VERIFICATION OF THE SEECOF–19 SUMMER 2018 CLIMATE OUTLOOK AND SEASONAL BULLETIN FOR SERBIA

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Temperature

The SEECOF-19 outlook for the summer 2018 in Serbia indicated warmer than normal temperature in Serbia with 70% probability relative to the 1981–2010 climatological base period (*Figure* A).
Climatological monitoring showed that the summer 2018 was warm in almost entire Serbia, with above-normal temperature based on the tercile method (*Figure* B). The outlook for a warm summer was correct.

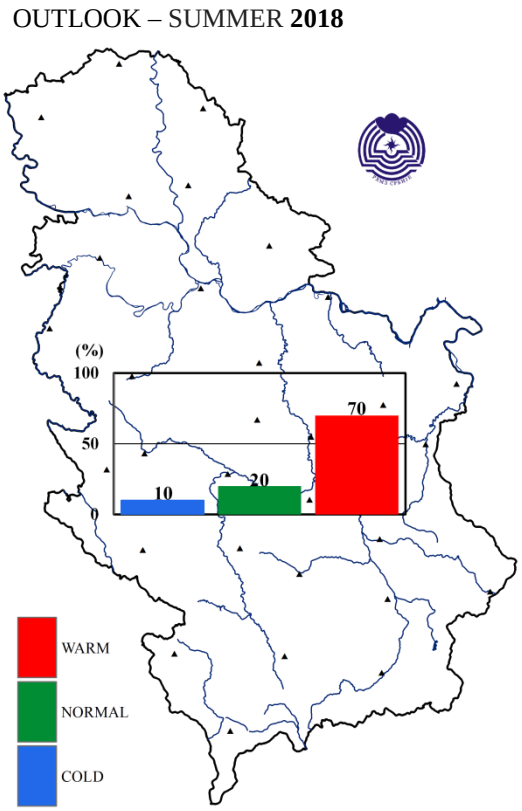

Figure A. SEECOF-19 - summer temperature outlook

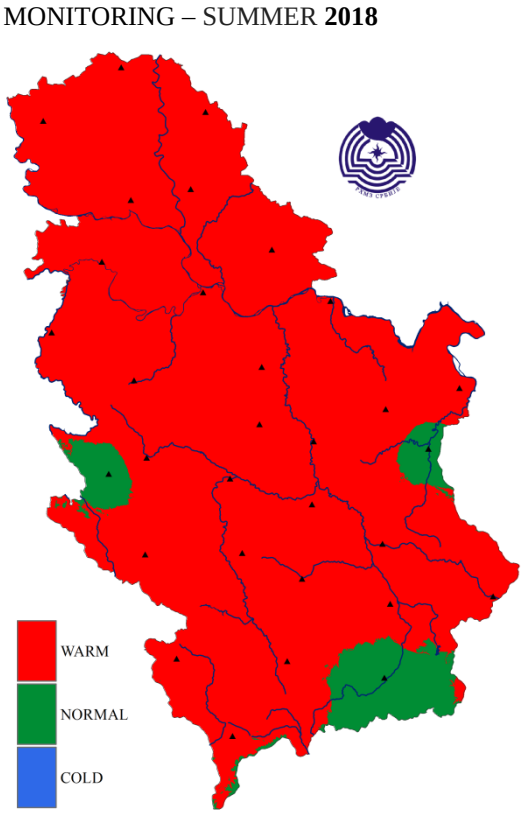

Figure B. Monitoring of the summer temperature using tercile method compared to the 1981-2010 base period

Precipitation

The SEECOF–19 climate outlook for the summer 2018 in Serbia indicated below-average conditions with the highest probability of 45% (*Figure* C). Consequently, relatively dry summer season was expected, with below-average precipitation sums.
Monitoring of precipitation showed wet summer conditions in most of Serbia, except in north-eastern part (*Figure* D).

OUTLOOK – SUMMER **2018**

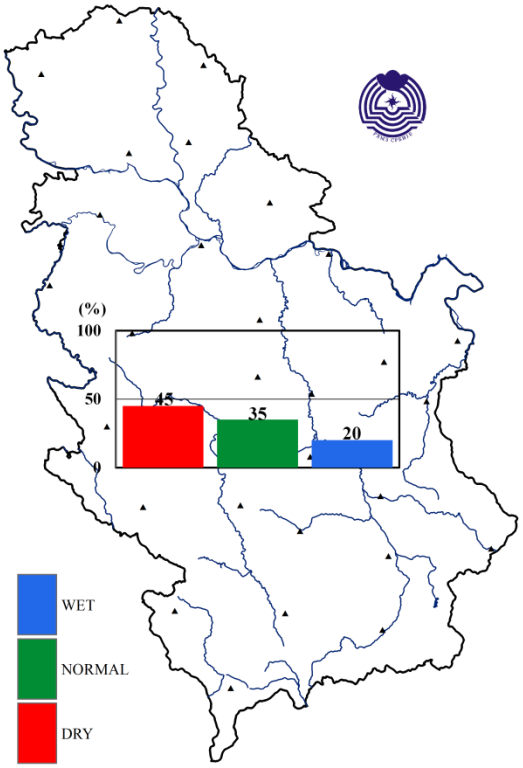

Figure C. SEECOF-19 - summer precipitation outlook

MONITORING – SUMMER **2018**

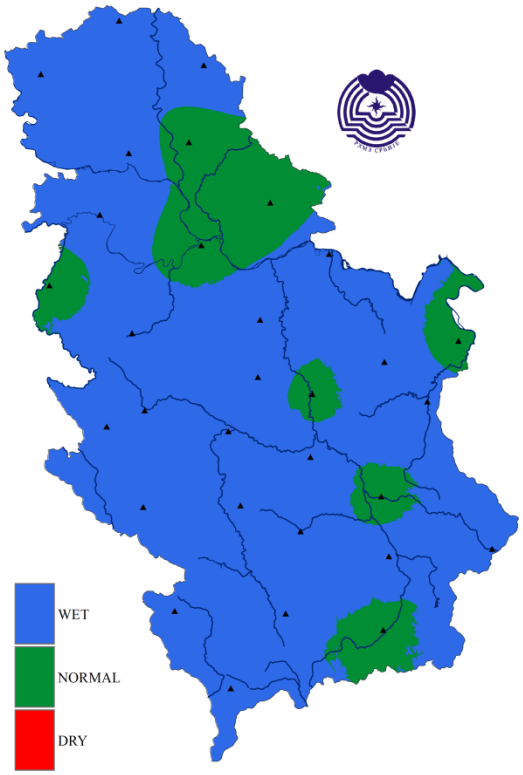

Figure D. Monitoring of the summer precipitation using tercile method relative to the 1981-2010 base period

Summer 2018			Air Temperature (°C)			
Station	Rank*	Rank**	33	50	66	Observed value
Beograd (1888-2018)	10	8	21.6	22.0	22.9	23.7
Palić (1945-2018)	7	7	20.9	21.3	21.9	22.9
Sombor (1942-2018)	10	7	20.6	21.0	21.3	22.6
Novi Sad (1948-2018)	10	8	20.8	21.0	21.6	22.5
Zrenjanin (1946-2018)	12	9	21.0	21.2	21.7	22.8
Kikinda (1948-2018)	11	9	20.8	21.3	21.7	22.6
Banatski Karlovac (1986-2018)	9	9	20.9	21.3	21.8	22.4
Loznica (1952-2018)	7	7	20.7	21.0	21.7	22.3
Sremska Mitrovica (1925-2018)	14	7	20.5	20.8	21.2	22.0
Valjevo (1926-2018)	16	10	20.5	20.9	21.6	22.0
Kragujevac (1925-2018)	20	10	20.6	21.2	21.6	21.9
Smederevska Palanka (1939-2018)	18	14	20.8	21.3	21.8	22.1
Veliko Gradište (1926-2018)	18	11	20.4	21.1	21.4	22.1
Crni Vrh (1967-2018)	9	10	15.9	16.3	16.6	17.1
Negotin (1927-2018)	15	10	22.0	22.7	23.1	**23.6**
Zlatibor (1950-2018)	21	18	16.3	16.8	17.3	17.2
Sjenica (1946-2018)	16	12	15.3	15.9	16.2	16.4
Pozega (1952-2018)	12	11	18.9	19.4	19.5	20.0
Kraljevo (1926-2018)	24	16	20.6	21.0	21.5	21.6
Kopaonik (1950-2018)	12	10	11.5	12.1	12.5	**12.9**
Kursumlija (1952-2018)	13	11	19.0	19.4	19.9	20.1
Krusevac (1927-2018)	25	16	20.7	21.1	21.5	21.6

Cuprija (1948-2018)	8	6	20.3	21.0	21.3	22.1
Nis (1925-2017)	20	11	21.2	21.9	22.2	22.5
Leskovac (1948-2018)	23	15	20.4	20.9	21.1	21.3
Zajecar (1929-2018)	32	22	20.9	21.8	22.0	21.6
Dimitrovgrad (1945-2018)	22	14	18.8	19.4	19.7	20.0
Vranje (1926-2018)	36	20	20.3	21.1	21.3	21.2

*Rank –period of stations work (warmest season)
**Rank – 1981-2018 period (warmest season)

Summer 2018			Precipitation sums (mm)			
Station	Rank*	Rank**	33	50	66	Observed Value
Beograd (1888-2018)	55	19	169.3	222.8	264.1	219.4
Palić (1945-2018)	19	9	161.4	197.6	219.0	230.9
Sombor (1942-2018)	7	3	180.2	187.8	215.1	305.8
Novi Sad (1948-2018)	11	8	174.5	187.8	236.8	295.6
Zrenjanin (1946-2018)	30	12	155.3	175.6	222.8	215.4
Kikinda (1948-2018)	3	3	152.4	174.9	205.7	322.2
Banatski Karlovac (1946-2018)	29	14	146.6	198.6	246.0	216.0
Loznica (1926-2018)	31	12	237.8	256.5	309.0	300.9
Sremska Mitrovica (1925-2018)	21	9	173.9	189.4	226.1	260.6
Valjevo (1926-2018)	17	8	214.0	233.9	286.7	326.2
Kragujevac (1925-2018)	21	7	154.8	195.4	230.6	246.8
Smederevska Palanka (1939-2018)	4	2	168.2	201.5	231.6	342.1
Veliko Gradište (1926-2018)	10	5	129.4	173.9	238.6	324.0

Crni Vrh (1967-2018)	4	1	169.4	196.9	249.3	396.7
Negotin (1927-2018)	26	13	105.8	138.2	188.9	175.0
Zlatibor (1950-2018)	2	2	230.7	288.4	313.0	530.3
Sjenica (1946-2018)	4	1	191.2	213.6	229.3	415.3
Pozega (1952-2018)	5	1	178.0	218.5	238.1	381.0
Kraljevo (1926-2018)	3	1	209.6	244.4	272.7	439.3
Kopaonik (1950-2018)	6	2	224.1	279.6	323.8	456.7
Kursumlija (1952-2018)	10	4	129.2	175.7	208.0	262.4
Krusevac (1927-2018)	5	1	137.0	172.5	209.9	321.7
Cuprija (1948-2018)	35	15	143.8	185.8	204.9	199.8
Nis (1925-2018)	40	15	125.9	150.2	178.7	159.1
Leskovac (1948-2018)	17	7	126.2	150.3	179.6	217.5
Zajecar (1929-2018)	37	12	115.7	156.2	172.8	175.9
Dimitrovgrad (1945-2018)	22	8	150.2	175.7	203.5	237.9
Vranje (1926-2018)	39	14	112.0	144.3	179.9	150.9

