenica and Kopaonik. The third heat wave was observed in the period from August 23 to September 2 in most of Serbia.

Table 1.

HEAT WAVES IN SERBIA - SUMMER 2019

(reference period 1981-2010)

JUNE

station/day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PALIĆ																														
SOMBOR																														
KIKINDA																														
ZRENJANIN																														
NOVI SAD																														
SR.MITROVICA																														
BEOGRAD																														
LOZNICA																														
VALJEVO																														
V.GRADIŠTE																														
SM.PALANKA																														
KRAGUJEVAC																														
KRALJEVO																														
POŽEGA																														
ZLATIBOR												VW	EW	VW	VW	VW														
ĆUPRIJA																														
KRUŠEVAC																														
NEGOTIN																														
ZAJEČAR																														
CRNI VRH																														
KOPAONIK																														
SJENICA																														
NIŠ																														
VRANJE																														
DIMITROVGRAD																														
LESKOVAC																														
KURŠUMLIJA																														
B.KARLOVAC																														

JULY

station/day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
PALIĆ																															
SOMBOR																															
KIKINDA																															
ZRENJANIN																															
NOVI SAD																															
SR.MITROVICA																															
BEOGRAD																															
LOZNICA																															
VALJEVO																															
V.GRADIŠTE																															
SM.PALANKA																															
KRAGUJEVAC																															
KRALJEVO																															
POŽEGA																															
ZLATIBOR																															
ĆUPRIJA																															
KRUŠEVAC																															
NEGOTIN																															
ZAJEČAR																															
CRNI VRH																															
KOPAONIK																															
SJENICA																															
NIŠ																															
VRANJE																															
DIMITROVGRAD																															
LESKOVAC																															
KURŠUMLIJA																															
B.KARLOVAC																															

AUGUST

station/day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
PALIĆ																											VW	VW	EW	EW	EW
SOMBOR																												VW	VW	VW	VW
KIKINDA																											VW	VW	EW	EW	EW
ZRENJANIN																											VW	VW	EW	EW	VW
NOVI SAD																											VW	VW	VW	VW	EW
SR.MITROVICA																											VW	VW	VW	VW	VW
BEOGRAD																											VW	VW	VW	VW	VW
LOZNICA																												VW	VW	VW	VW
VALJEVO																										VW	VW	VW	VW	VW	VW
V.GRADIŠTE																										VW	VW	VW	VW	VW	EW
SM.PALANKA																										VW	VW	VW	VW	VW	VW
KRAGUJEVAC																											VW	VW	VW	VW	VW
KRALJEVO																											VW	VW	VW	VW	VW
POŽEGA							VW	VW	VW	VW	VW	EW	EW															VW	VW	VW	VW
ZLATIBOR																													VW	VW	VW
ĆUPRIJA																										VW	VW	VW	VW	VW	VW
KRUŠEVAC																											VW	VW	VW	VW	VW
NEGOTIN																										VW	VW	VW	VW	VW	VW
ZAJEČAR																															
CRNI VRH																												VW	VW	VW	VW
KOPAONIK							EW	EW	VW	VW	VW	EW	EW																		
SJENICA							VW	EW	VW	EW	VW	EW	EW																		
NIŠ																													VW	VW	VW
VRANJE							VW	EW	VW	VW	EW	EW	EW										VW	VW	VW	VW	VW	VW	VW	VW	
DIMITROVGRAD							VW	EW	VW	VW	VW	EW	EW																		
LESKOVAC							VW	EW	VW	VW	EW	EW	EW											VW	VW	VW	VW	VW	VW	VW	VW
KURŠUMLIJA																															
B.KARLOVAC																											VW	VW	VW	VW	EW

EW	EXTREMELY WARM
VW	VERY WARM

[7] Heat wave, according to the percentile method, is a period during which maximum daily air temperature is in the very warm and extremely warm categories for 5 days or longer

Precipitation

Summer precipitation sums were within the average in most of Serbia relative to the normal for the 1981-2010 base period. Precipitaion sums relative to the normal ranged from 71% in Valjevo to 140% in Zajecar (*Figure 17*). Seasonal precipitation sums ranged from 141.5 mm in Negotin to 321.8 mm at Kopaonik (*Figure 16*).

