



VERIFICATION OF THE SEECOF-29 SUMMER 2023 CLIMATE OUTLOOK AND SEASONAL BULLETIN FOR THE TERRITORY OF SERBIA

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Temperature

The SEECOF-29 outlook for the summer 2023 in Serbia indicated above- normal temperature in Serbia with 50% probability relative to the 1991–2020 climatological base period (*Figure A*).

Climatological monitoring showed that the summer 2023 was warm in most of Serbia, with above-normal temperature based on the tercile method (*Figure B*). The outlook for a warm summer was correct.

OUTLOOK – SUMMER 2023

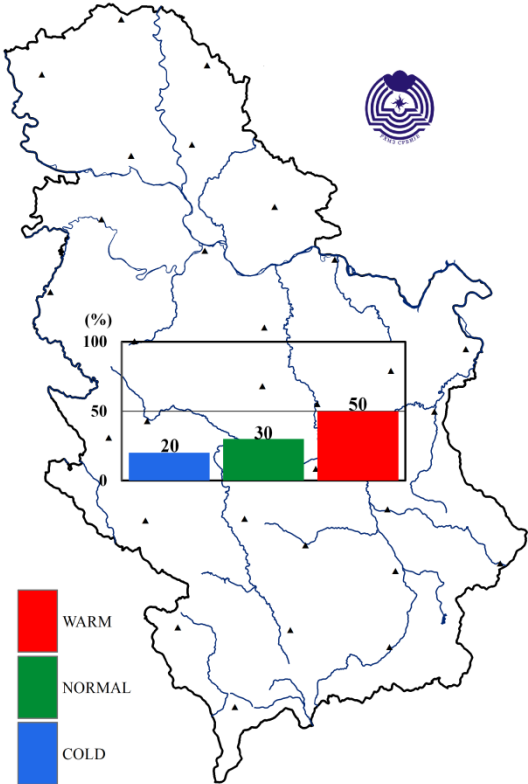


Figure A. SEECOF-29 - summer temperature outlook

MONITORING – SUMMER 2023

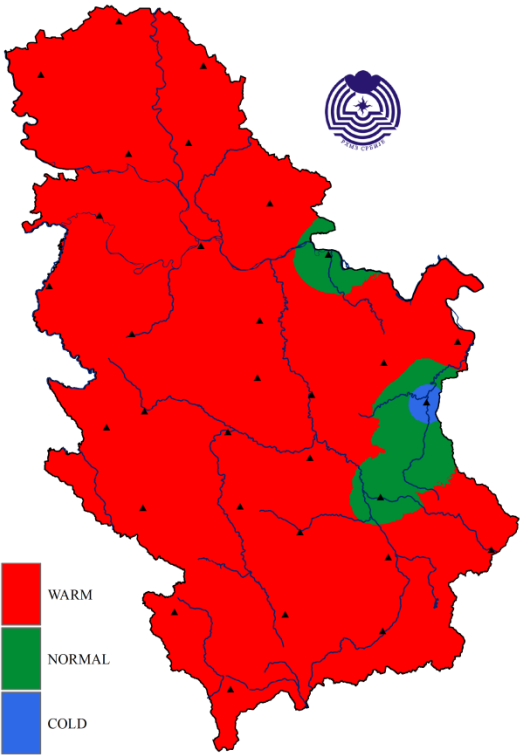


Figure B. Monitoring of the summer temperature using tercile method compared to the 1991-2020 base period

Precipitation

According to the SEECOF-29 outlook for the summer 2023, approximately equal probabilities for below, near or above normal precipitation were indicated for Serbia, relative to the 1991–2020 climatological base period (*Figure C*), hence climatology (average seasonal precipitation) was suggested.

Based on the climatological monitoring of precipitation, the summer of 2023 was wet in most of Serbia whilst average and below-average precipitation sums were recorded in some parts of northern and western Serbia (*Figure D*). The outlook for the average summer precipitation sums was correct for some parts of northern, western and central Serbia.

OUTLOOK – SUMMER 2023

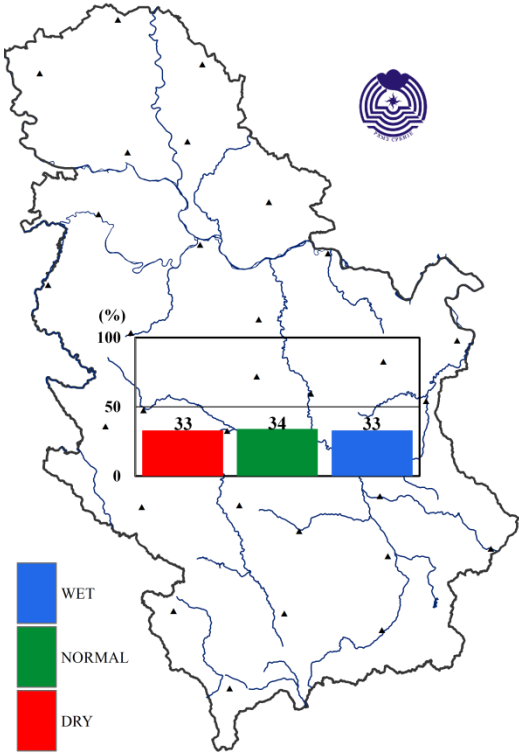


Figure C. SEECOF-29 - summer precipitation outlook

MONITORING – SUMMER 2023

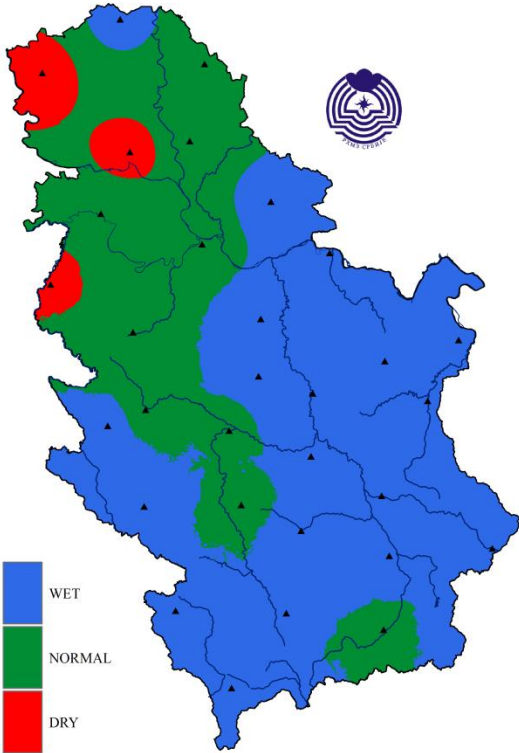


Figure D. Monitoring of the summer precipitation using tercile method compared to the 1991-2020 base period

Summer 2023			Air Temperature (°C)			
Station	Rank*	Rank**	33	50	66	Observed value
Beograd (1888-2023)	10	9	22.5	23.2	23.6	24.1
Palić (1945-2023)	7	7	21.6	22.1	22.7	23.3
Sombor (1942-2023)	10	7	21.2	21.7	22.2	22.8
Novi Sad (1948-2023)	9	8	21.1	21.8	22.2	23.3
Zrenjanin (1946-2023)	13	10	21.5	22.2	22.7	23.1
Kikinda (1948-2023)	9	9	21.6	22.1	22.6	23.2
Banatski Karlovac (1986-2023)	10	10	21.3	21.8	22.1	22.6
Loznica (1952-2023)	9	9	21.2	21.8	22.2	22.9
Sremska Mitrovica (1925-2023)	14	9	20.9	21.6	21.7	22.5
Valjevo (1926-2023)	12	9	21.2	21.9	22.1	22.6
Kragujevac (1925-2023)	17	11	21.5	21.7	22.0	22.3
Smederevska Palanka (1939-2023)	15	11	21.6	21.9	22.2	22.3
Veliko Gradište (1926-2023)	22	15	21.2	21.8	22.2	22.1
Crni Vrh (1967-2023)	10	10	16.4	16.7	17.0	18.0
Negotin (1927-2023)	15	10	22.9	23.3	23.7	23.8
Zlatibor (1950-2023)	12	10	16.9	17.4	17.8	18.2
Sjenica (1946-2023)	9	8	15.9	16.3	16.6	17.2
Pozega (1952-2023)	10	9	19.4	19.8	20.1	20.4
Kraljevo (1926-2023)	16	11	21.3	21.7	21.8	22.2
Kopaonik (1950-2023)	7	7	12.3	12.6	12.9	13.9
Kursumlija (1952-2023)	8	7	19.6	20.0	20.2	20.9
Krusevac (1927-2023)	17	11	21.3	21.6	22.0	22.2

Cuprija (1948-2023)	10	8	21.3	21.6	21.8	22.7
Nis (1925-2023)	21	13	22.1	22.4	22.8	22.8
Leskovac (1948-2023)	14	10	21.1	21.5	21.9	22.1
Zajecar (1929-2023)	34	25	21.7	22.0	22.2	21.7
Dimitrovgrad (1945-2023)	8	5	19.6	19.9	20.3	21.1
Vranje (1926-2023)	17	10	21.2	21.4	21.7	22.3

*Rank –period of stations work (warmest season)

**Rank – 1981-2023 period (warmest season)

Station	Rank*	Rank**	Precipitation sums (mm)			
			33	50	66	Observed Value
Beograd (1888-2023)	63	22	156.7	234.3	264.1	210.1
Palić (1945-2023)	11	7	141.5	208.1	229.4	258.4
Sombor (1942-2023)	56	29	180.1	203.0	242.7	172.5
Novi Sad (1948-2023)	60	33	168.9	203.1	265.3	133.5
Zrenjanin (1946-2023)	35	16	140.9	177.1	226.4	209.6
Kikinda (1948-2023)	34	13	140.3	174.9	207.0	203.4
Banatski Karlovac (1946-2023)	14	7	158.6	209.7	269.3	284.9
Loznica (1926-2023)	88	38	219.1	257.9	301.5	140.7
Sremska Mitrovica (1925-2023)	62	28	153.1	184.7	202.4	163.2
Valjevo (1926-2023)	40	18	189.6	219.7	318.1	260.2
Kragujevac (1925-2023)	22	9	166.4	210.5	233.2	247.1
Smederevska Palanka (1939-2023)	17	9	144.4	195.2	247.0	270.0
Veliko Gradište (1926-2023)	6	4	163.5	189.8	245.6	382.1