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

**Rank – 1981-2018 period (highest seasonal precipitation)

Country	Seasonal temperature JJA		Seasonal precipitation JJA		High Impact Events
	Observed	SEECOF-19 climate outlook for temperature	Observed	SEECOF-19 climate outlook for precipitation	
Serbia (1)	Above normal in almost entire Serbia	**Above-normal** (10, 20, 70) in entire Serbia	Above normal in most of Serbia, except in north-eastern part	**Below-normal** (45, 35 20) in entire Serbia	* **Summer 2018** The 10th warmest summer for Belgrade. The 6th wettest summer for Serbia. The warmest summer for Serbia based on the minimum air temperature. There were 74 days with apparent temperature above 30 degrees, which is 7 days more compared to the previous summer which ranked as the second warmest since 1951 up to date. * **June** The second wettest June for Zlatibor, third wettest for Veliko Gradiste. On June 30, Novi Sad observed record-breaking daily precipitation sum for June. Sjenica registered 27 rainy days, thereby breaking the previous record * **July** 7th wettest July for Serbia, wettest on record for Kraljevo, 2nd wettest for Pozega, Sjenica and Kopaonik. Record-breaking number of days with precipitation above 0.1 mm registered at 6 MMS. * **August** August 2018 was the 3rd warmest for Palic and 4th warmest for Banatski Karlovac. The wettest August on record for Crni Vrh. Record-breaking daily precipitation sums in Zrenjanin and Crni Vrh. The number of tropical nights was surpassed in Sombor, Palic and Belgrade.

SEASONAL BULLETIN FOR SERBIA - SUMMER 2018

Warm and rainy, humid summer. The 10th warmest summer for Belgrade. The 6th wettest summer for Serbia. The warmest summer for Serbia based on the minimum air temperature. There were 74 days with apparent temperature above 30 degrees, which is 7 days more compared to the previous summer which ranked as the second warmest since 1951 up to date. Record-breaking number of days with precipitation in Sjenica and Kopaonik. Record-breaking number of summer thunder days at Zlatibor, Sjenica, Leskovac, Kursumlija, Zrenjanin, Krusevac and Kragujevac.

Analysis of the 2018 summer season for Serbia relative to the 1981-2010 base period

Temperature

The mean summer air temperature ranged from 20.0°C in Pozega and Dimitrovgrad to 23.7°C in Belgrade, and on the mountains from 12.9°C at Kopaonik to 17.2°C at Zlatibor (*Figure 1*).

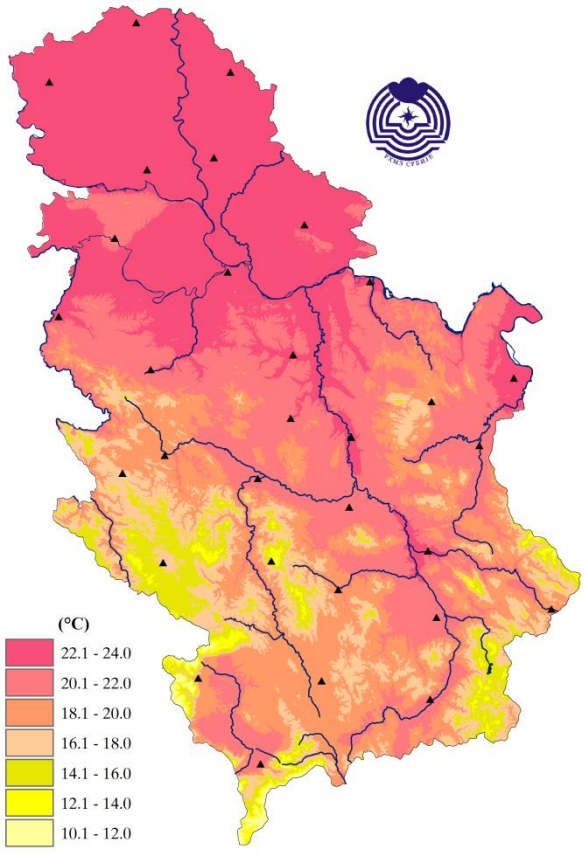

Figure 1. Spatial distribution of the mean seasonal air temperature (°C) during summer

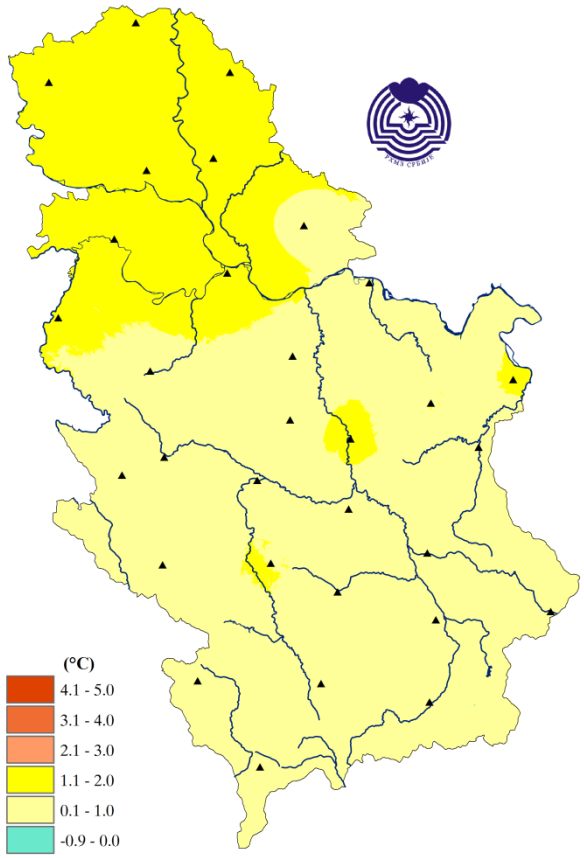

Figure 2. Mean seasonal air temperature anomaly in Serbia during summer relative to the 1981-2010 base period

Departure of the mean air temperature from the normal[1], in summer ranged from 0.1ºC in Zajecar to 1.5ºC in Sombor and Palic, and on the mountains from 0.4°C at Zlatibor to 0.9°C at Kopaonik and Crni Vrh (*Figure 2*).

Based on the percentile method[2], mean summer air temperature was in the categories of very warm and warm in most of the country, and normal category in some parts of the western, central, eastern and southern Serbia (*Figure 3*).

Based on the tercile method, mean summer air temperature was in the warm category in most of Serbia, apart from eastern, western and southern parts of the country where it fell under the normal category (*Figure 4).*

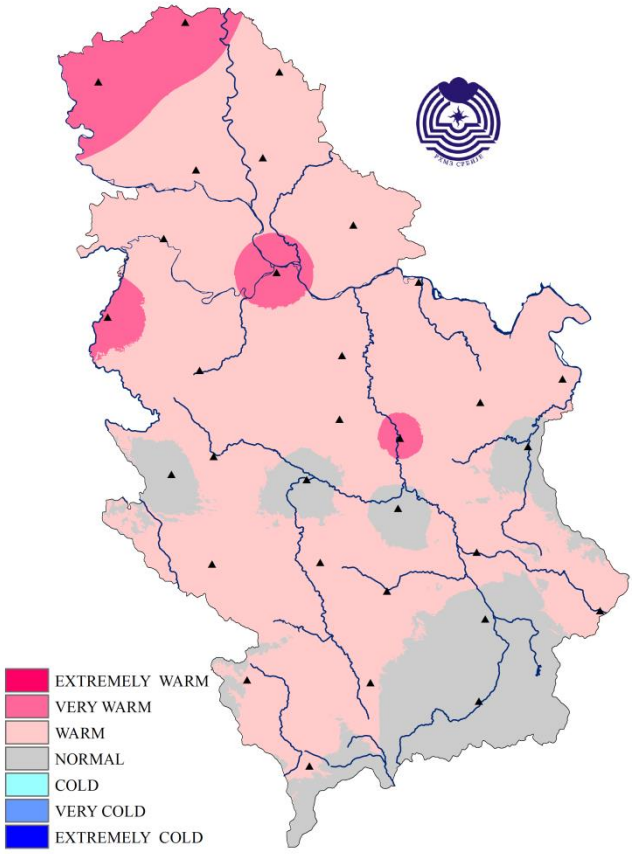

Figure 3. Air temperature assessment in Serbia during summer using percentile method compared to the 1981-2010 base period

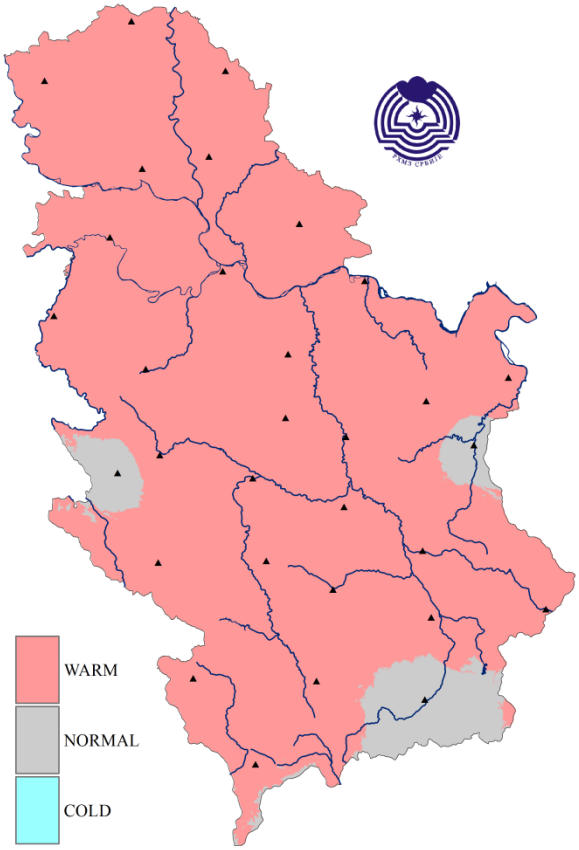

Figure 4. Air temperature assessment in Serbia during summer using tercile method compared to the 1981-2010 base period

Summer 2018 ranks as the 13th warmest for Serbia with the mean air temperature of 21.1°C. The warmest summer in Serbia was the summer of 2012, with the mean air temperature of 23.3°C (*Figure 5*). Belgrade observed its 10th warmest summer since 1888 with the mean air temperature of 23,7°C and the warmest summer on record for Belgrade was registered in 2012 with the mean air temperature of 26.0°C (*Figure 6*).

[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] nth 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

The summer of 2018 was the 7th warmest for Loznica and Palic, 8th warmest for Cuprija, 9th warmest for Banatski Karlovac and Crni Vrh.