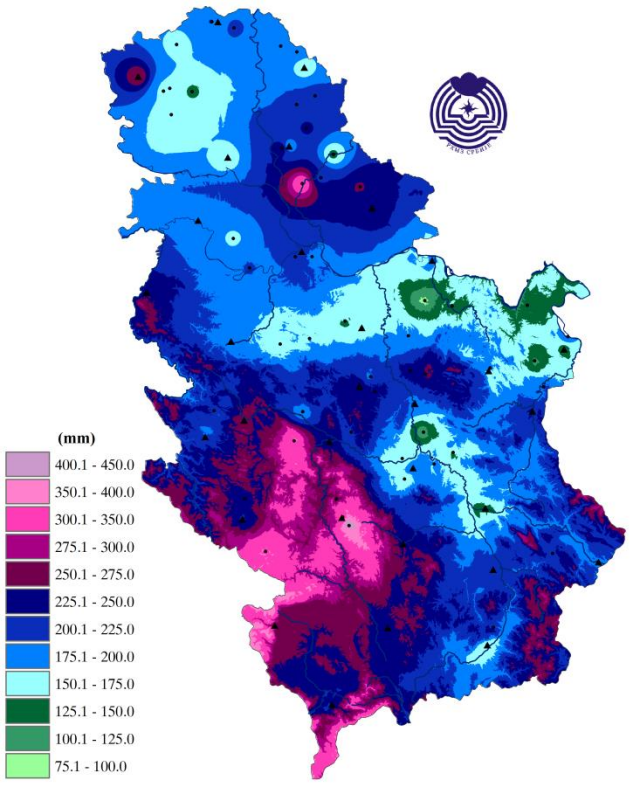

Figure 16. Spatial distribution of summer precipitation sums according to data from 28 major meteorological, 14 climatological and 37 rain gauge stations

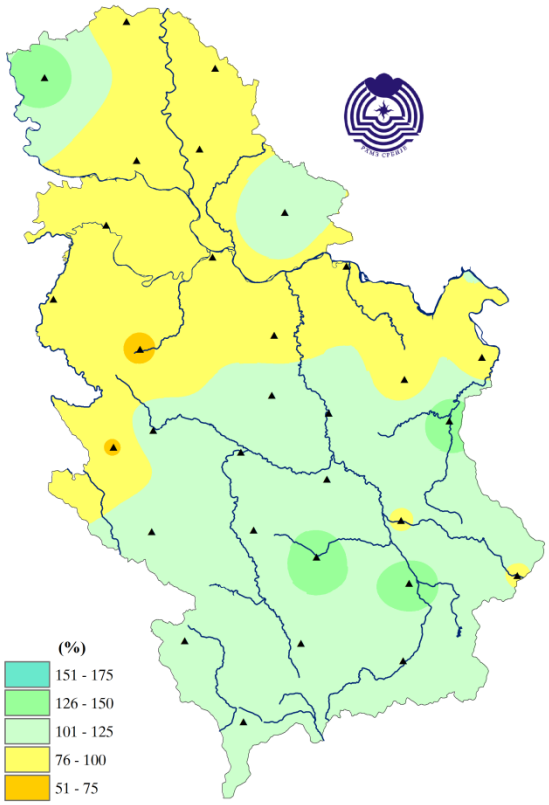

Figure 17. Spatial distribution of summer precipitation sums in the percentages of the 1981-2010 normal

Based on the percentile method, summer precipitation sums were in the normal category in most of Serbia, rainy category in parts of northern, central and southeastern parts of the country, and dry in parts of western Serbia (*Figure 18*).

Based on the tercile method, precipitation sums were within the average in most of Serbia, rainy category in certain parts of northern, central and southeastern regions, and dry category in parts of northern, central and western Serbia (*Figure 19*).