Crni Vrh (1967-2023)	11	6	169.4	196.6	254.7	348.7
Negotin (1927-2023)	11	7	112.7	146.9	192.2	254.0
Zlatibor (1950-2023)	17	12	233.9	284.6	331.5	335.1
Sjenica (1946-2023)	9	3	192.9	215.8	233.1	325.5
Pozega (1952-2023)	33	15	175.4	221.1	280.5	256.9
Kraljevo (1926-2023)	32	17	146.8	238.5	280.1	263.7
Kopaonik (1950-2023)	31	22	246.6	288.6	323.8	274.9
Kursumlija (1952-2023)	4	3	137.5	186.2	215.3	329.1
Krusevac (1927-2023)	2	1	154.3	182.5	210.9	415.7
Cuprija (1948-2023)	2	1	143.8	197.1	205.8	329.6
Nis (1925-2023)	8	4	116.5	151.2	176.6	236.0
Leskovac (1948-2023)	21	12	115.0	152.6	187.0	211.9
Zajecar (1929-2023)	26	10	115.9	163.3	183.1	212.9
Dimitrovgrad (1945-2023)	27	12	159.3	174.8	203.5	224.4
Vranje (1926-2023)	43	21	108.0	144.3	172.7	150.5

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

**Rank – 1981-2023 period (highest/lowest seasonal precipitation)

Country	Seasonal temperature JJA		Seasonal precipitation JJA		High Impact Events
	Observed	SEECOF-29 climate outlook for temperature	Observed	SEECOF-29 climate outlook for precipitation	
Serbia (1)	Above normal in most of Serbia	Above-normal (20, 30, 50) in entire Serbia	Above normal in most of Serbia, average and below-average precipitation sums in some parts of northern and western Serbia	No predictive signal (33, 34, 33) in entire Serbia	<ul style="list-style-type: none"> ❖ <i>11th warmest summer for Serbia since 1951</i> ❖ <i>3rd warmest summer for Serbia based on the minimum air temperature</i> ❖ <i>Record-breaking number of tropical nights on Palic and Sombor</i> ❖ <i>Rainy summer in the east, parts of southwestern, central and southeastern Serbia</i> ❖ <i>2nd wettest summer for Krusevac and Cuprija</i> ❖ <i>Number of days with precipitation sums of 20 mm and above exceeded in Krusevac</i>

Analysis of the summer season 2023 for Serbia relative to the 1991-2020 base period

Temperature

Summer 2023 ranks as the 11th summer for Serbia for the record-keeping period from 1951 to 2023 (*Figure 1*), the warmest summer was the summer of 2012. Summer 2023 ranks as the 7th warmest for Palic and Kopaonik (*Figure 2*), 8th warmest for Kursumlija and Dimitrovgrad. 16 out of 20 warmest summer seasons was registered as of the year 2000.

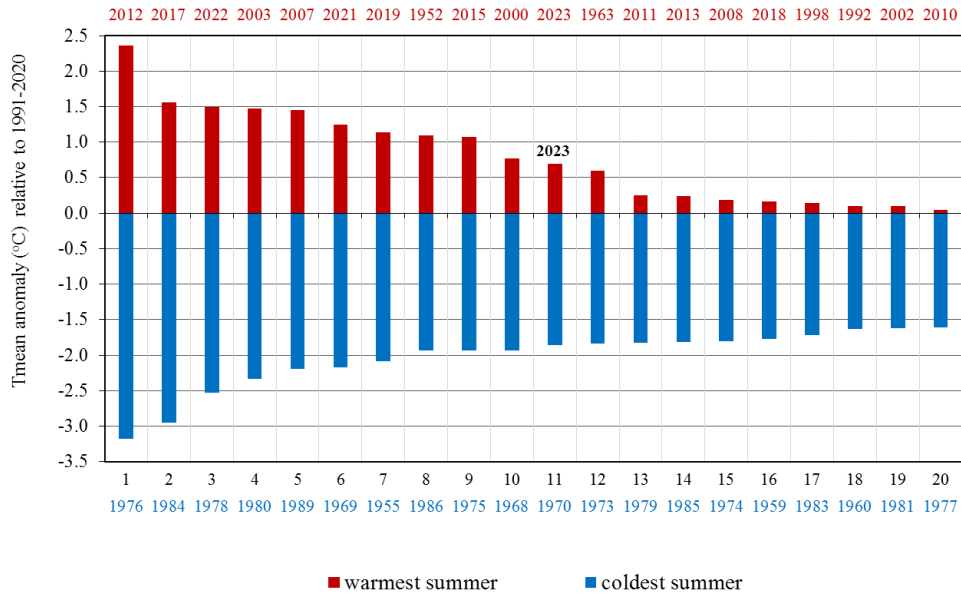
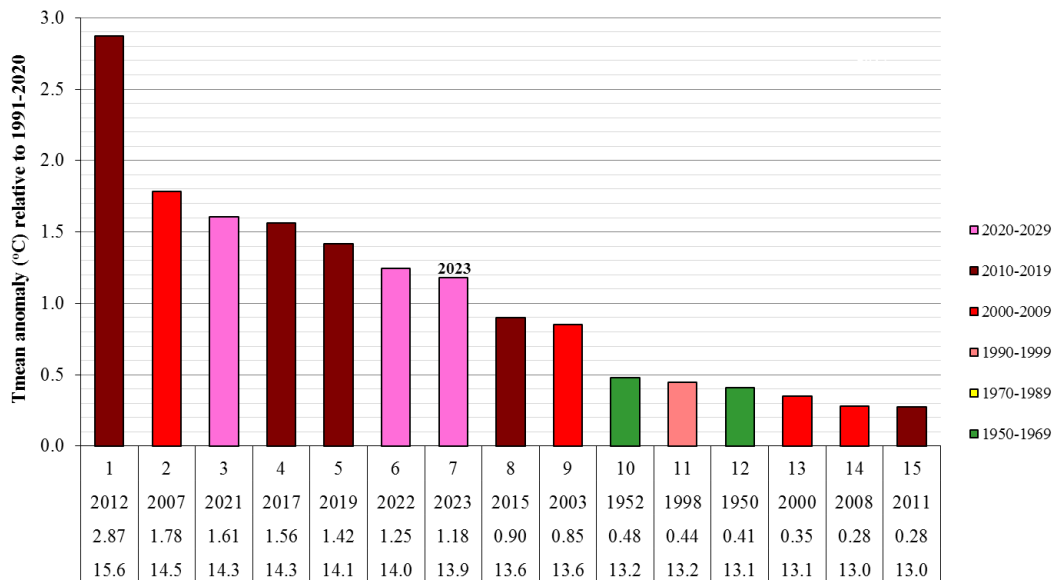


Figure 1. Rank of twenty warmest and coldest summers in Serbia for the 1951-2023 period

**Anomaly of mean seasonal temperature relative to 1991-2020 base period
Kopaonik - 1950-2023 period**



ranking - year - Tmean anomaly (°C) relative to 1991-2020 - Tmean

Figure 2. Rank of the warmest summers on Kopaonik

Mean summer air temperature ranged from 20,4°C in Pozega to 24,1°C in Belgrade, and on the mountains from 13,9°C at Kopaonik to 18,2°C at Zlatibor (*Figure 3*).

Departure of the mean summer air temperature from the normal¹ ranged from -0,2°C in Zajecar to +1,4°C in Novi Sad, and in the upland from +0,7°C at Zlatibor to +1,2°C at Kopaonik (*Figure 4*).

Based on the percentile method², mean summer air temperature was in the following categories: warm in most of Serbia, very warm in Dimitrovgrad, normal in Smederevska Palanka, Veliko Gradiste, Kraljevo, Krusevac, Nis and Zajecar (*Figure 5*).

Based on the tercile method, mean summer air temperature was in the warm category in most of the country, normal in Veliko Gradiste and Nis, and cold category in Zajecar (*Figure 6*).