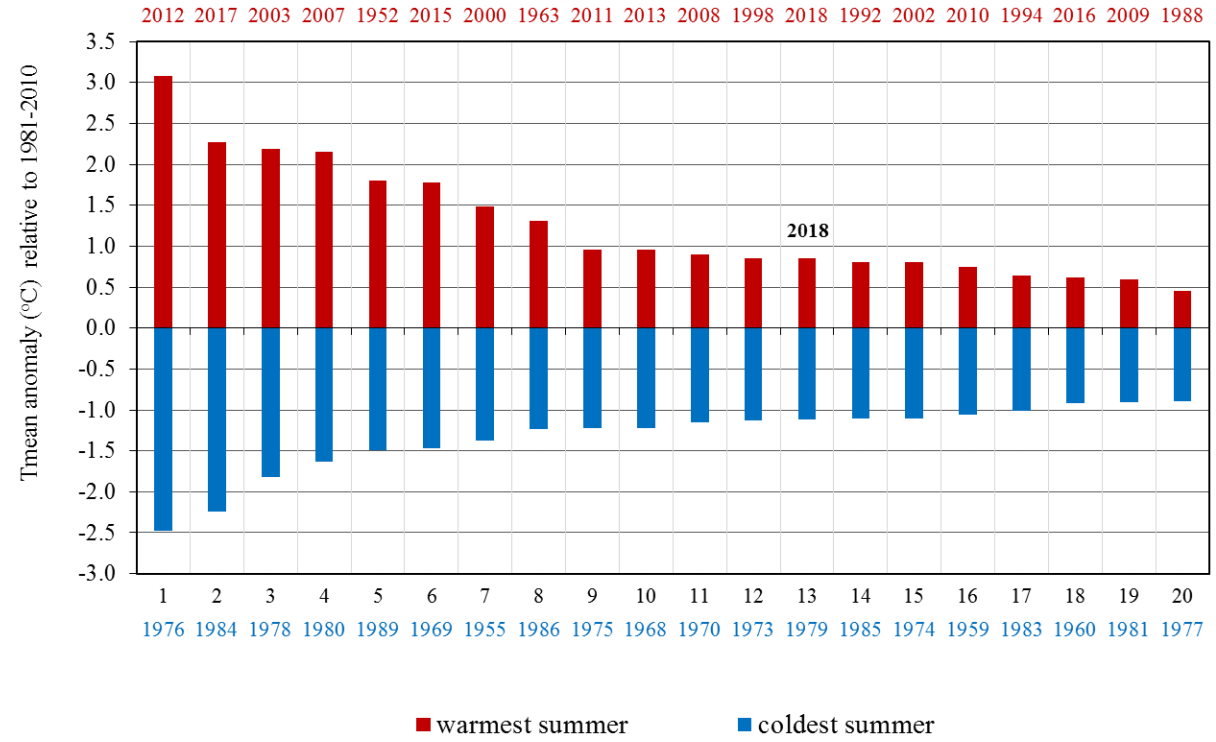

Figure 5. Rank of the warmest and coldest summer seasons in Serbia for the 1951-2018 period relative to the 1981-2010 period

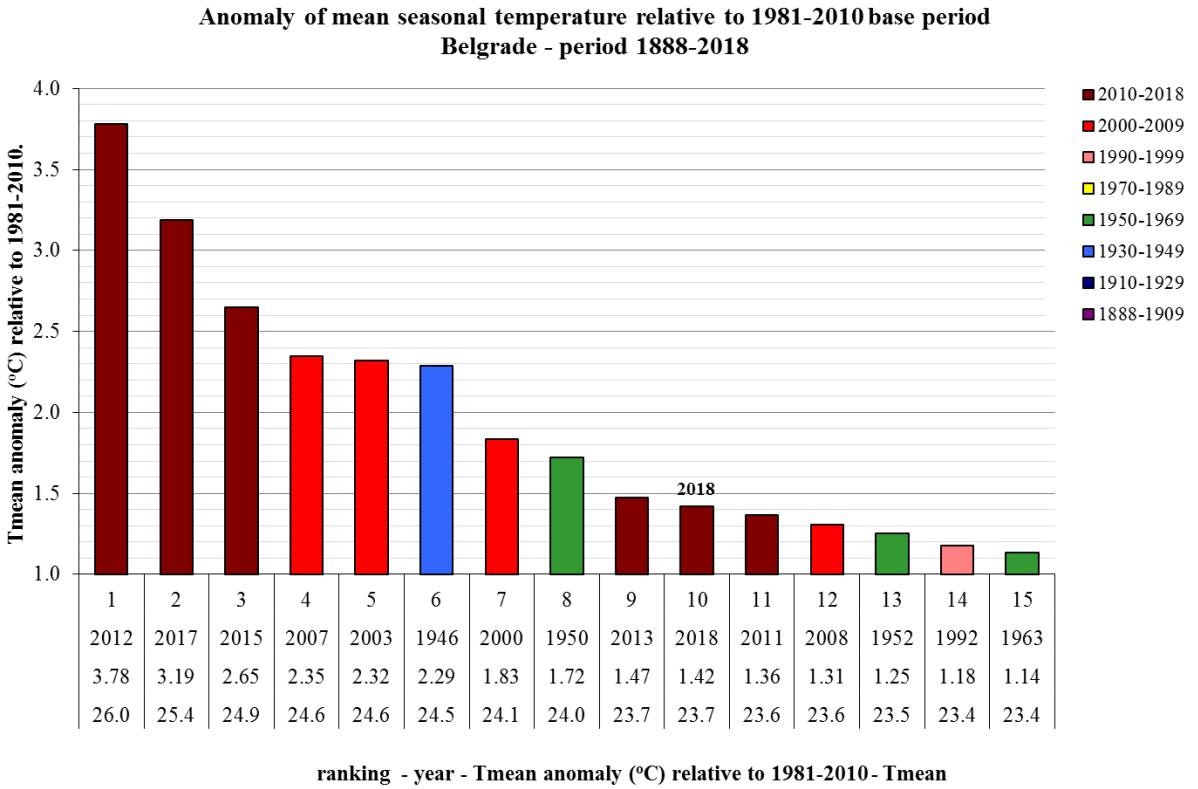

Figure 6. Rank of the warmest summer seasons in Belgrade for the 1888-2018 period

The number of summer days[3] ranged from 69 days in Valjevo and Pozega to 87 days in Negotin, which is 12 days above the average. In the mountains, their number ranged from 0 at Kopaonik to 34 in Sjenica. Belgrade observed 76 summer days, which is 8 days above the average (*Figure 7*).

The number of tropical days[4] ranged from 22 days in Pozega to 58 days in Negotin, which is 18 days above the average. In the upland, there weren't any tropical days recorded. Belgrade observed 39 tropical days, which is 7 days above the average (*Figure 8*).

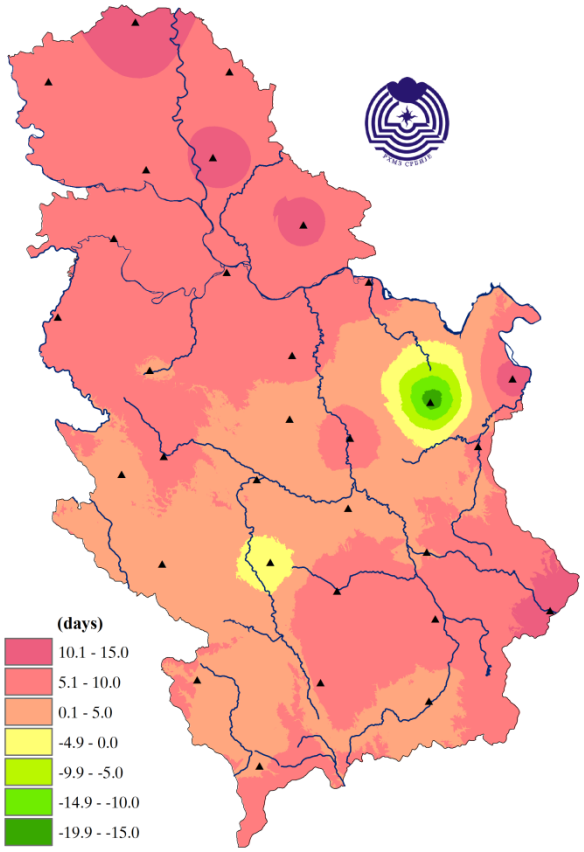

Figure 7. Deviation of the number of summer days compared to the normal 1981-2010

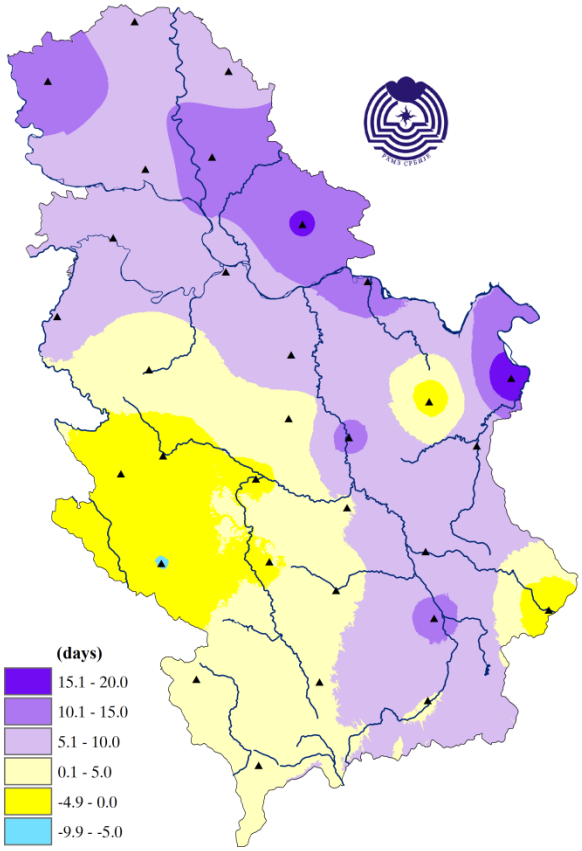

Figure 8. Deviation of the number of tropical days during summer compared to the normal 1981-2010

The highest number of tropical nights[5] , total of 40, was recorded in Belgrade, which is 24 days above the average for Belgrade. The number of tropical nights was the following: Negotin observed 15 days and Palic observed 12 tropical nights which is 8 and 6 nights above the average for these stations, respectively. Rest of the country saw up to 9 days, whereas Smederevska Palanka, Pozega, Kraljevo, Kuršumlija, Leskovac, Zajecar, Dimitrivgrad, Vranje and on the mountains there weren't any tropical nights.

[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 35.4°C was measured in Kraljevo on June 12.

The lowest summer air temperature of 1.1°C was measured in Sjenica on June 24.

During most of the summer, mean, maximum and minimum daily air temperature was above the multiannual average. Summer periods were observed in the first half of June and nearly entire August, briefly interrupted with abrupt change given the incursion of the cold air mass in August 27. The last decade of June and the beginning of July was marked by colder period (*Figure 9*).