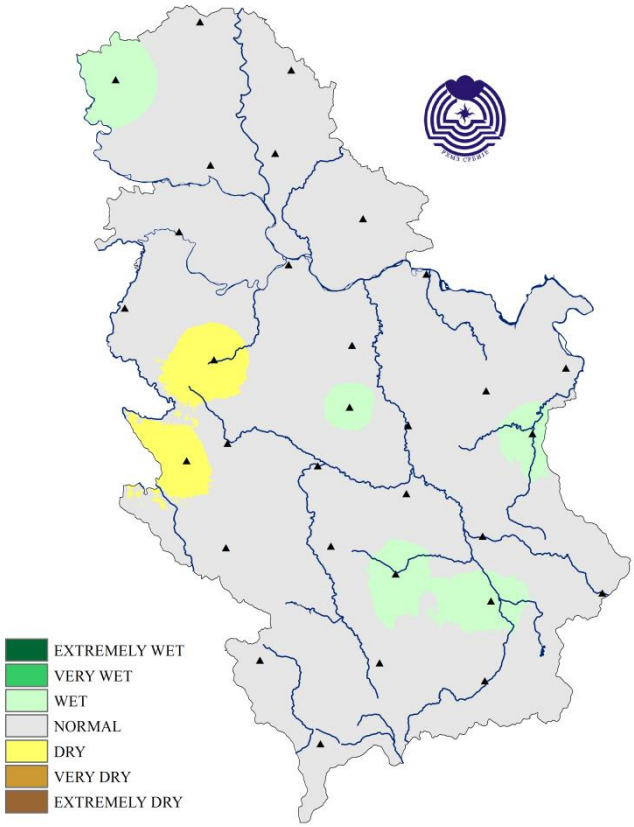

Figure 18. Seasonal precipitation sums according to the percentile method

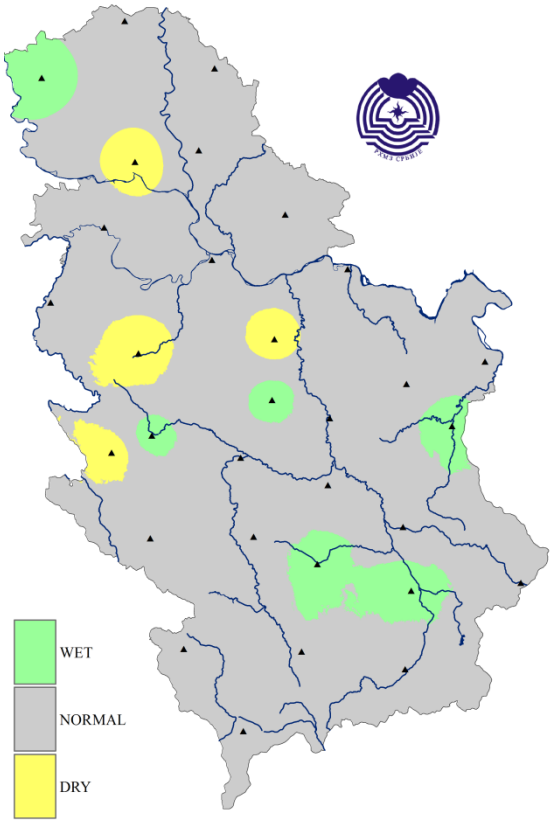

Figure 19. Seasonal precipitation sums according to the tercile method

The maximum daily precipitation sum of 84.2 mm was registered in Kraljevo on June 3.

Number of days with precipitation was below the summer average for most of Serbia, whereas in certain parts of northern, central and southeastern Serbia it was above the average. The fewest number of days with precipitation, total of 19, was registered in Negotin, which is 5 days below the average. The highest number of days with precipitation, total of 36 days, was observed at Kopaonik, which is 2 days below the average (*Figure 20*). The highest negative