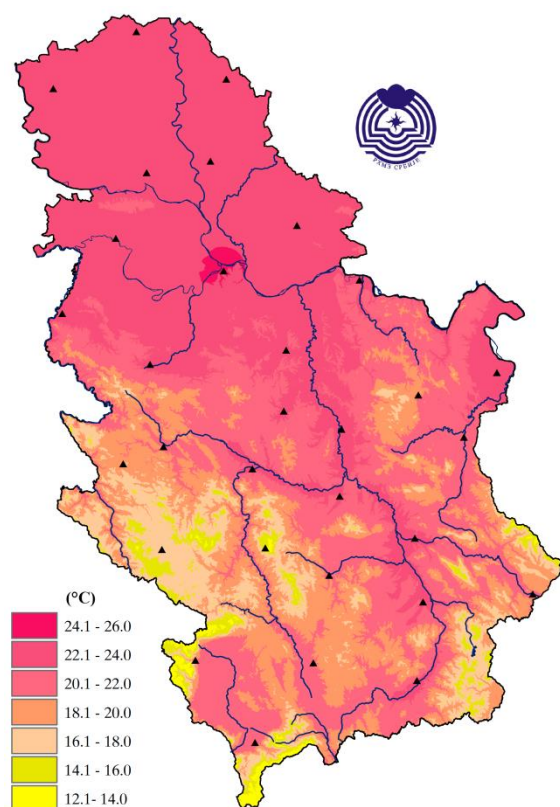


Figure 3. Spatial distribution of mean summer air temperature

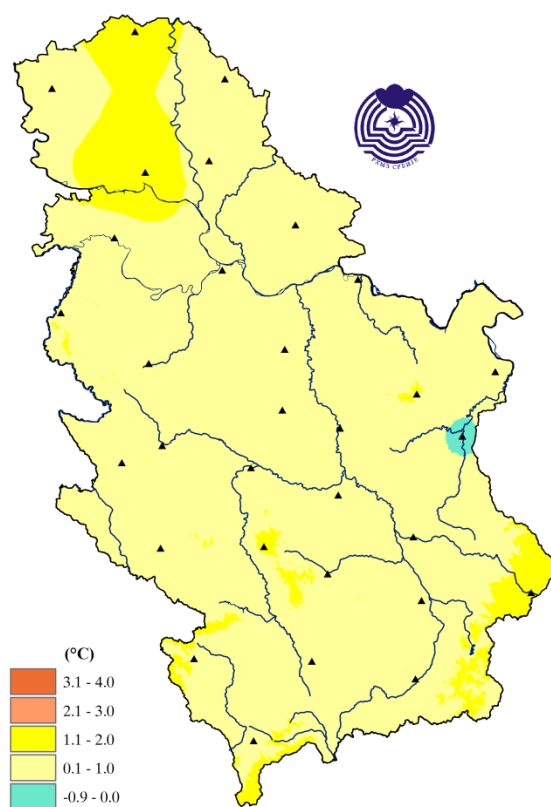


Figure 4. Spatial distribution of mean summer air temperature anomaly from the normal

¹ Term *normal* refers to *climatological standard normal*, that is, the average value of a particular climate element, calculated for the period from January 1, 1991 to December 31, 2020

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

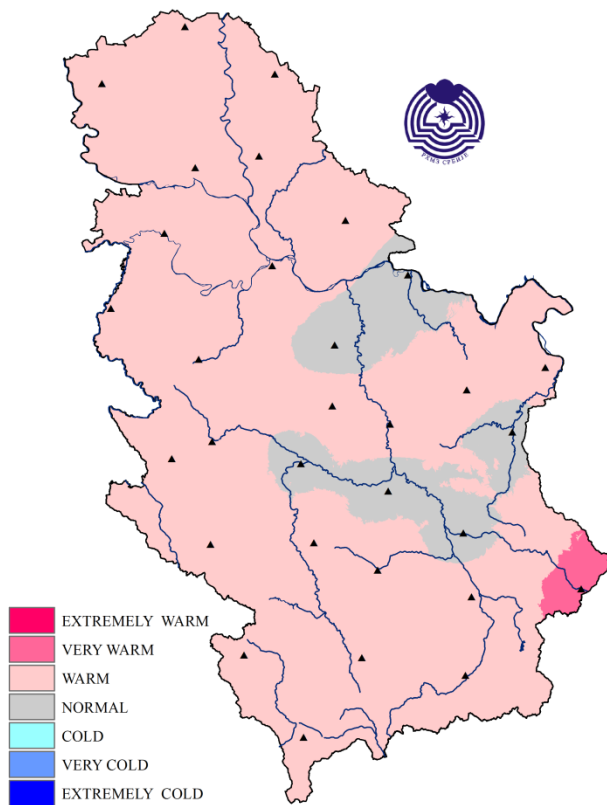


Figure 5. Spatial distribution of mean summer air temperature according to the percentile method

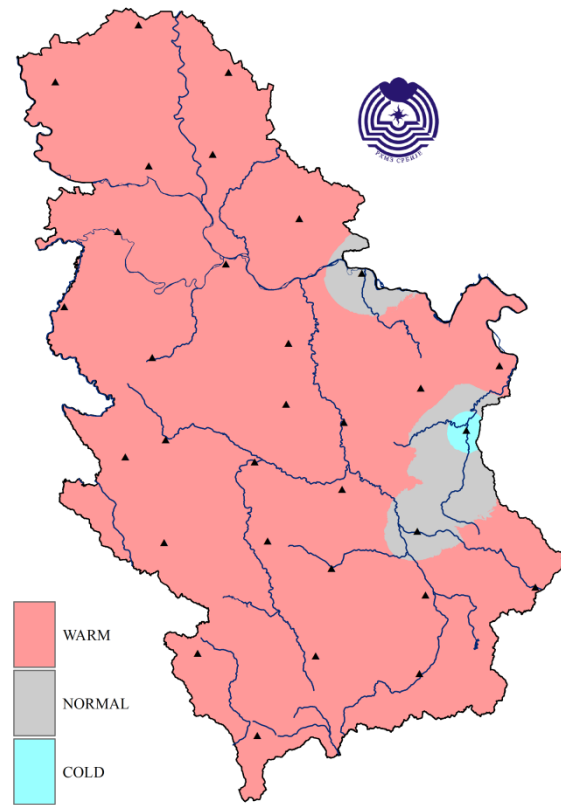


Figure 6. Spatial distribution of mean summer air temperature according to the tercile method

In the summer of 2023, the highest daily air temperature of 39,0°C was measured in Dimitrovgrad and Nis on August 4.

The lowest summer air temperature of 3,3°C was measured at Kopaonik on June 29 and August 9. As for the lowland, Vranje observed air temperature of 7,5°C on August 9.

Number of summer days³ ranged from 68 days in Pozega and Kurusmlija to 81 days in Kikinda, Banatski Karlovac and Leskovac and on the mountains, from 3 days at Kopaonik to 43 days in Sjenica. Belgrade observed 78 summer days, which is 5 days above the average. Departure of the number of summer days was above the average in most of Serbia, and up to 8 days above the average at Crni Vrh, and 1 day below the average in Vranje, Zajecar, Kursumlija and Negotin, and 4 days below the average in Kragujevac (*Figure 7*).

Number of tropical days⁴ ranged from 33 days in Pozega to 52 days in Negotin, and on the mountains from zero at Kopaonik to 16 days in Sjenica. Belgrade recorded 45 tropical days, which is 7 days above the summer average. Number of tropical days was above the average at most places, up to 11 days in Sombor, Dimitrovgrad and Kikinda. At Crni Vrh and Kragujevac, number of tropical days was up to 1 days below the average, and in Nis up to 4 days below the average (*Figure 8*).

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

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

The highest number of tropical nights⁵, total of 31, was recorded in Belgrade, which is 7 days above the average. As for the upland, the highest number of tropical nights, total of 7, was observed at Crni Vrh, which is 4 days above the summer average. **Record-breaking number of tropical nights** was registered on Palic and Sombor. Palic observed 21 tropical nights thereby besting the previous record of 19 nights set in 2015, whereas previous record of 11 nights from 2022 was broken in Sombor with 12 tropical nights recorded during the summer of 2023.

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

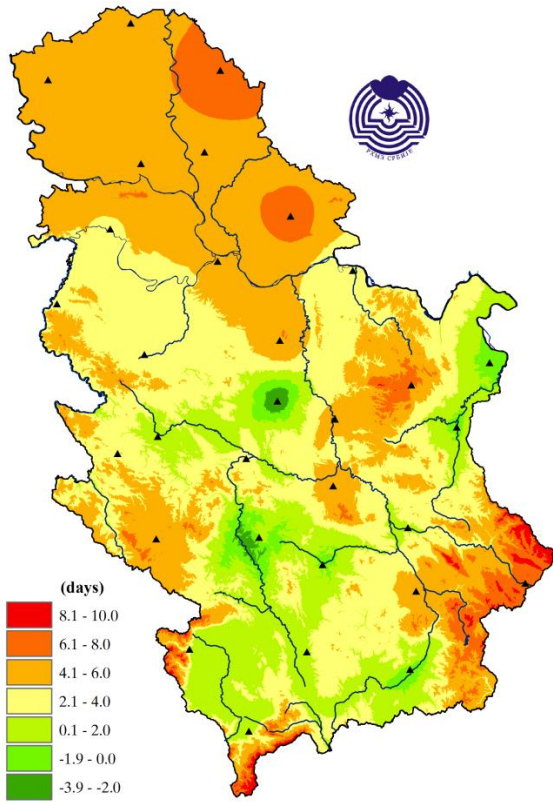


Figure 7. Deviation of the number of summer days from the normal

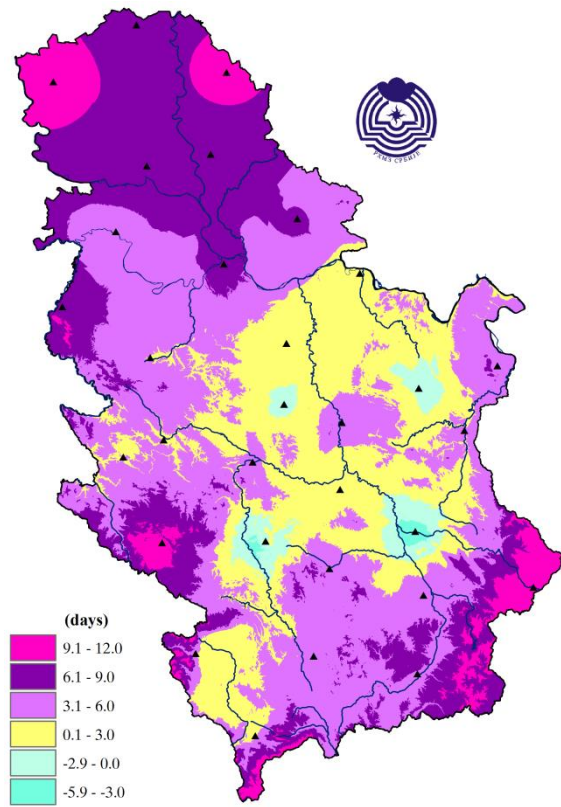


Figure 8. Deviation of the number of tropical days from the normal

During summer, mean, maximum and minimum air temperature in Belgrade were above the multiannual average at the beginning of the third decade of June, most of June and beginning and end of August and below the average in the mid-June and end of June, end of July and from the middle of the first to the middle of the second decade of August (Figure 9).