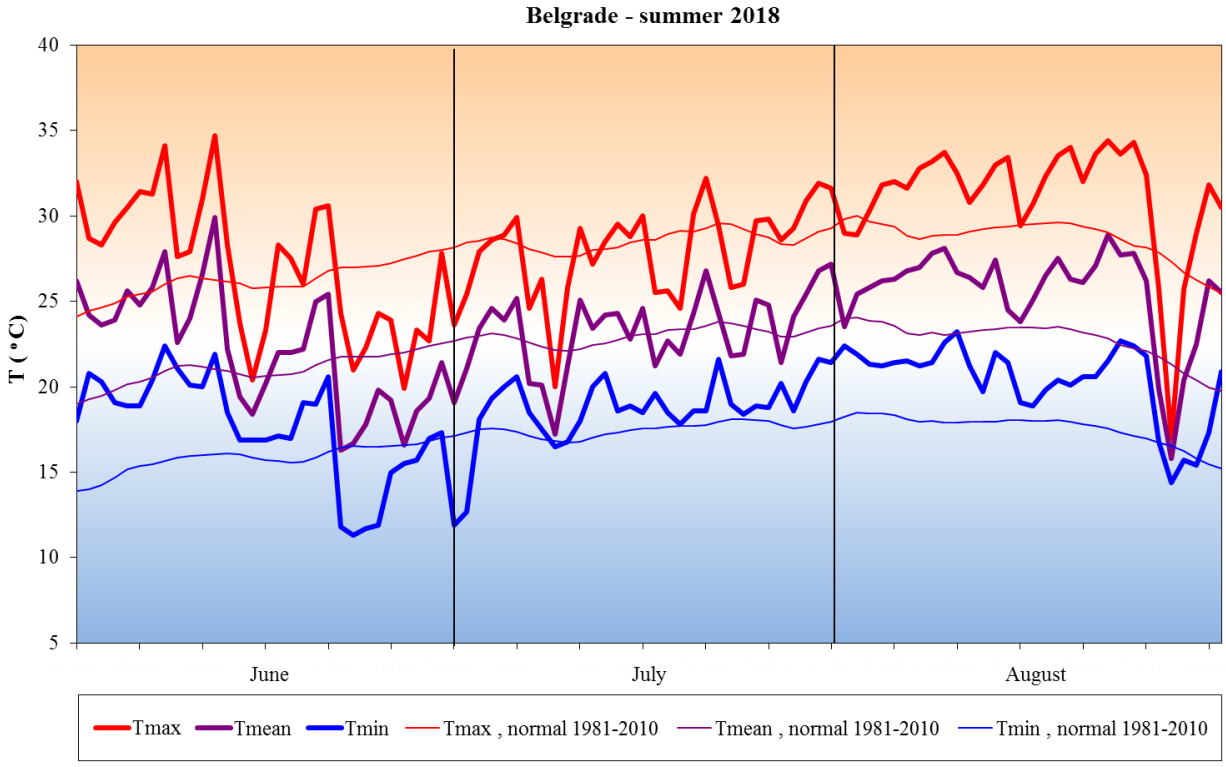

Figure 9. Three-month course of the mean, maximum and minimum air temperature in Belgrade

Figures 10 and 11 show three-month course of the mean daily air temperature during summer for Belgrade and Kopaonik.

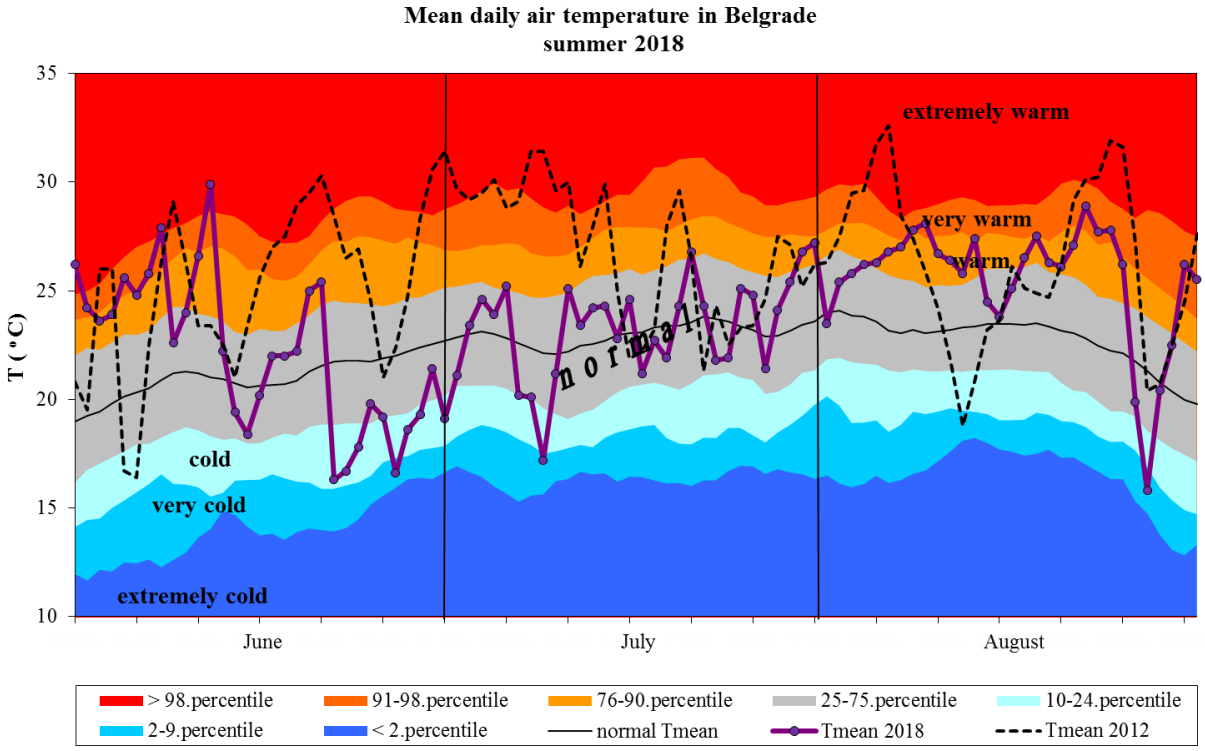

Figure 10. Three-month course of the mean daily air temperature for Belgrade

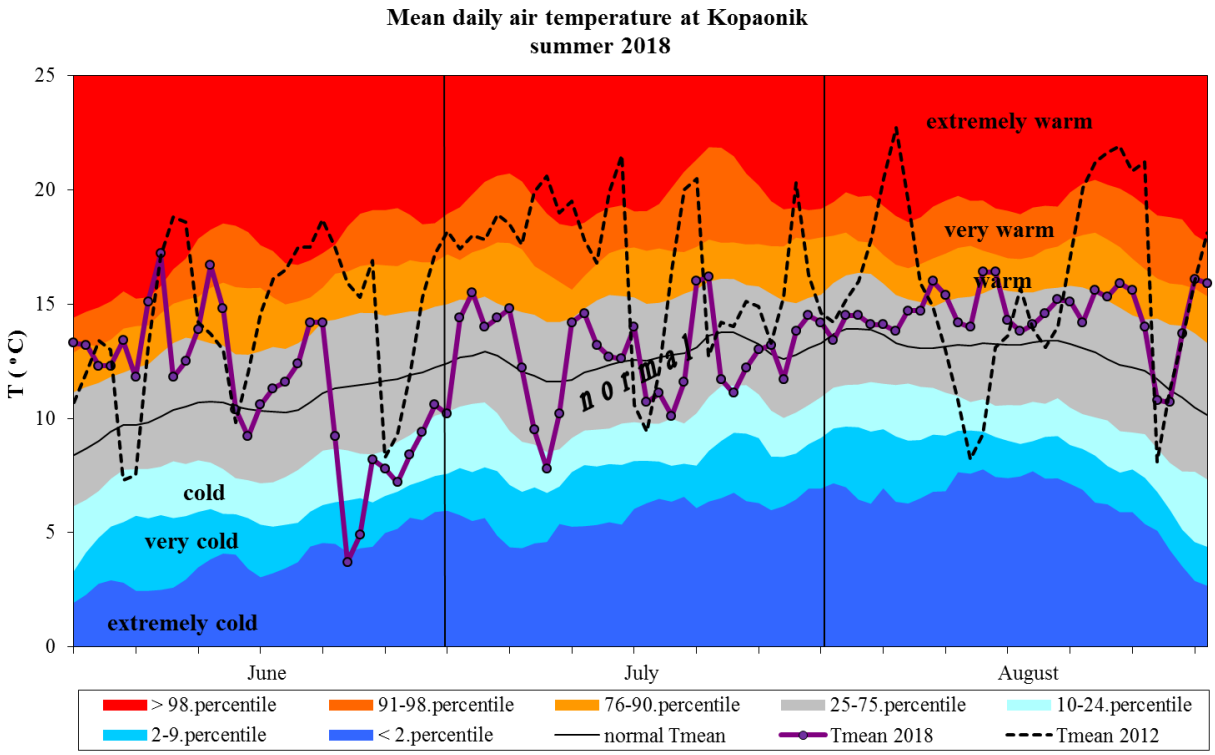

Figure 11. Three-month course of the mean daily air temperature for Kopaonik

Figure 12 shows assessment of the mean air temperature and precipitations sums in Serbia for summer season (June, July and August) based on the tercile distribution relative to the 1981-2010 base period. Summer 2018 was characterized by **warm and rainy conditions**, that is air temperature and precipitation were in the upper tercile. Based on the minimum air temperature (*Figure 13), this summer was the warmest on record.*

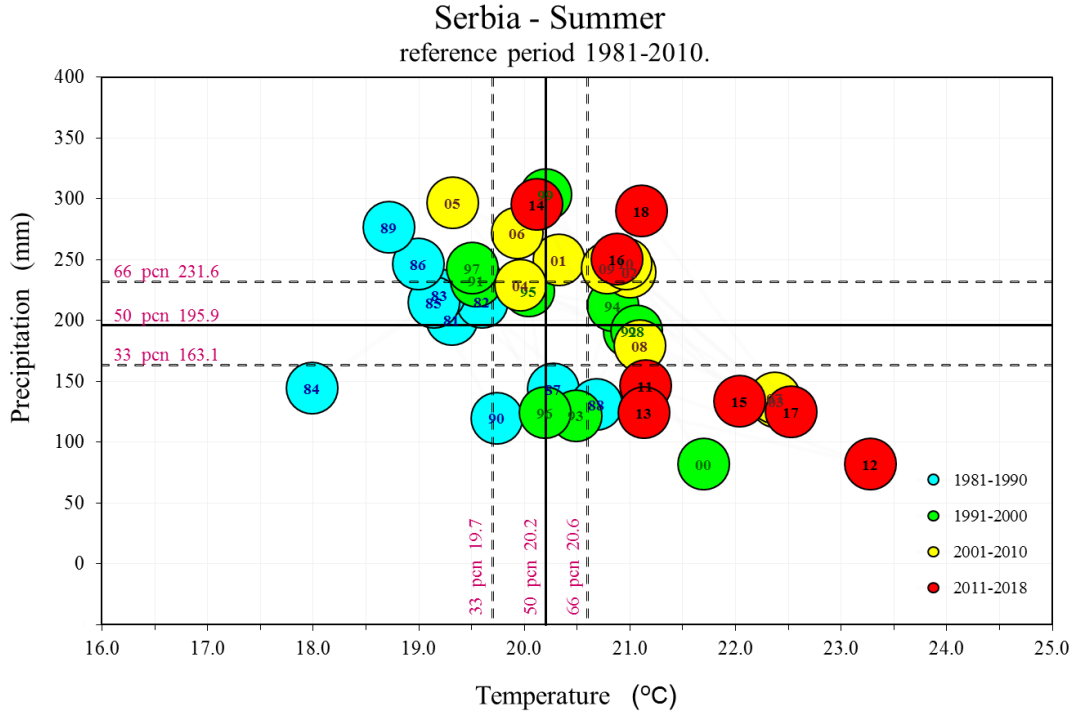

Figure 12. Assessment of **mean** air temperature and precipitation for summer in Serbia with the accompanying terciles relative to the 1981-2010 base period