departure of the number of rainy days was recorded in Sremska Mitrovica and Zlatibor, 8 days below the average, whereas Kursumlija and Vranje recorded 6 days above the average.

Most of Serbia experienced above average number of thunderdays (*Figure 21*). The fewest number of thunderdays, total of 14 days, was recorded in Sremska Mitrovica (5 days below the average) and the highest number of thunderdays, total of 33 days was observed at Zlatibor (10 days above the average).

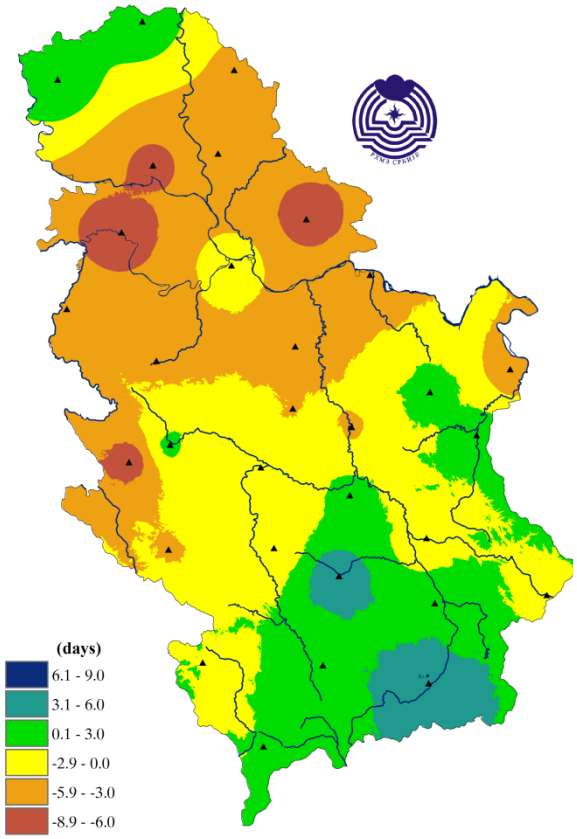

Figure 20. Deviation of the number of days with precipitation during summer compared to the 1981-2010 normal

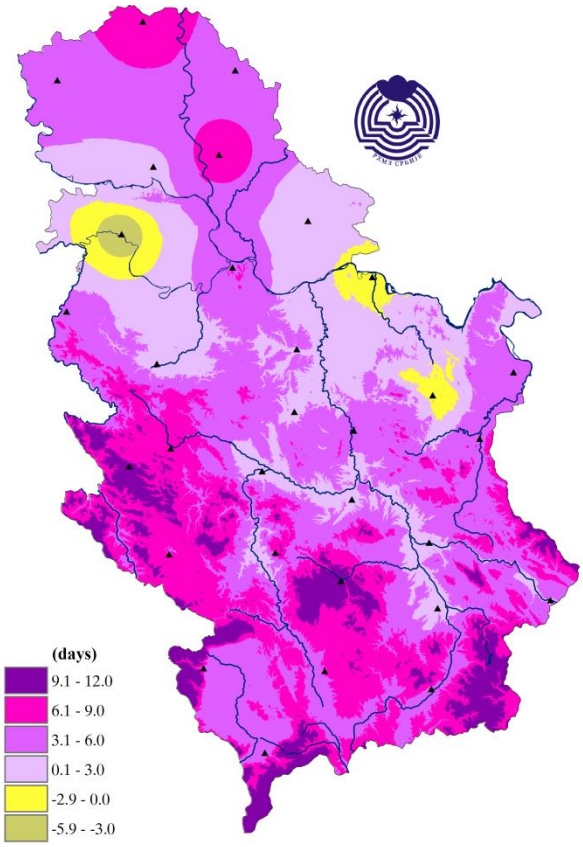

Figure 21. Deviation of the number of days with thunder during summer compared to the 1981-2010 normal