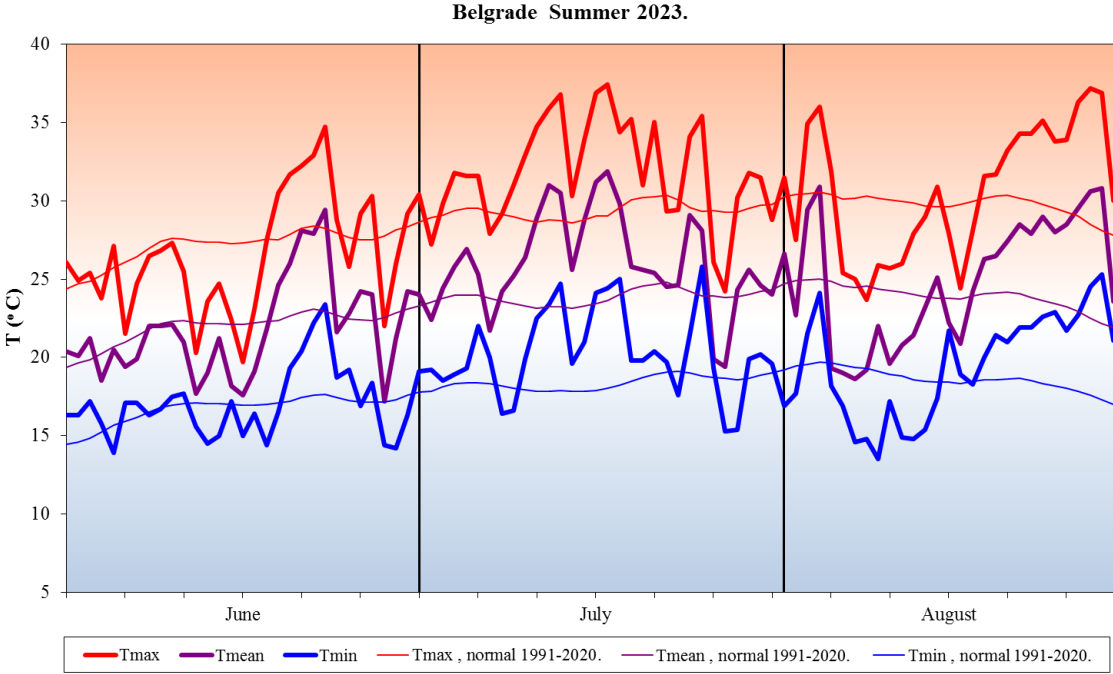


Figure 9. Three – month course of mean, maximum and minimum daily air temperature in Belgrade

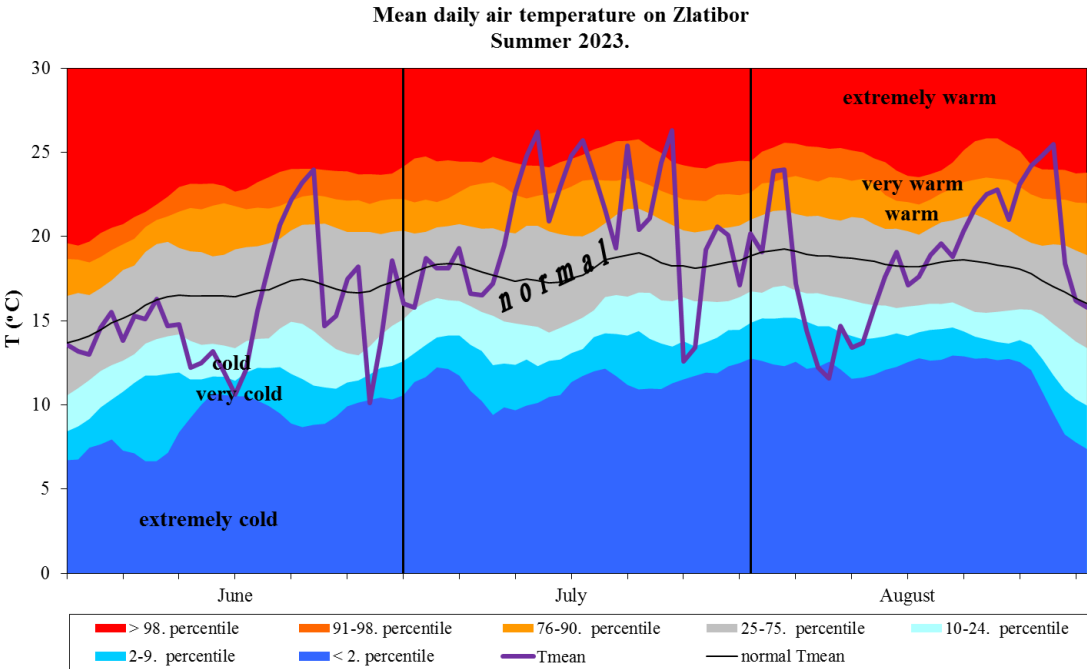


Figure 10. Three – month course of mean daily air temperature at Zlatibor

Figures 11 and 12 show assessment of the mean, maximum and minimum air temperature and precipitation sums for Serbia for the summer based on the tercile distribution relative to the 1991-2020 base period. It can be noted that the summer 2023 was **the 3rd warmest summer with the minimum air temperature**, whereas the maximum air temperature was slightly above the boundary of upper tercile. Precipitation sums were slightly above the boundary of upper tercile.

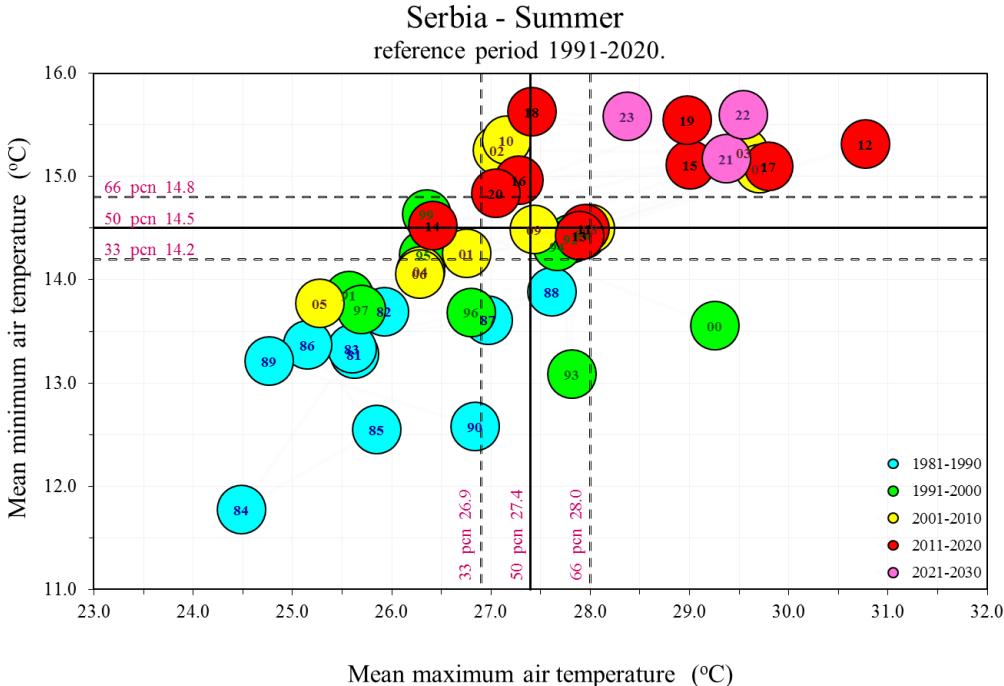


Figure 11. Assessment of precipitation sums and mean air temperature for summer in Serbia based on the accompanying terciles relative to the 1991-2020 base period

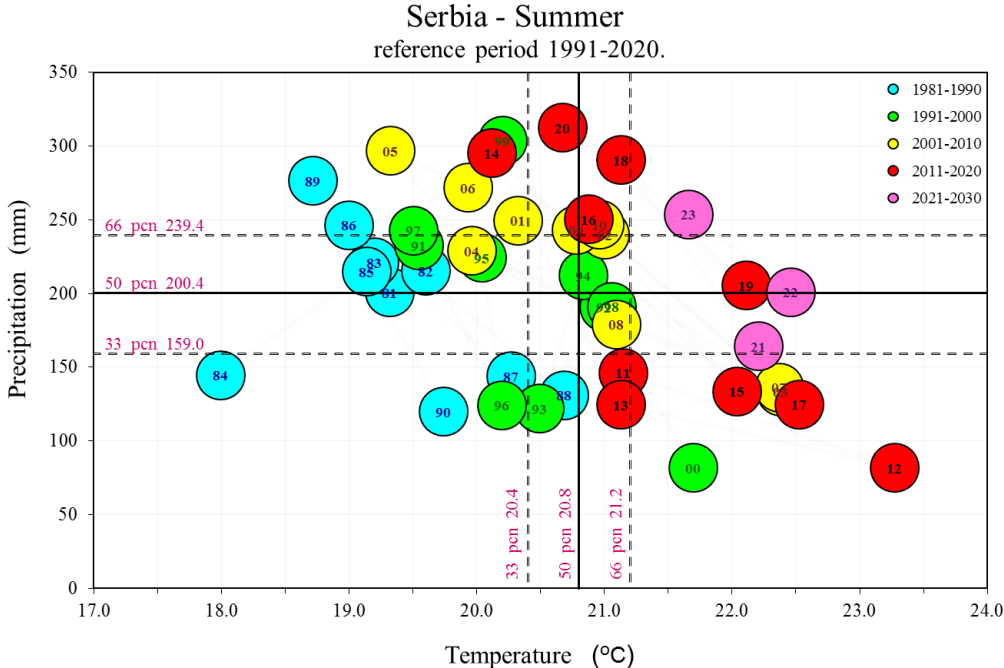


Figure 12. Assessment of maximum and minimum air temperature for summer in Serbia based on the accompanying terciles relative to the 1991-2020 base period