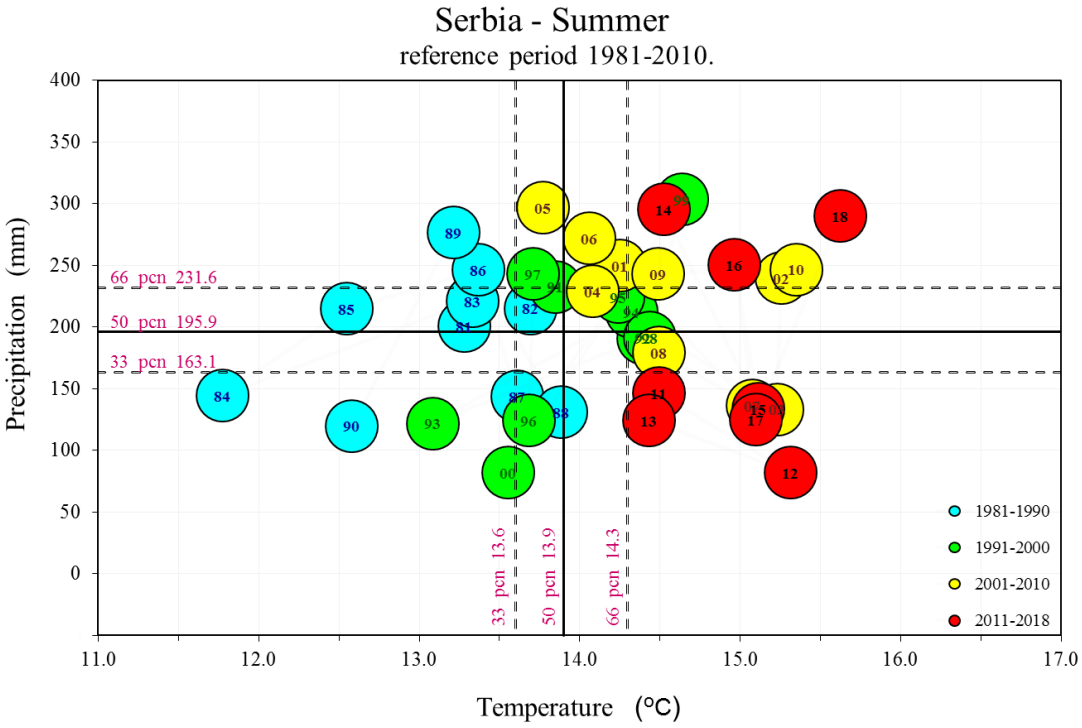

Figure 13. Assessment of the **minimum** air temperature and precipitation sums for summer in Serbia with the accompanying terciles relative to the 1981-2010 base period

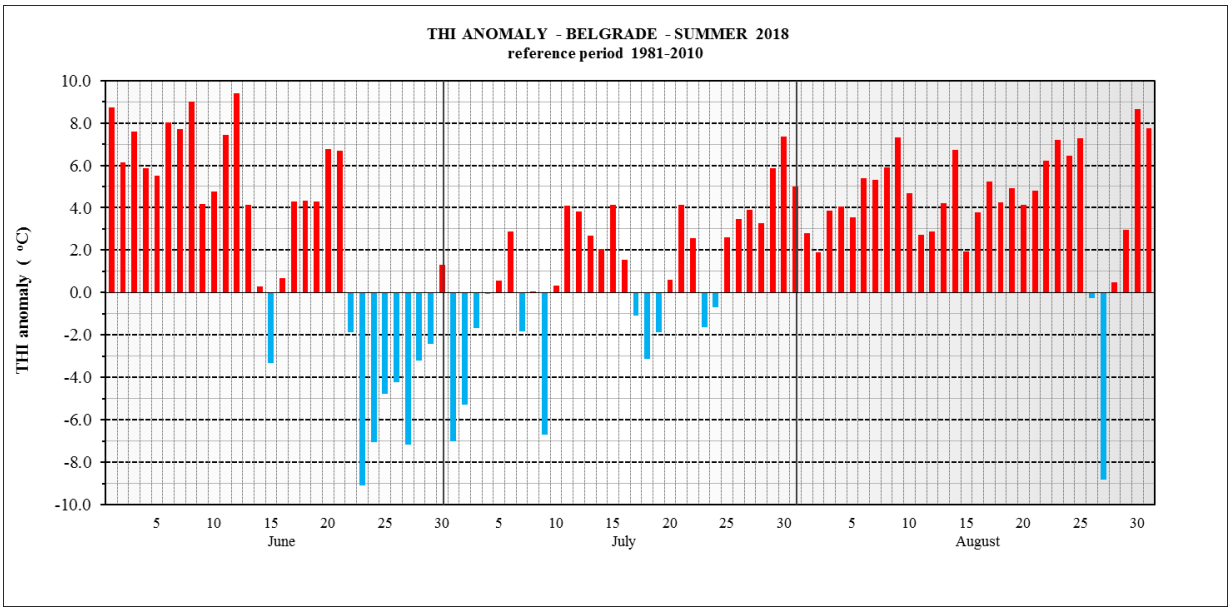

Figure 14.

Departure of the Temperature Heat Index (THI)[6] was positive most of the summer (Figure 14). The greatest difference between the apparent temperature (feels like temperature) and the maximum daily air temperature was observed at the end of July and the beginning of August (Figure 15), measuring 8.1°C on July 30. The maximum air temperature of 31.9°C was measured that day, nevertheless the feels like temperature was 40.0°C which is at the same time the highest summer 2018 value.

There were in total 74 days with THI above 30°C, which is 7 days more compared to the previous summer, which ranked as the second warmest on record since 1951 up to date.

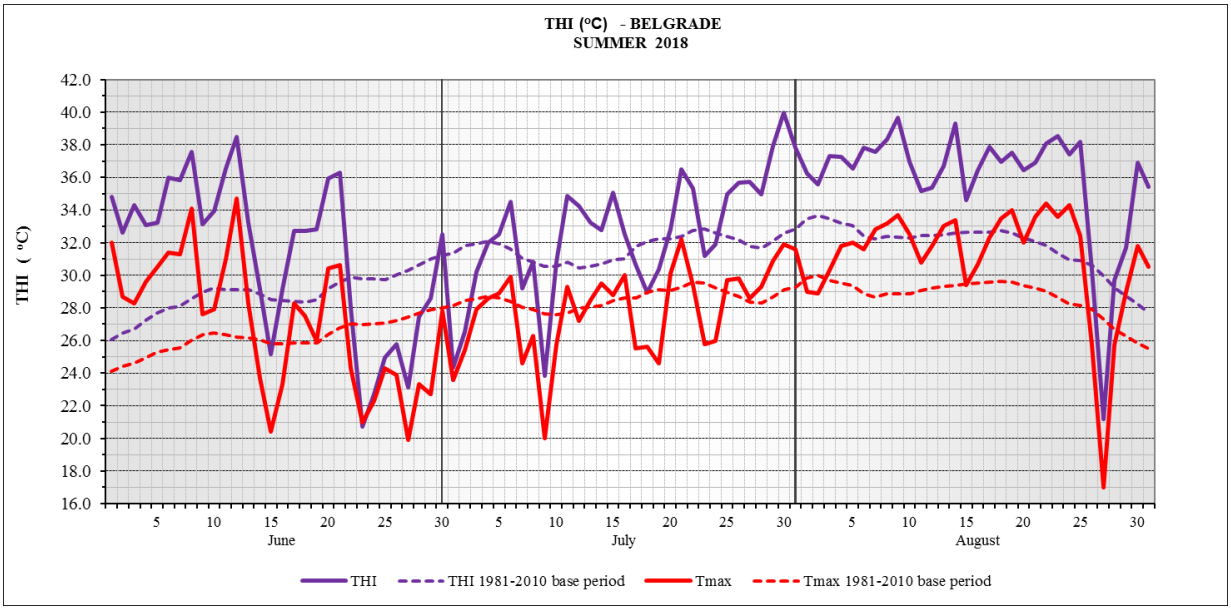

Figure 15.

[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.

Precipitation

In entire Serbia, summer precipitations sums were above average relative to the normal for the 1981-2010 base period. Precipitations sums relative to the normal ranged from 102% in Vranje to 203% in Sjenica (*Figure 17*). The seasonal precipitation totals ranged from 150.9 mm in Vranje to 530.3 mm at Zlatibor (*Figure 16*).

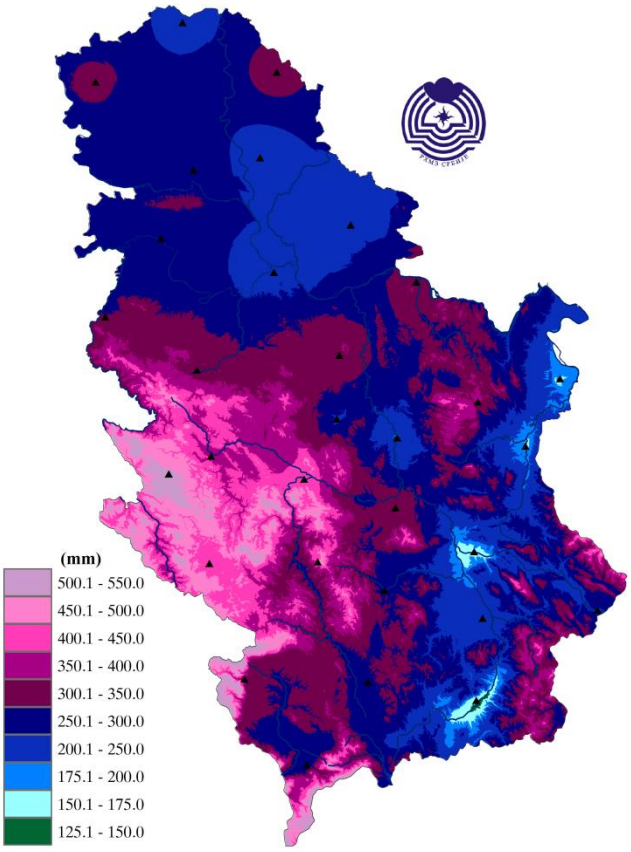

Figure 16. Spatial distribution of the precipitation sums during summer expressed in mm for the 1981-2010 base period

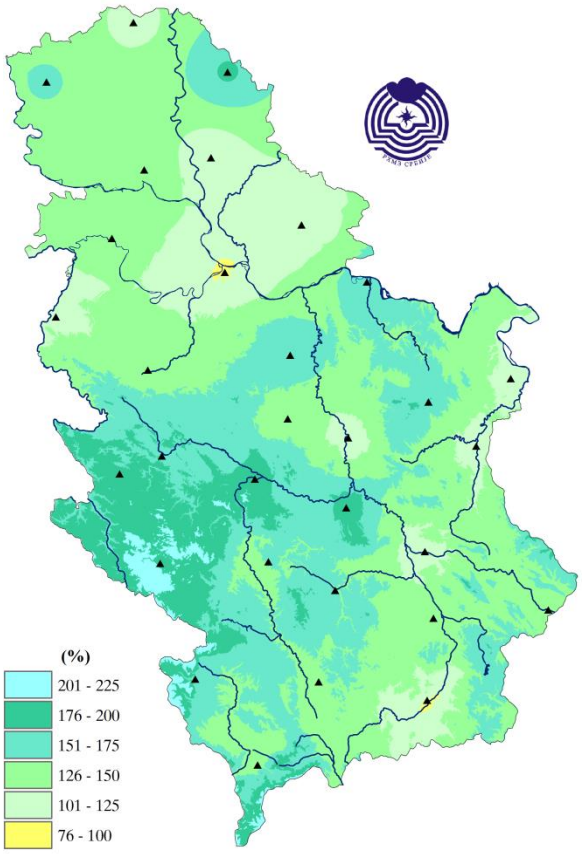

Figure 17. Spatial distribution of the precipitation sums during summer expressed in the percentages of normal for the 1981-2010 base period

Based on the percentile method, summer precipitation sums were in the following categories: rainy and normal in most of Serbia, extremely rainy and very rainy in parts of northern, western and central Serbia (*Figure 18*).