Figures 22 and 23 show the cumulative precipitation sums for Kursumlija and Zlatibor in summer per months compared to the average cumulative precipitation sums.

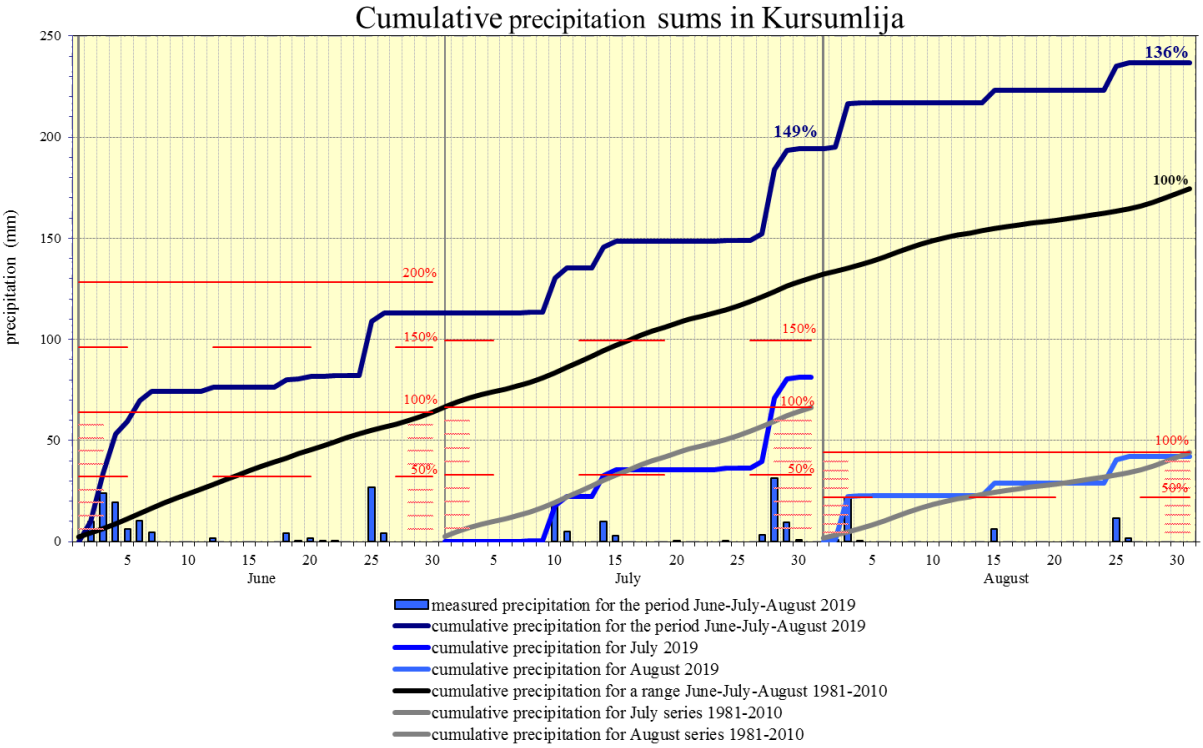

Figure 22. Cumulative precipitation sums in Kursumlija

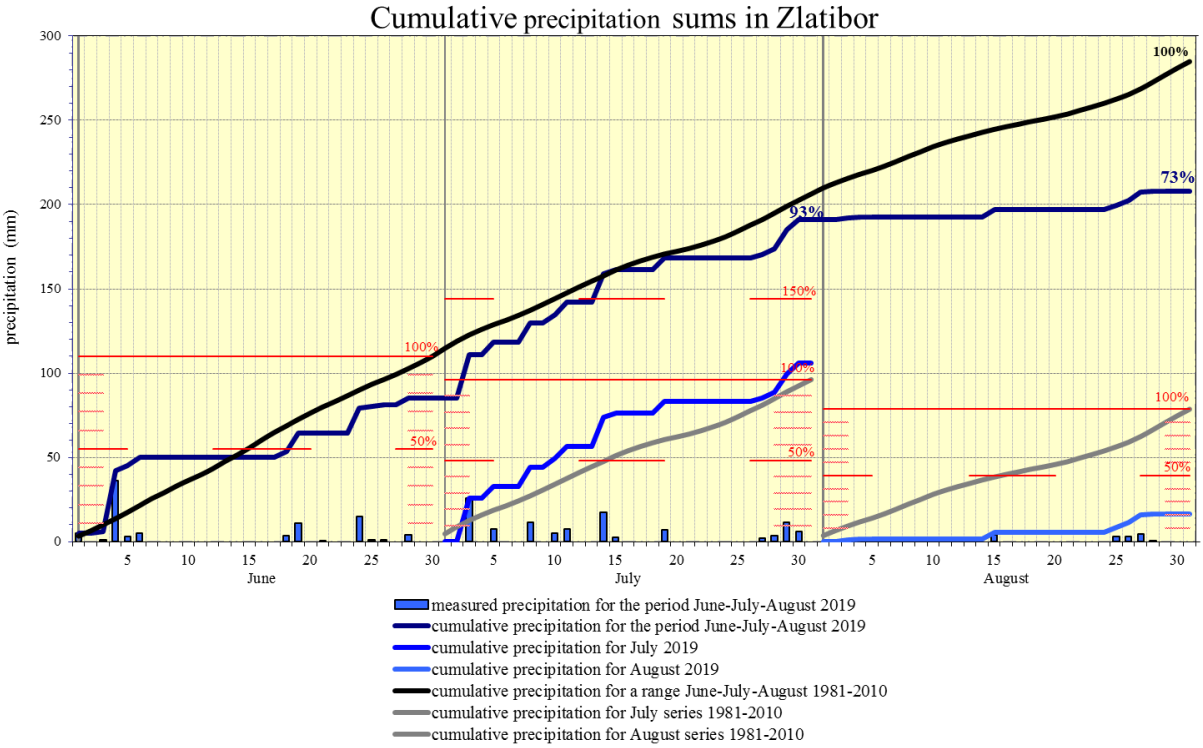

Figure 23. Cumulative precipitation sums in Zlatibor

Cloud cover, bright and cloudy days

Mean summer cloud cover in the lowland ranged from 3/10 in Negotin (*Figure 24*) to 5/10 in Pozega (*Figure 25*), and in the hilly-mountainous regions it was around 4/10.