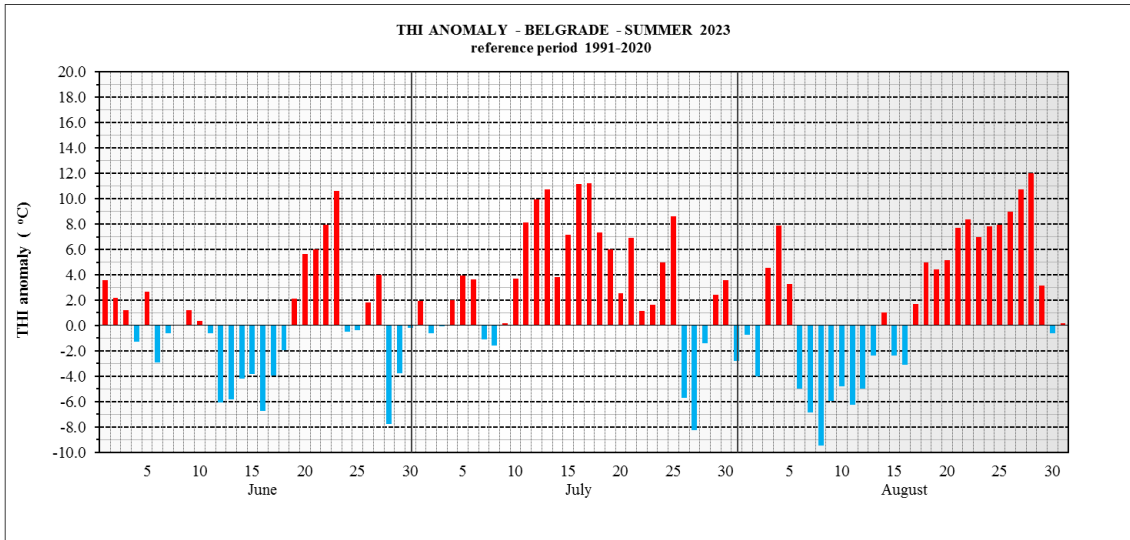


Figure 13.

Departure of the Temperature Humidity Index (THI)⁶ was positive most of the summer (Figure 13). The highest difference between the *feel like* temperature and the maximum daily air temperature was recorded on June 23 amounting to 7,5°C (Figure 14). On that day, the maximum air temperature was 34,7°C whilst the *feel like* temperature was 42,2°C. The maximum THI of 43,4°C was measured on 17 July 2023. There were 16 days with THI above 40°C and 65 days with THI above 30°C.

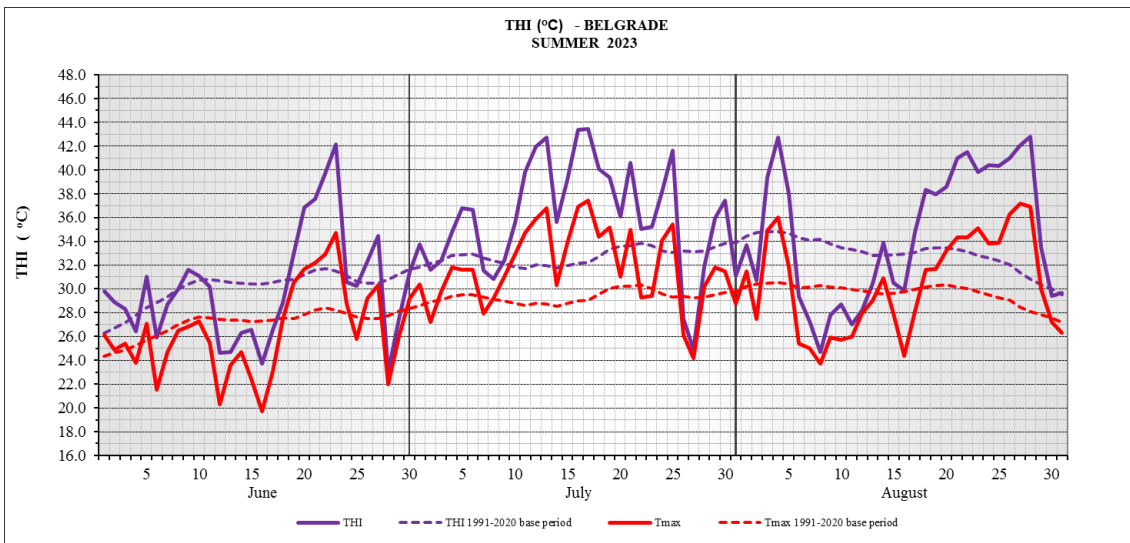


Figure 14.

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

Precipitation

Summer precipitation totals ranged from 133,5 mm in Novi Sad to 415,7 mm in Krusevac (Figure 15). Precipitation sums relative to the normal ranged from 55% in Loznica to 225% in Krusevac (Figure 16).

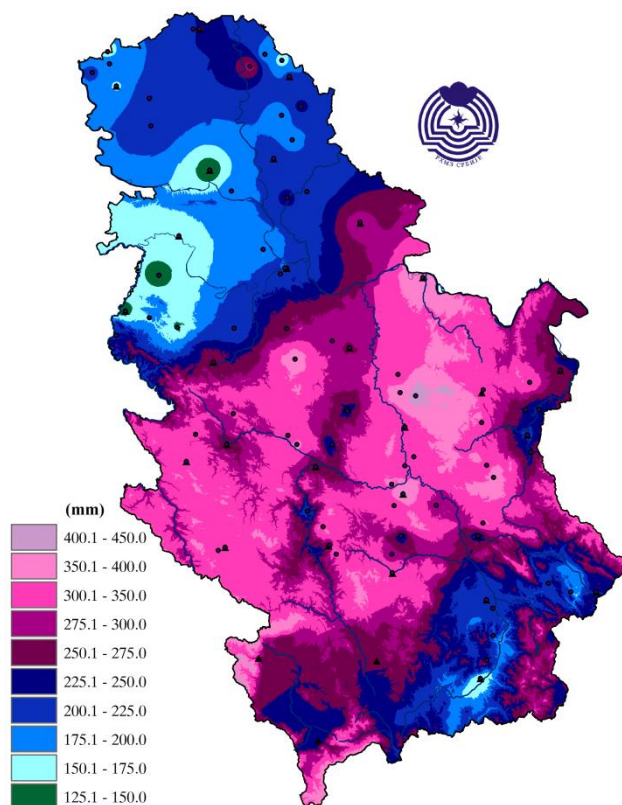


Figure 15. Spatial distribution of summer precipitation sums based on data from 28 principal, 15 climatological and 46 rain gauge stations

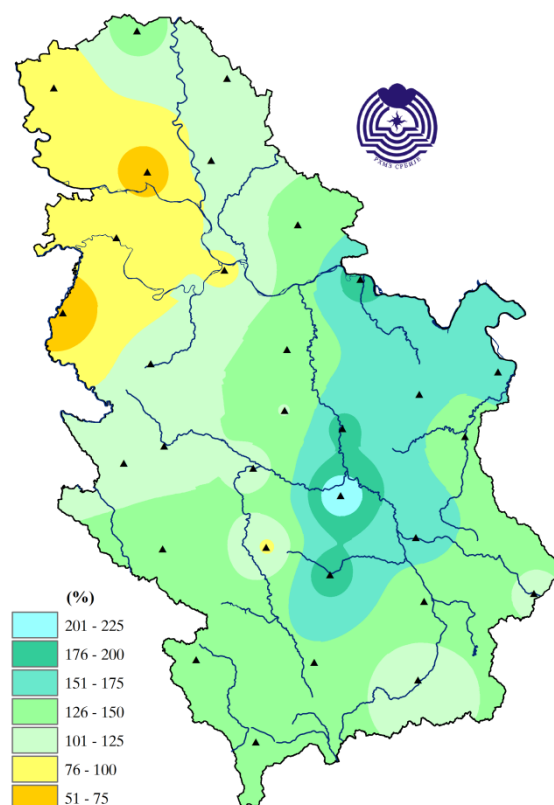


Figure 16. Spatial distribution of summer precipitation sums in percentage of normal

Based on the percentile method, summer precipitation was in the following categories: normal and rainy in most of Serbia, dry in Loznica, very rainy in Veliko Gradiste, Sjenica and Nis, and extremely rainy in Kursumlija, Krusevac and Cuprija (Figure 17).

Based on the tercile method, precipitation sums were in the dry category in Sombor, Novi Sad and Loznica, normal category in Vranje, parts of northern, northwestern and central Serbia, elsewhere it was rainy (Figure 18).

The maximum daily precipitation sum of 78,8 mm was recorded in Banatski Karlovac on August 16. On June 13, Cuprija observed precipitation sum of 74,4 mm; on August 6, Veliko Gradiste recorded 57,5 mm; on June 16, Valjevo recorded 56,6 mm while Kursumlija observed 50,8 mm on the same day.