Based on the tercile method, precipitation sums were above the average in most of Serbia, and in the normal category in eastern, southern and some parts of northeast and west (*Figure 19*).

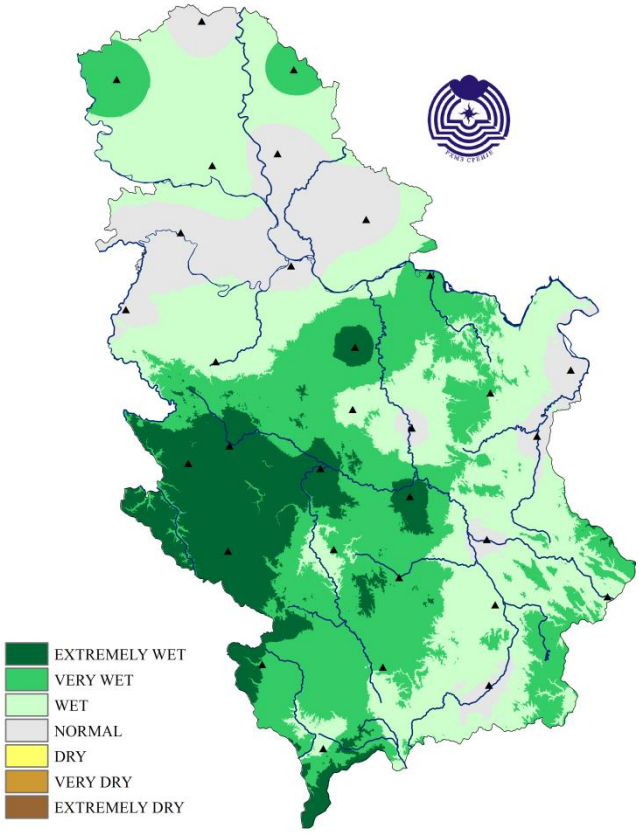

Figure 18. Assessment of the precipitation sums based on the percentile method during summer relative to the 1981-2010 base period

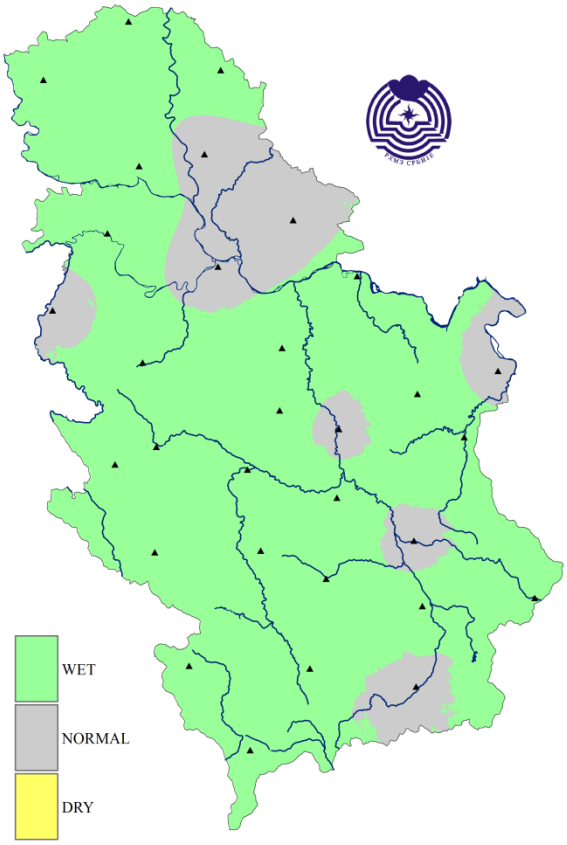

Figure 19. Assessment of the precipitation sums based on the tercile method during summer relative to the 1981-2010 base period

The maximum daily precipitation sums of 132.5 mm was registered at Crni Vrh on July 2, thereby besting the previous summer record of 100.7 mm set in 1969, on June 15. Record-breaking daily precipitation sums were also observed in Novi Sad (on June 30) and Zrenjanin (4 July), with 116.2 mm and 80.7 mm of precipitation, respectively. In Zrenjanin, the previous record of 91.6 mm was set on 10 July 1967 whereas in Banatski Karlovac, the previous record of 75.1 mm was set on 10 July 1999.

The number of days with precipitation was above summer average in the entire country. The fewest number of days with precipitation was observed in Negotin, total of 30 days whilst Sjenica recorded the highest number of days, total of 61, which is 25 days above the average (*Figure 20*), thereby breaking the previous record of 55 days from 2014. Maximum number of days with precipitation, total of 58 days, was exceeded at Kopaonik (53 days from 1955) and Zlatibor with 57 days which equals the previous record from 1989.

The number of thunder days was above the average in the entire country (*Figure 21).* The fewest number of thunder days was registered in Banatski Karlovac, total of 21 days (3 days above the average) and the highest number was observed at Zlatibor, total of 46 days (23 days above the average). Record-breaking number of thunder days in summer was observed in the following places: Zlatibor with 46 days (40 days from 1959), Sjenica with 44 days (38 days from 1972), Leskovac with 43 days (41 days from 1975), Kursumlija with 38 days (35 days from 1966), Zrenjaninu with 37 days (31 day from 1975), Krusevac with 33 days (29 days from 1972 and 1975), Kragujevac with 32 days (27 days from 1938). Kopaonik observed 34 days thunder days which equals the previous record set in 1986.

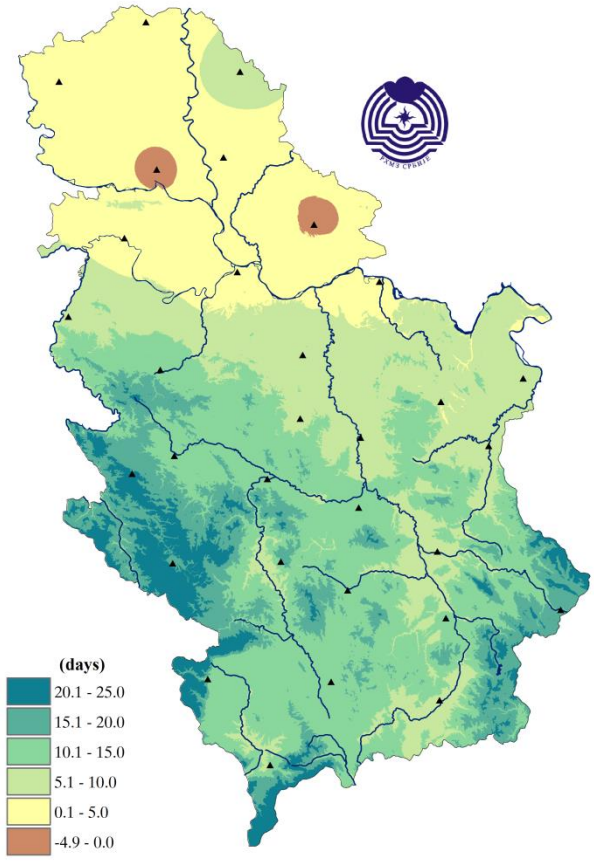

Figure 20. Deviation of the average number of days with precipitation of 1 mm and above during summer

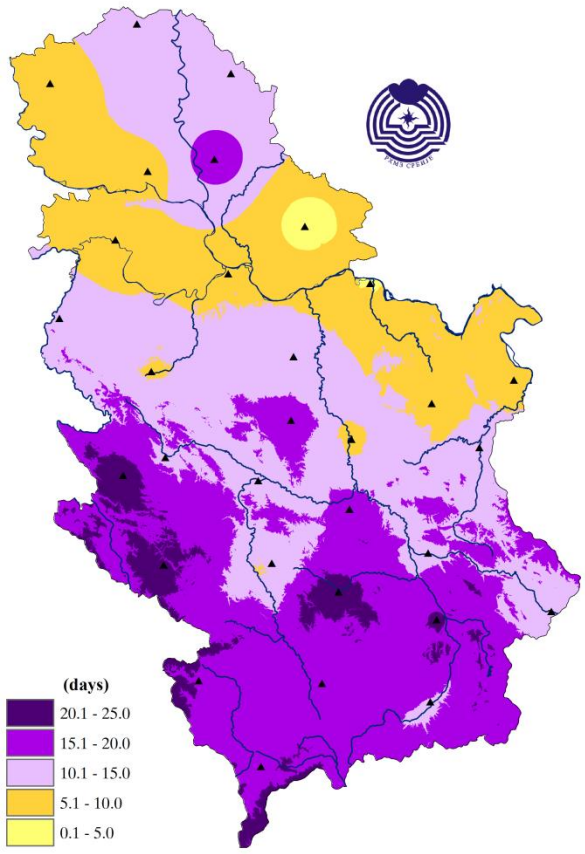

Figure 21. Deviation of the average number of days with thunder during summer

Based on the analysis of the wettest and driest summer seasons in Serbia for the 1951-2018 period, it can be concluded that summer 2018 ranked as the 6th wettest summer for Serbia (*Figure 22*).