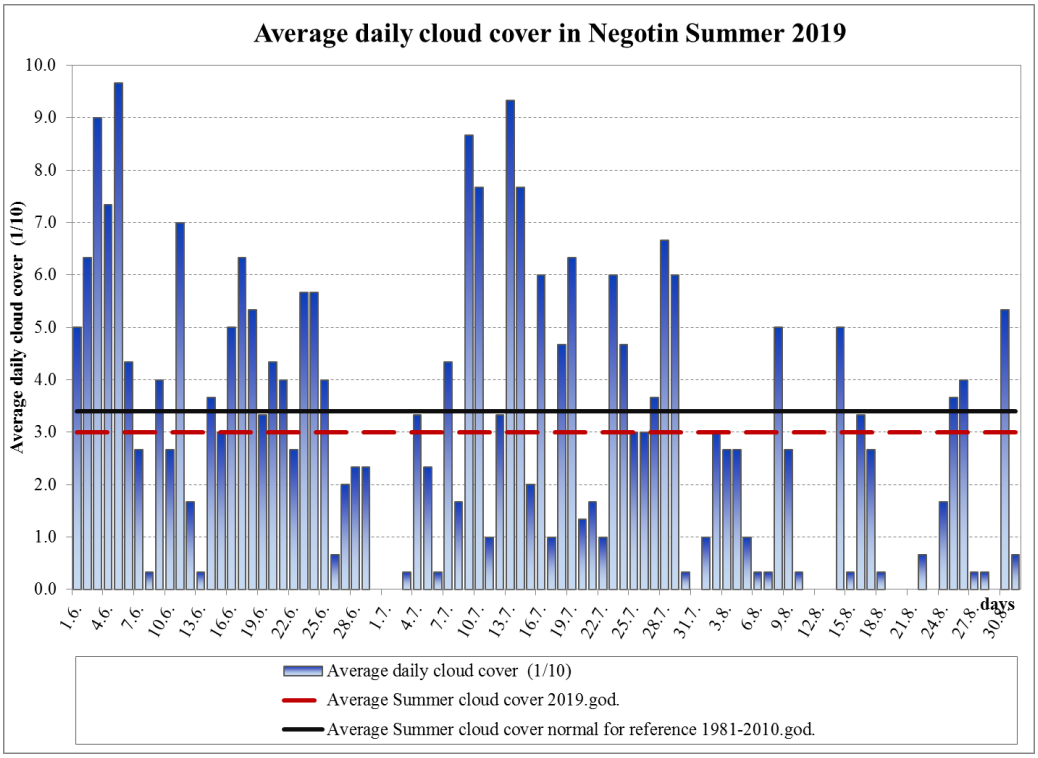

Figure 24. Average daily cloud cover in Negotin

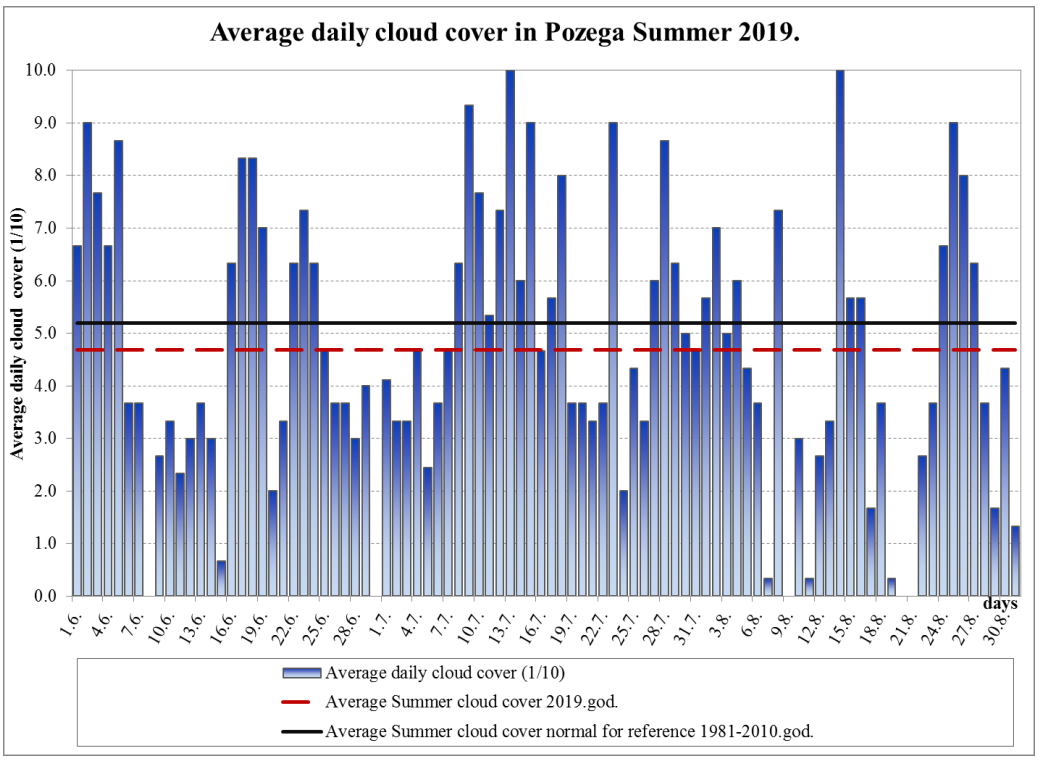

Figure 25. Average daily cloud cover in Pozega

In summer, number of bright days in the lowland ranged from 12 in Pozega to 41 days in Nis, and on the mountains from 21 at Kopaonik to 32 at Crni Vrh. Number of bright days at the territory of Serbia varied in comparison to the summer average, ranging from 6 days below the average in Zrenjanin to 10 days above the average in Nis and Sremska Mitrovica.

The recorded number of cloudy days in summer was below the average in entire Serbia, ranging from 2 days in Veliko Gradiste (11 days below the average) to 11 days in Pozega (8 days below the average). Number of cloudy days at the mountains ranged from 10 days in Sjenica to 12 days at Kopaonik.

Sunshine duration (insolation)

In summer, sunshine duration was above the average in most of Serbia apart from Zajecar. Insolation ranged from 746.3 hours in Sjenica to 992.4 hours in Negotin (*Figure 26)*.

Relative to the normal for the 1981-2010 base period, sunshine duration ranged from 95% in Zajecar to 126% in Krusevac (*Figure 27*).