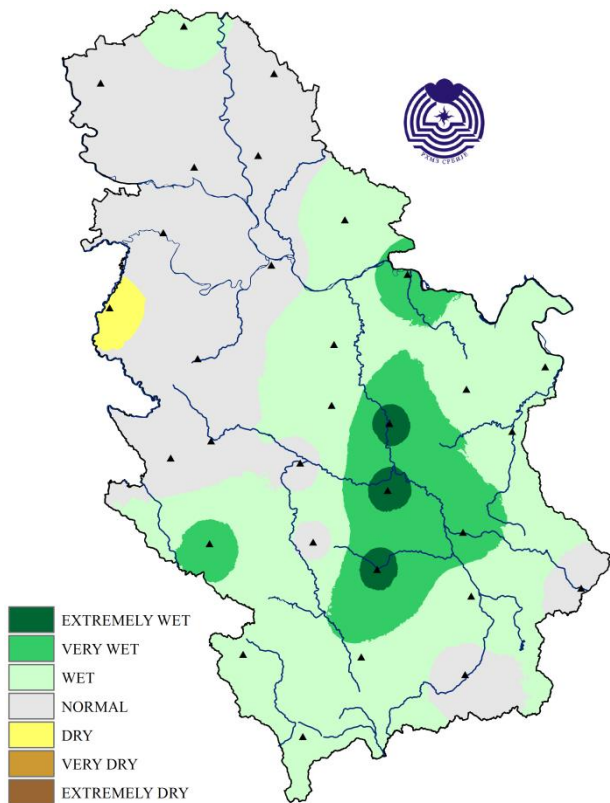


Figure 17. Summer precipitation sums according to the percentile method

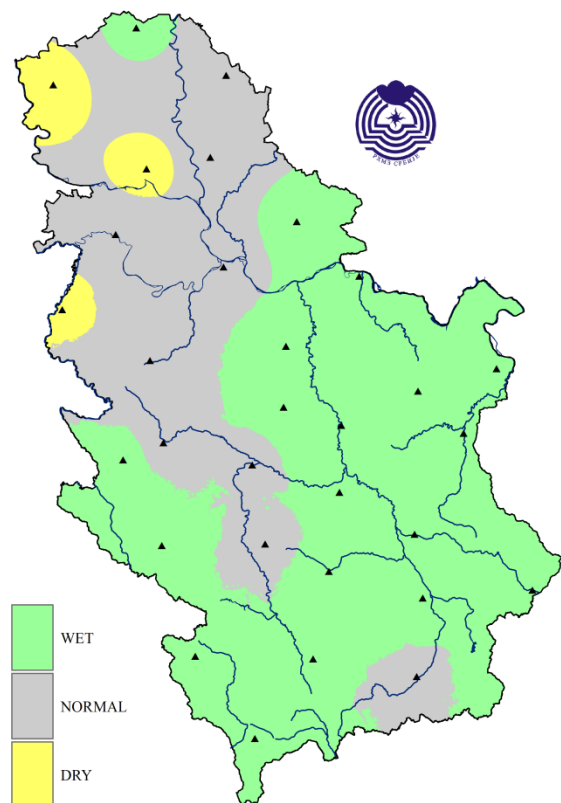


Figure 18. Summer precipitation sums according to the tercile method

Summer 2023 ranks as **the 2nd wettest** for Krusevac and Cuprija, in Krusevac after 1955 and in Cuprija after 1969 (Figures 19 and 20). The summer 2023 ranks as the 4th wettest for Kursumlija and 6th wettest for Veliko Gradiste.

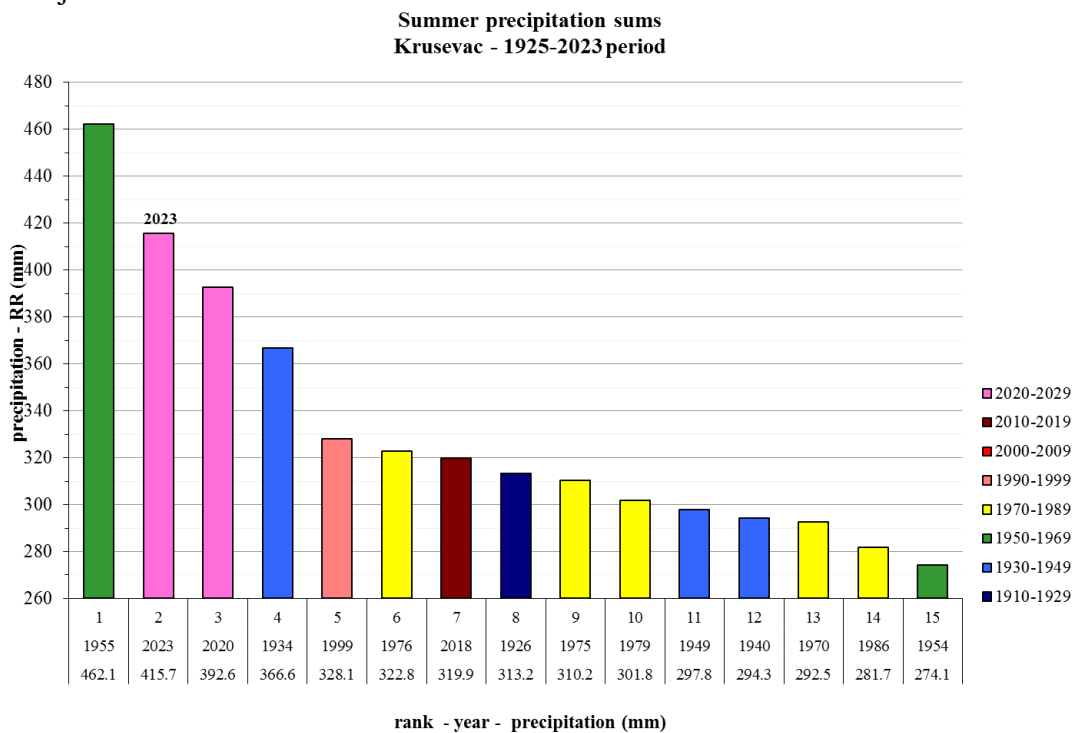


Figure 19. Rank of the wettest summers in Krusevac

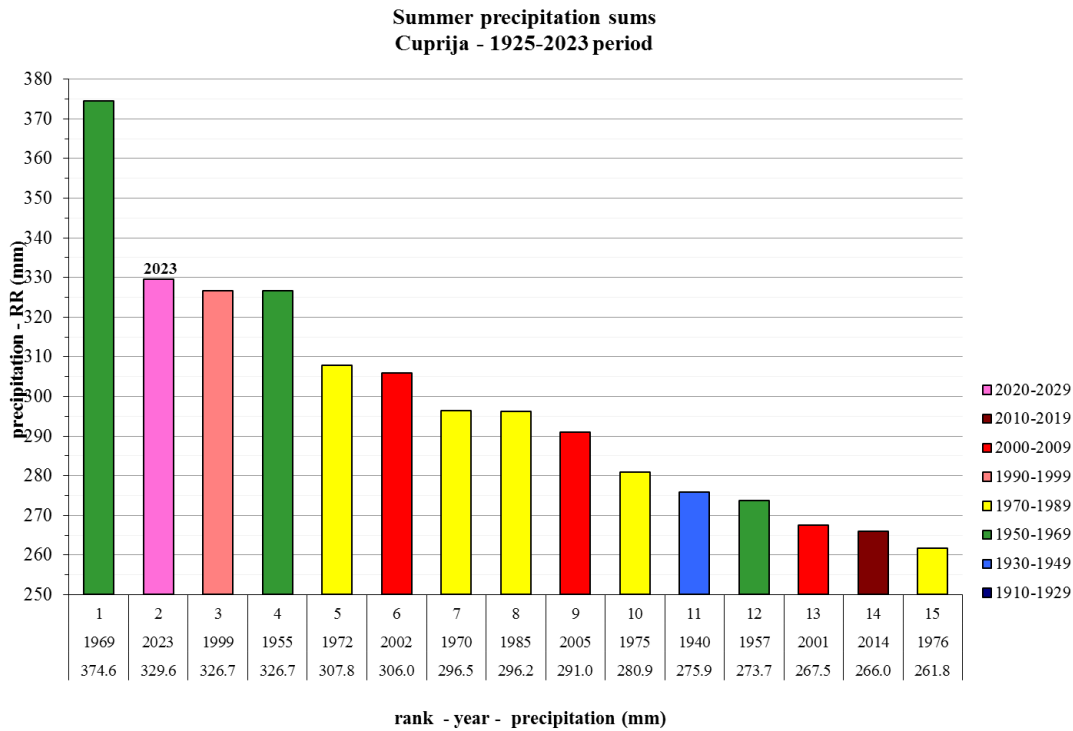


Figure 20. Rank of the driest summers in Cuprija

Number of days with precipitation during summer ranged from 26 days in Zrenjanin to 42 days in Sjenica. The recorded number of days with precipitation was above the average in most of Serbia, up to 11 days above the average in Negotin and Krusevac (*Figure 21*). Number of days with precipitation was below the average in parts of northern and northwestern Serbia.

Aside from Loznica and Kraljevo, days with daily precipitation sums above 20 mm were registered in entire Serbia (*Figure 22*). Krusevac observed 10 days with precipitation above 20 mm thereby **breaking the previous record** of 7 days set in the summer of 1955 and the summer of 2020.

One day with precipitation sum of 50 mm and above was observed in Banatski Karlovac, Valjevo, Veliko Gradiste, Kursumlija and Cuprija.

In summer, number of thunder days ranged from 10 in Kikinda (7 days below the average) to 32 days at Crni Vrh. The recorded number of thunder days was 13 days below the average in Kikinda, and 12 days above the average in Kursumlija (*Figure 23*).