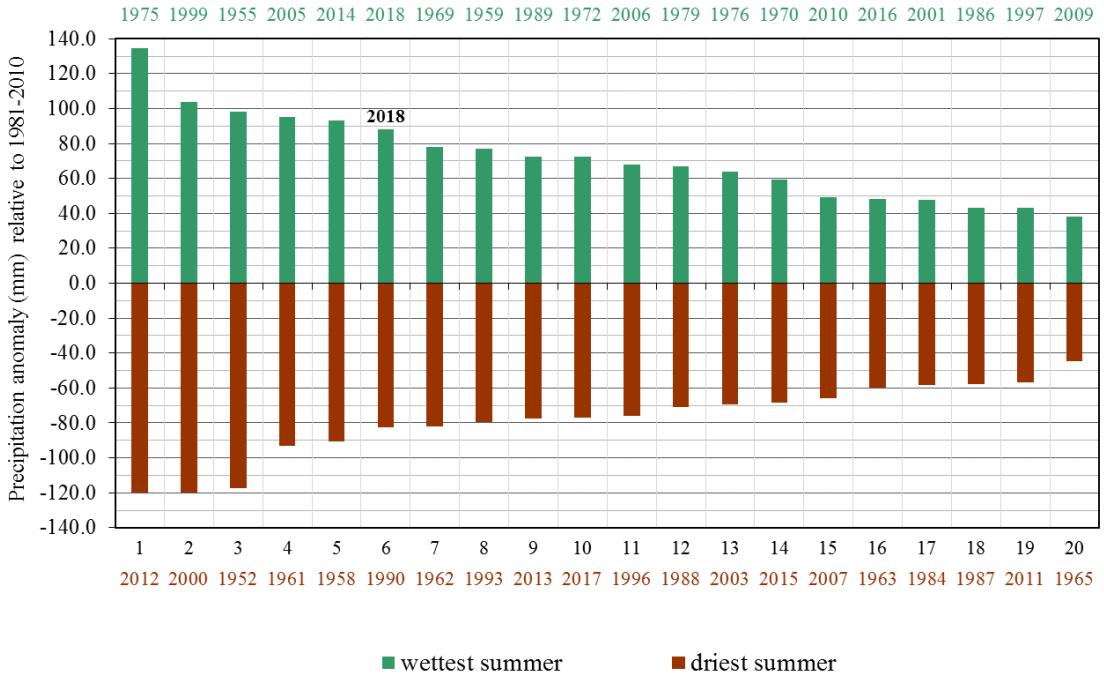

Figure 22. Rank of the wettest and driest summers for Serbia for the 1951-2018 period relative to 1981-2010 base period

Zlatibor observed its second wettest summer only behind summer of 1989 (*Figure 23*). Summer of 2018 was the third wettest summer for Kikinda and Kraljevo, in the period from 1925 to 2018.

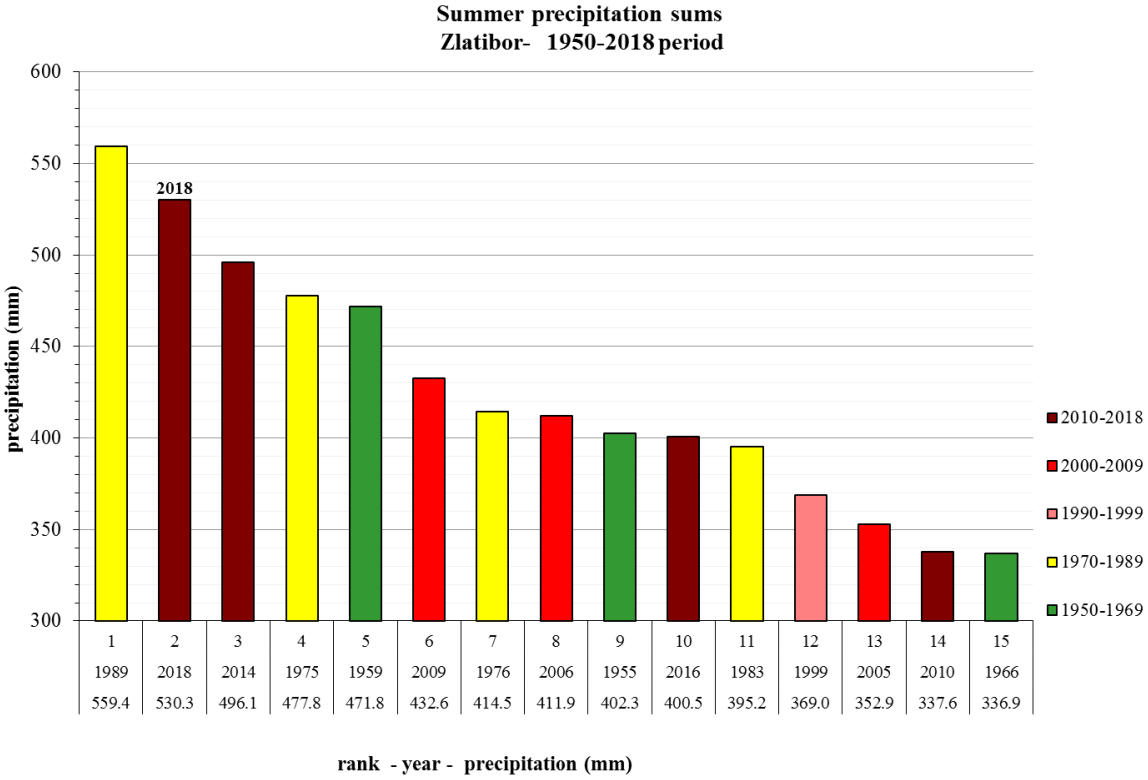

Figure 23. Summer precipitation sums for Zlatibor in the 1950-2018 period in the ascending order (15 years out of series with the highest summer precipitation sums)

Figure 24 shows cumulative precipitation sums per month for Sjenica during summer relative to the average cumulative precipitation sums

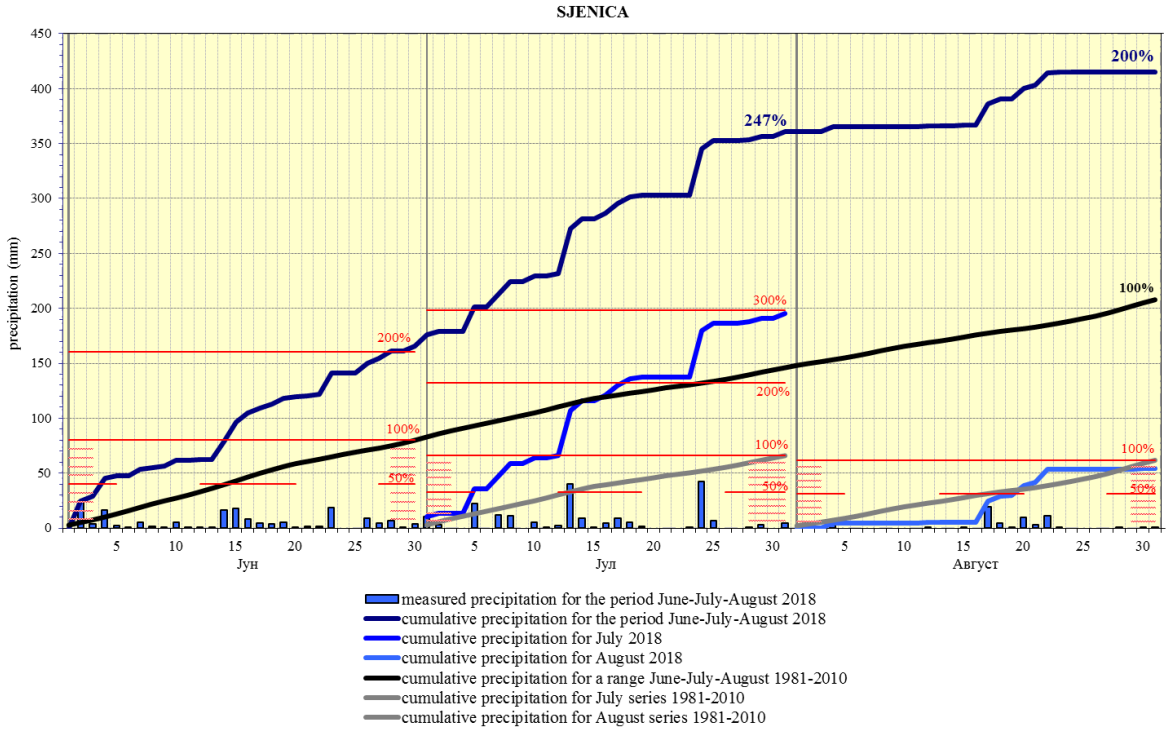

Figure 24. Cumulative precipitation sums in Sjenica

Cloud cover, bright and cloudy days

Mean summer cloud cover in the lowland ranged from 4/10 in Negotin (*Figure 25*) to 6/10 in Pozega, and in the hilly-mountainous regions, at Zlatibor, Kopaonik and Sjenici (*Figure 26*) it was 6/10. In Banatski Karlovac, the maximum mean summer cover cloud was exceeded.