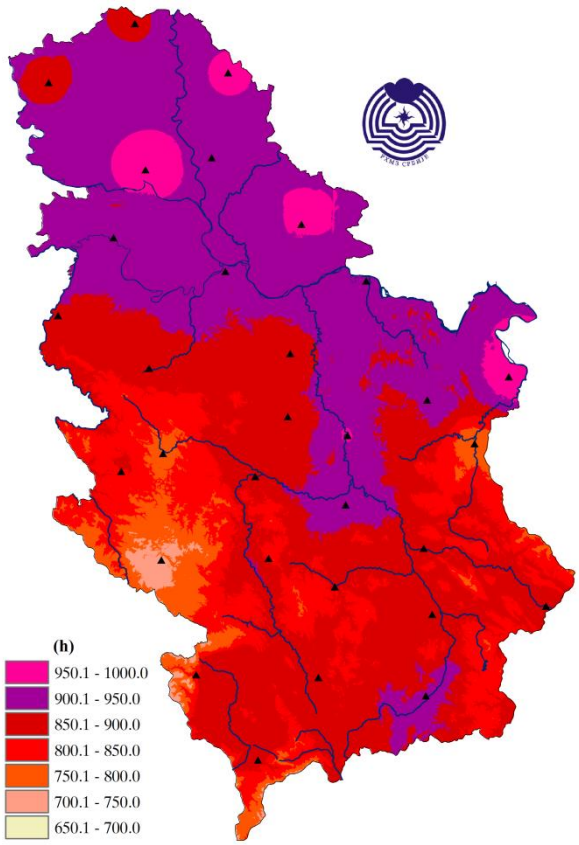

Figure 26. Insolation expressed in hours during summer

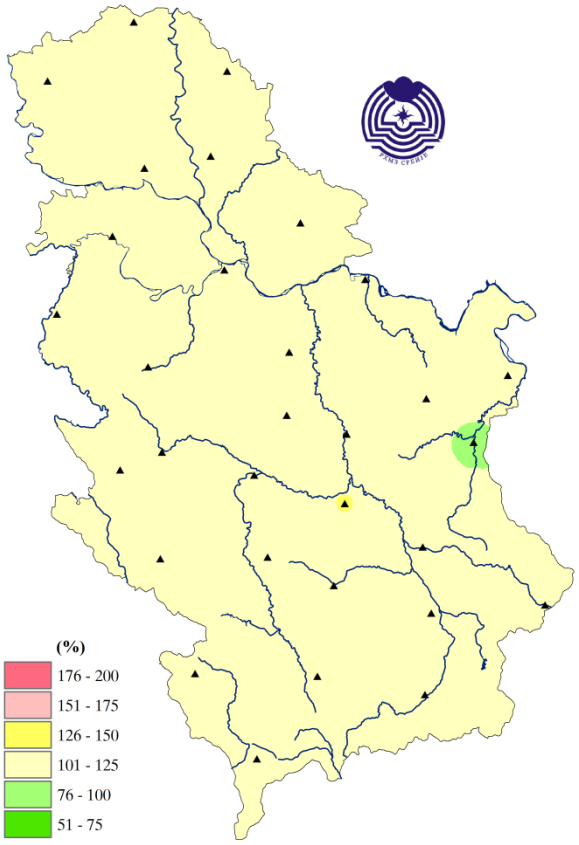

Figure 27. Insolation during summer expressed in percentages of 1981-2010 normal

Analysis of the 2019 summer season for Serbia relative to the 1961-1990 base period

Temperature

Departure of the mean air temperature from the normal for the 1961–1990 base period during summer ranged from 1.9ºC in Zajecar to 3.8ºC in Belgrade, on the mountains from 2.6°C in Sjenica to 3.5°C at Kopaonik (*Figure 28*).

Based on the percentile method, mean air temperature was in the extremely warm category across the entire country apart from Zajecar where it was in the very warm category (*Figure 29*).

Based on the tercile method, mean air temperature was above the average in entire Serbia.

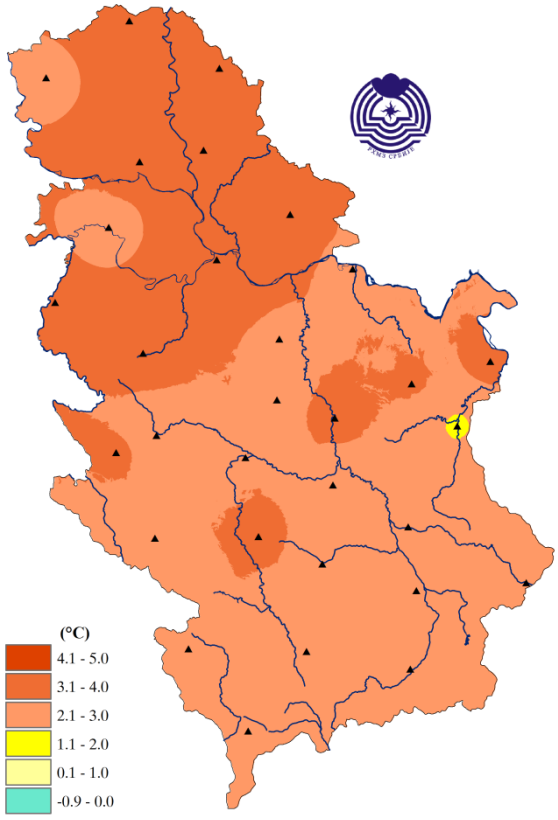

Figure 28. Mean seasonal air temperature anomaly compared to the 1961-1990 normal

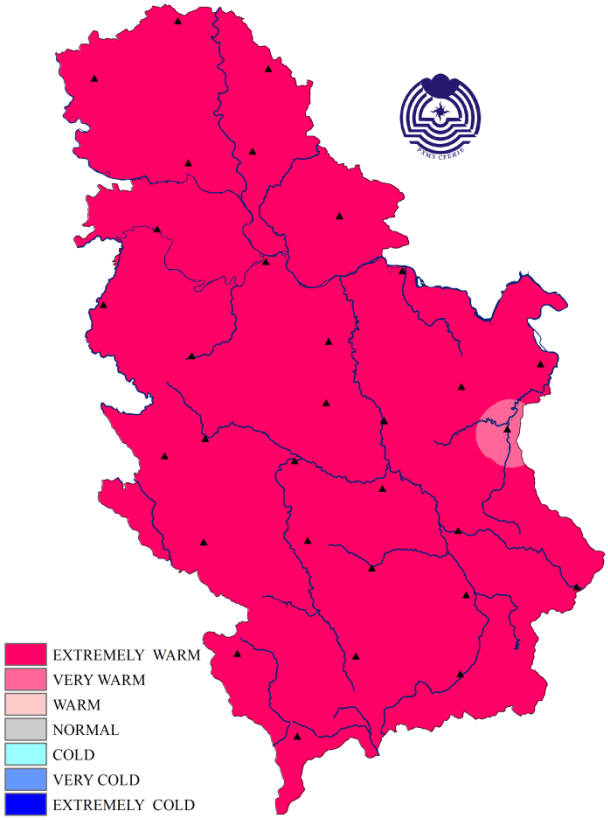

Figure 29. Spatial distribution of mean seasonal air temperature according to the percentile method