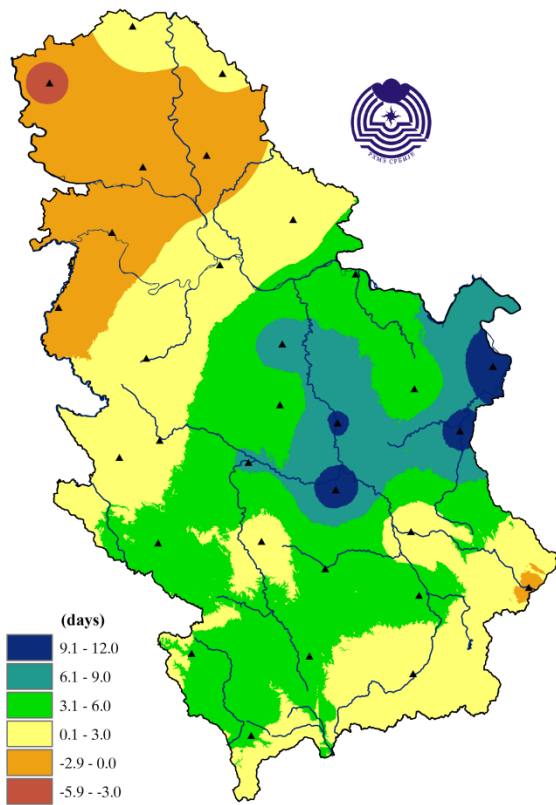


Figure 21. Deviation of number of days with precipitation of 0.1 mm and more from the normal

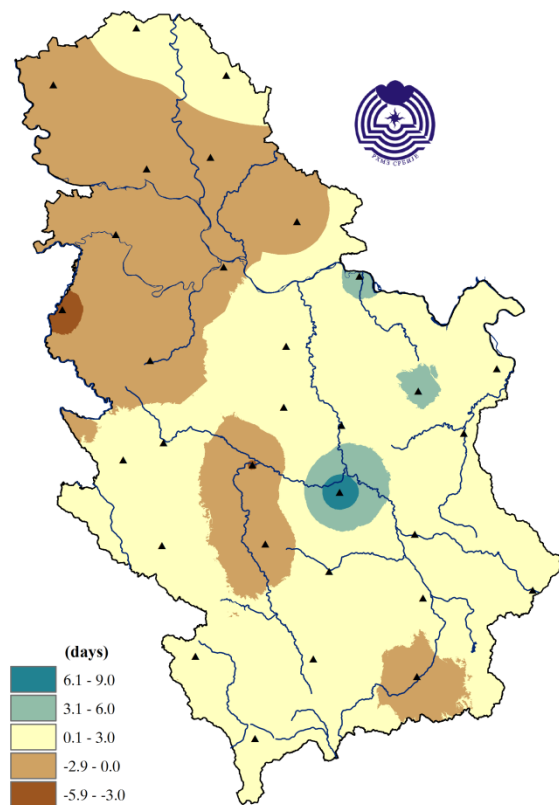


Figure 22. Deviation of number of days with precipitation of 20 mm and more from the normal

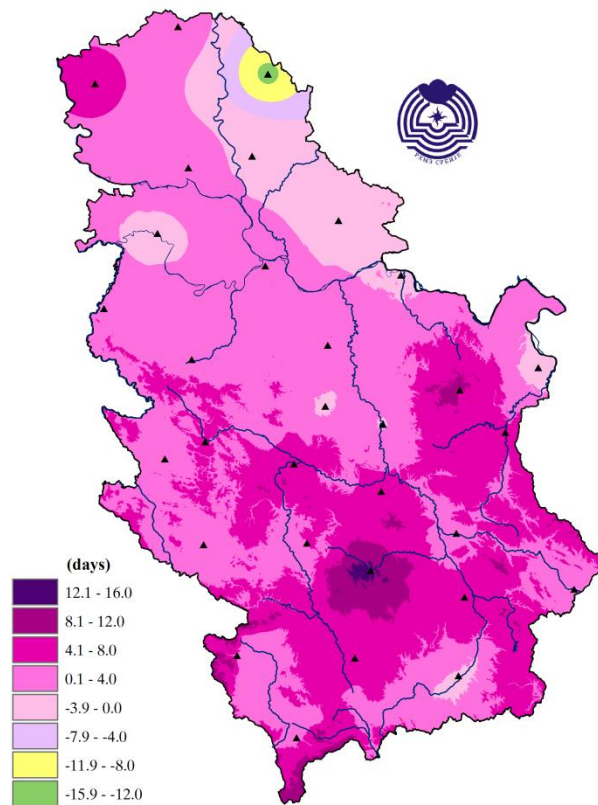


Figure 23. Deviation of number of days with thunder from the normal

Figures 24 and 25 show cumulative precipitation sums for Krusevac and Kursumlija during summer per months relative to the average cumulative precipitation sums.

Cumulative precipitation sums in Krusevac

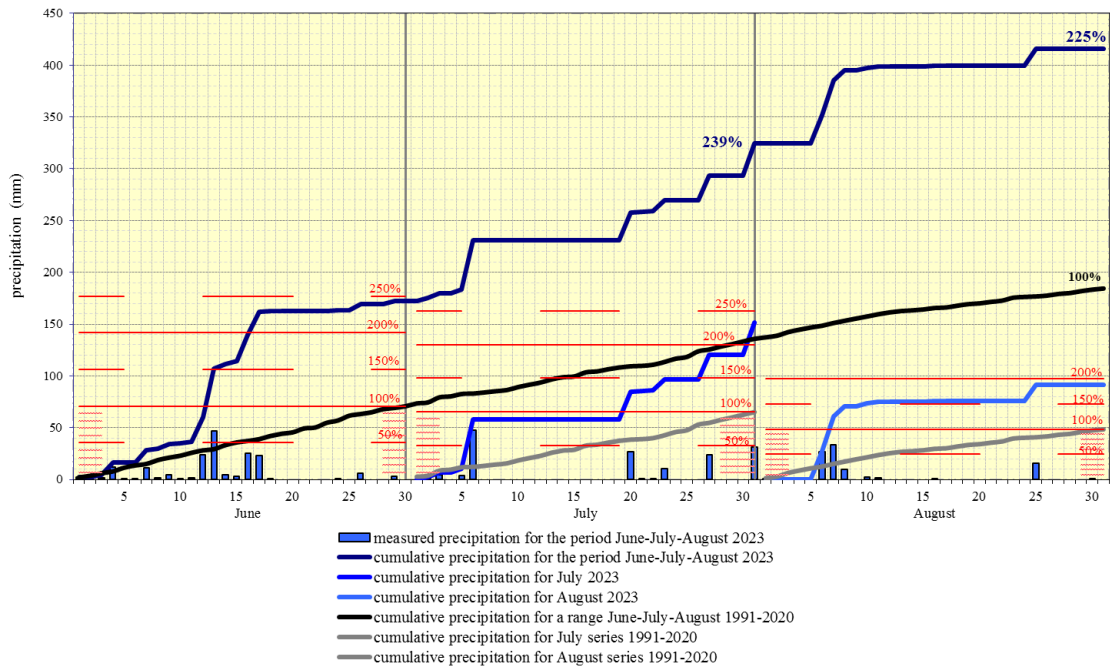


Figure 24. Cumulative precipitation sums for Krusevac

Cumulative precipitation sums in Kursumlija

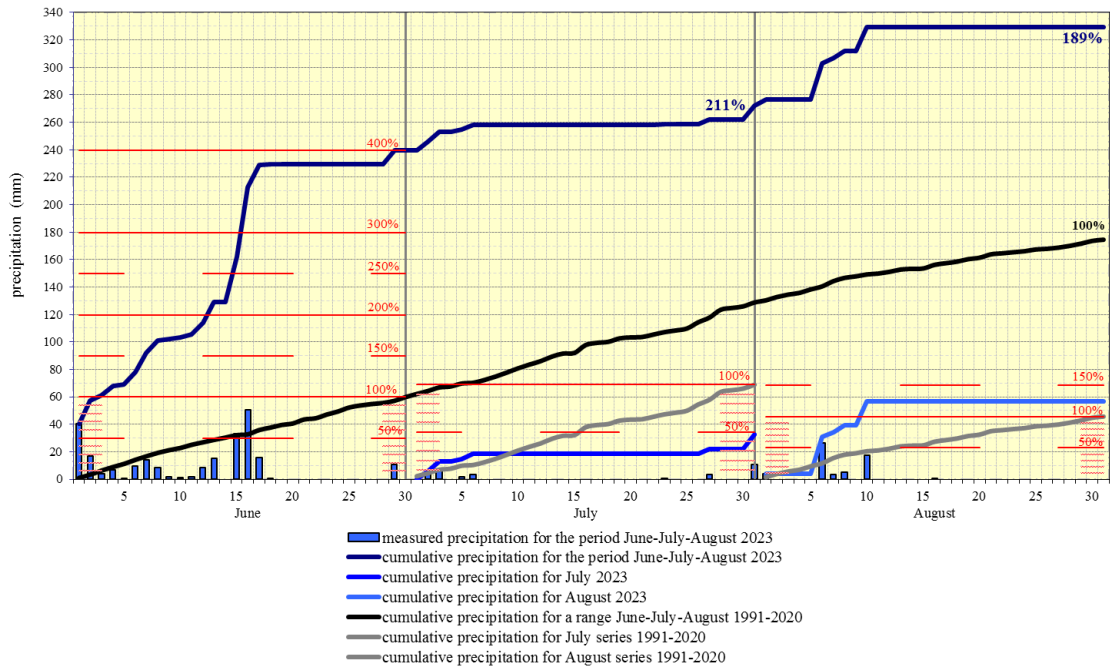


Figure 25. Cumulative precipitation sums for Kursumlija

Sunshine duration (insolation)

Sunshine duration during summer ranged from 670,5 hours in Zajecar to 954,1 hours in Kikinda (Figure 26).

Relative to the normal for the 1991-2020 base period, insolation ranged from 84% in Zajecar to 106% in Kikinda (Figure 27).