Precipitation

Summer precipitation sums were within the average in most of Serbia relative to the normal for the 1961-1990 base period. Precipitation sums compared to the normal ranged from 71% in Valjevo and Crni Vrh to 144% in Sombor (*Figure 30*).

Based on the percentile method, summer precipitation sums were in the following categories: within the average in most of Serbia, rainy in northwestern parts of the country, rainy in Banatski Karlovac, Zajecar, Kursumlija and Leskovac, and dry category at Crni Vrh, Zlatibor and Valjevo (*Figure 31*).

Precipitation sums based on the tercile method were in the following categories: within the average in most of Serbia, above the average in Sombor, Banatski Karlovac, Pozega, Zajecar, Kursumlija and Leskovac, and below the average in Novi Sad, Valjevo, Smederevska Palanka, Crni Vrh and Zlatibor.

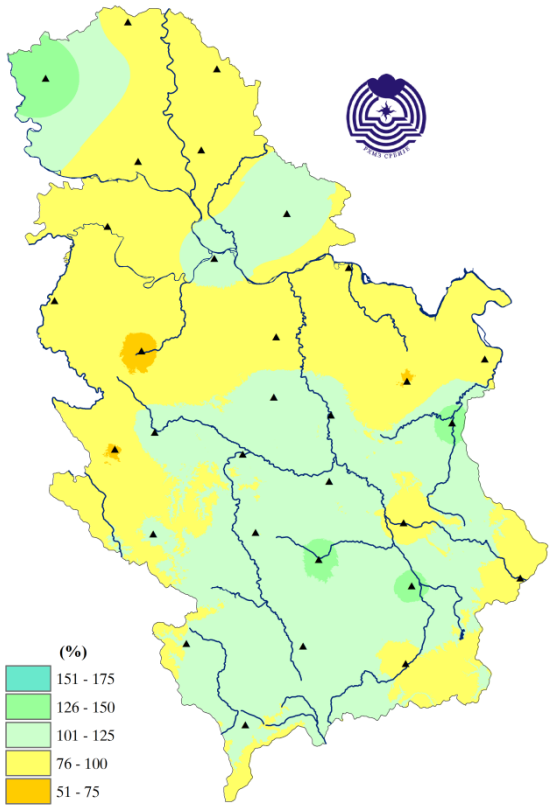

Figure 30. Spatial distribution of Spring precipitation sums in the percentages of the 1961-1990 normal

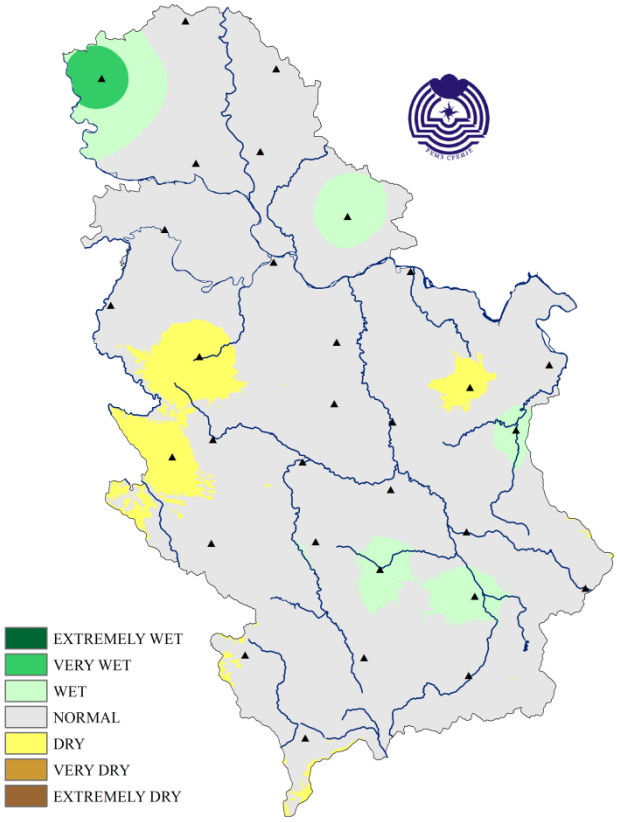

Figure 31. Seasonal precipitation sums according to the percentile method

Note: Climatological analysis of the meteorological elements was performed based on the provisional data obtained from 28 main meteorological stations.