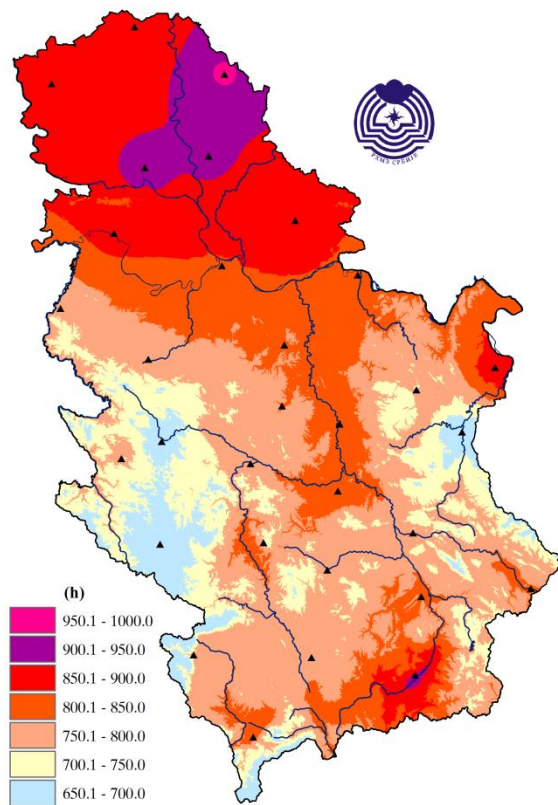


Figure 26. Insolation in hours

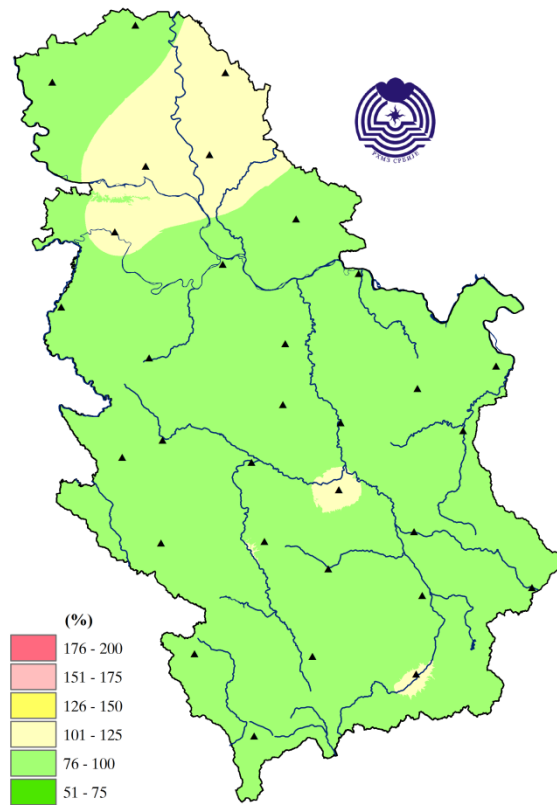


Figure 27. Insolation in percentage of normal

Analysis of the summer season 2023 for Serbia relative to the 1961-1990 base period

Temperature

In summer, departure of the mean air temperature from the normal for the 1961-1990 base period ranged from +1,5°C in Zajecar to +3,1°C on Palic and Belgrade, and on the mountains from +2,5°C in Sjenica to +3,3°C at Kopaonik (*Figure 28*).

Based on the percentile method, mean summer air temperature was in the extremely warm category in most of Serbia and warm category in Smederevska Palanka and Zajecar (*Figure 29*).

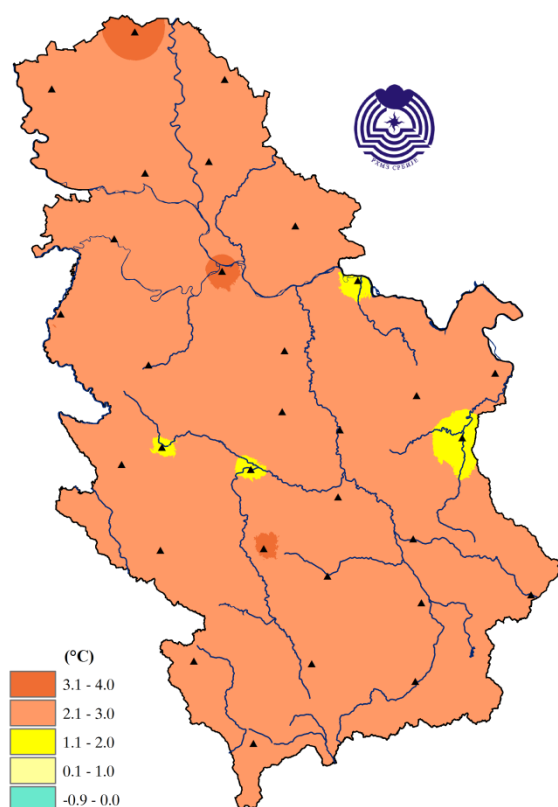


Figure 28. Spatial distribution of mean summer air temperature anomaly from the 1961-1990 normal

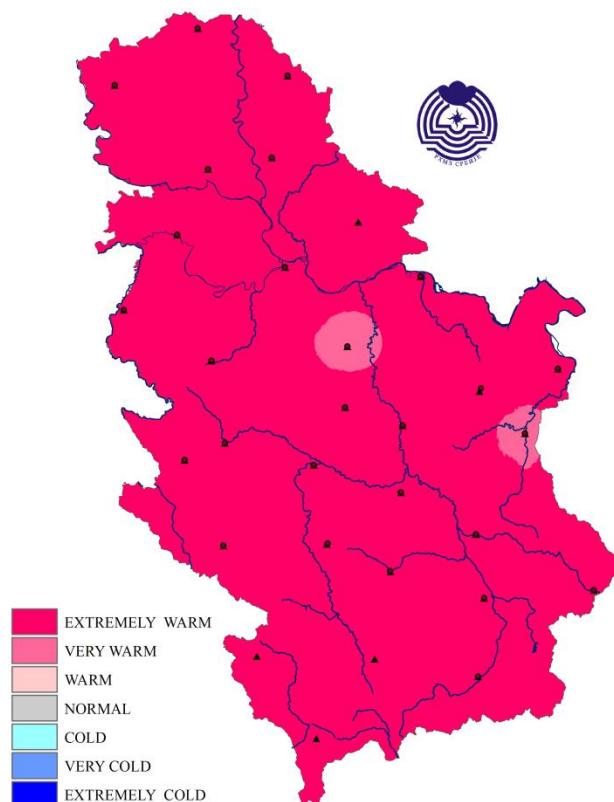


Figure 29. Spatial distribution of mean summer air temperature according to the percentile method

Precipitation

Summer precipitation sums relative to the normal for the 1961-1990 base period ranged from 54% in Loznica to 219% in Krusevac (*Figure 30*).

Based on the percentile method, summer precipitation sums were in the following category: normal and rainy in most of Serbia, dry in Novi Sad, very dry in Loznica, very rainy in Veliko Gradiste, Sjenica, Kursumlija, Cuprija and Nis, and extremely rainy in Krusevac (*Figure 31*).

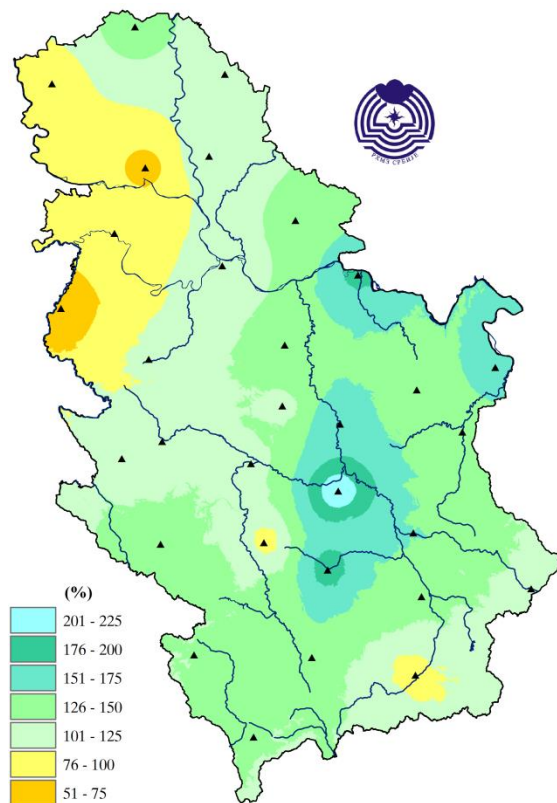


Figure 30. Spatial distribution of spring precipitation sums in percentage of the 1961-1990 normal

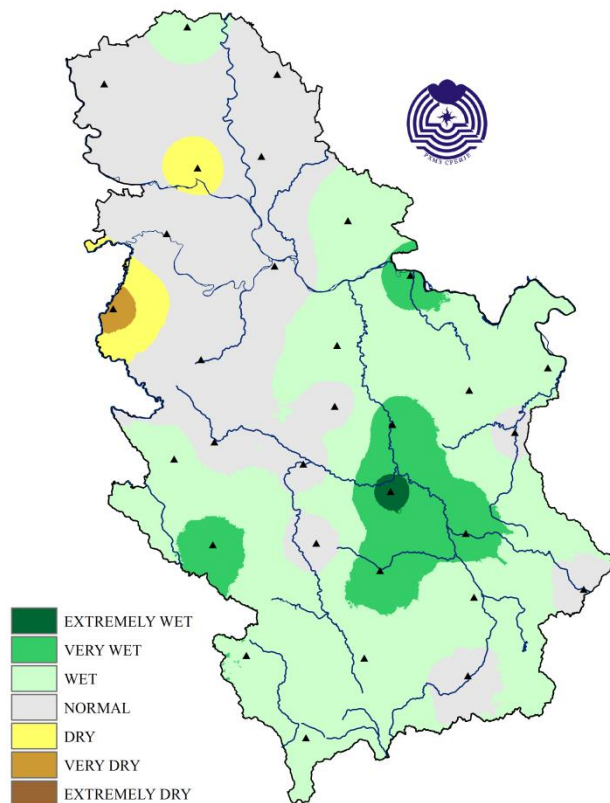


Figure 31. Summer precipitation sums according to the percentile method

Note: Climatological analysis of the meteorological elements based on the preliminary data obtained from the 28 principal meteorological stations