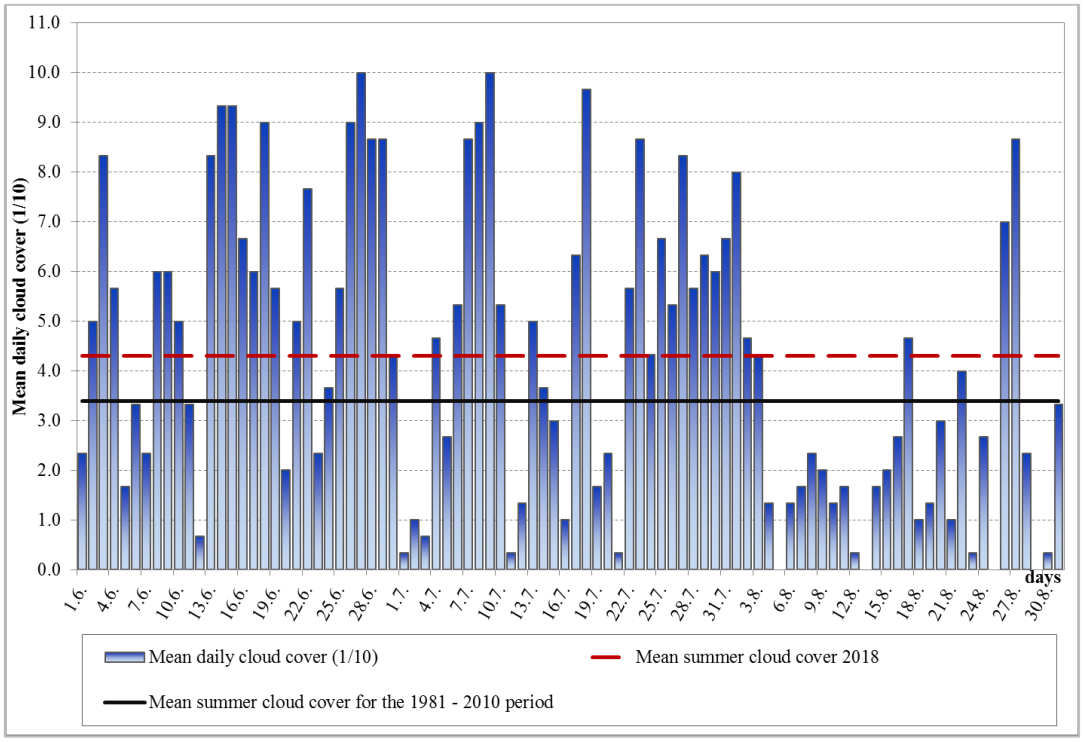

Figure 25. Mean daily cloud cover in Negotin

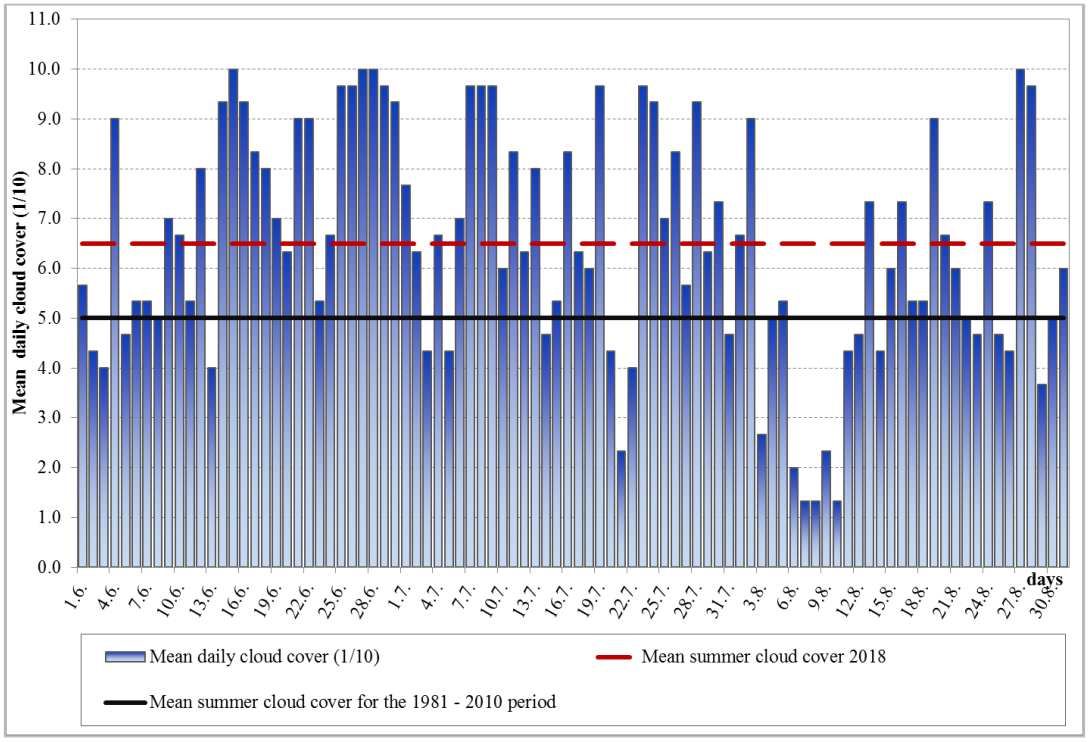

Figure 26. Mean daily cloud cover in Sjenica

During summer, the number of bright days in the lowland ranged from 1 in Pozarevac to 26 days in Negotin, and on the mountains from 3 in Sjenica to 15 at Crni Vrh. The observed number of bright days was 6 to 20 days below the summer average for the entire country (*Figure 27*). The summer minimum of the number of bright days (21 day from 1997) was surpassed in Banatski Karlovac where there was 13 bright days, Novi Sad and Zrenjanin reached the current minimum, with 10 and 18, respectively.

The number of cloudy days in summer ranged from 13 days in Kikinda, to 25 days in Kragujevac, Pozega and Kraljevo. Mountains saw 28 cloudy days (Kopaonik). In summer 2018 there were 2 to 12 days above average (*Figure 28*). The summer maximum of number of cloudy days was exceeded in Kursumlija with 20 days (the previous maximum was 19 days from 1979) and Banatski Karlovac with 18 days (the previous maximum was 17 days, from 1986, 1989 and 1999).

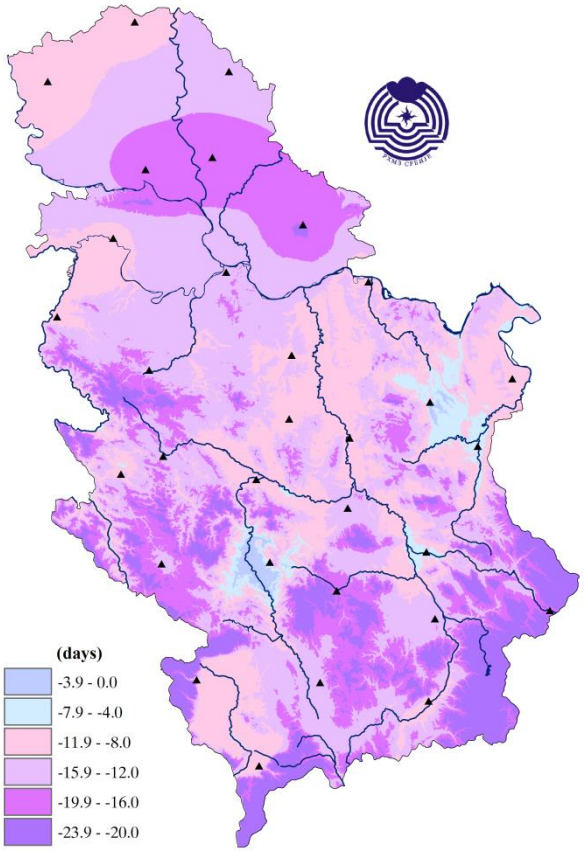

Figure 27. Deviation of the average number number of bright days during summer 2018

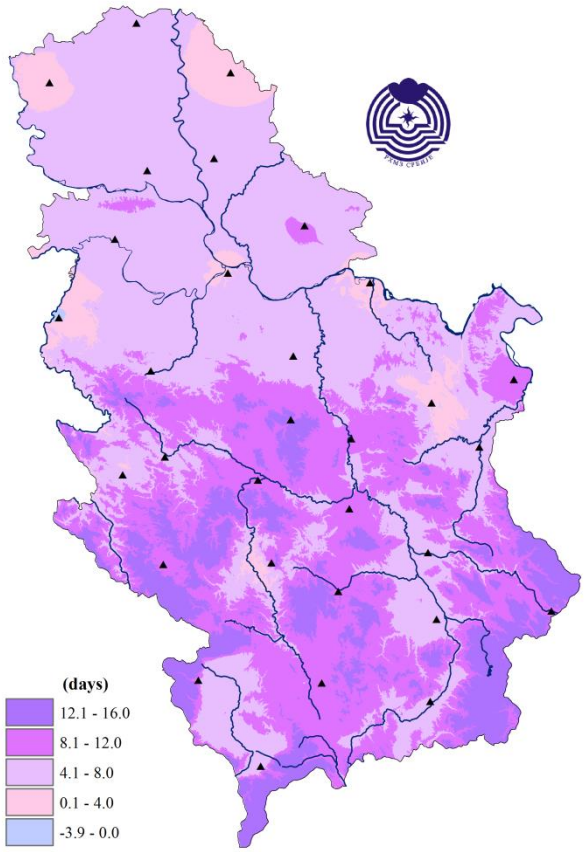

Figure 28. Deviation of the average number of cloudy days during summer 2018

Sunshine duration (insolation)

Sunshine duration in summer was below the average in most of Serbia aside from Sombor. Insolation values were in a range from 524.2 hours in Sjenica to 848.5 hours in Negotin (*Figure 29)*. The minimum insolation values were surpassed in the following places: Sjenica with 524,2 hours (previously 570.7 hours from 1959), at Kopaonik with 524.2 hours (previously 638.6 hours from 1989), Zajecar with 524.2 hours (previously 666.0 hours from 2002) and Banatski Karlovac with 524.2 hours (previously 773.1 hours from 1991).

In relation to the normal for the 1981-2010, insolation was in a range from 71% in Sjenica to 101% in Sombor (*Figure 30*).

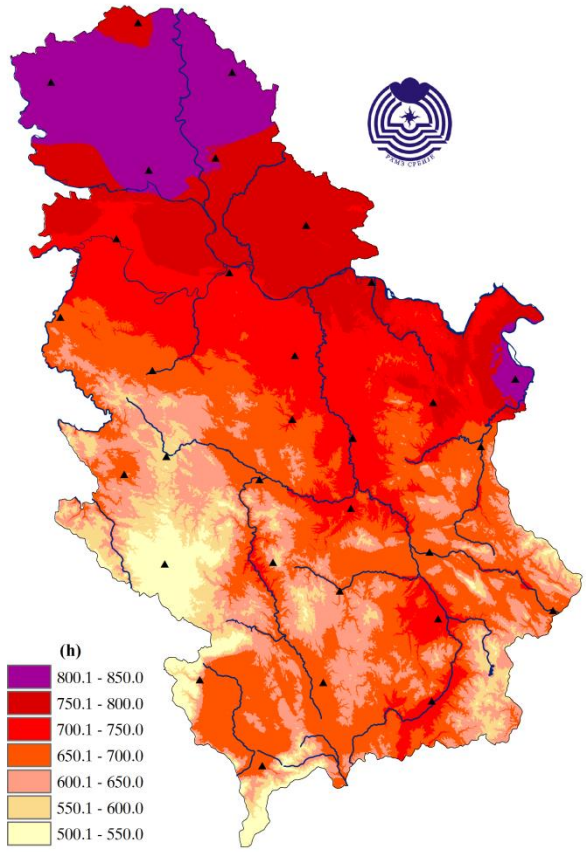

Figure 29. Insolation expressed in hours during summer

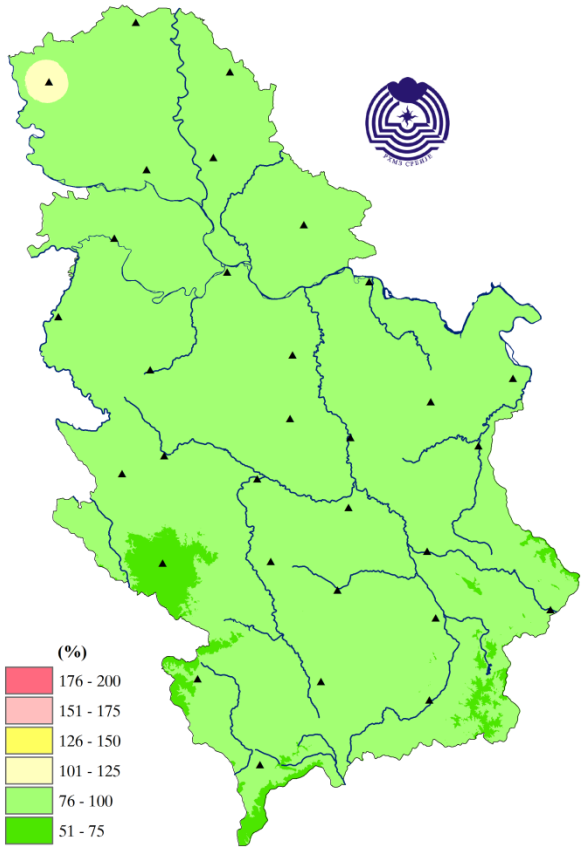

Figure 30. Insolation expressed in the percentages of normal during summer

Analysis of the 2018 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 1.2ºC in Vranje to 2.7ºC at Palic, and on the mountains from 1.5°C at Zlatibor to 2.3°C at Kopaonik (*Figure 31*).

Based on the percentile method, mean air temperature was in the categories of extremely warm and very warm across entire Serbia (*Figure 32).*

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

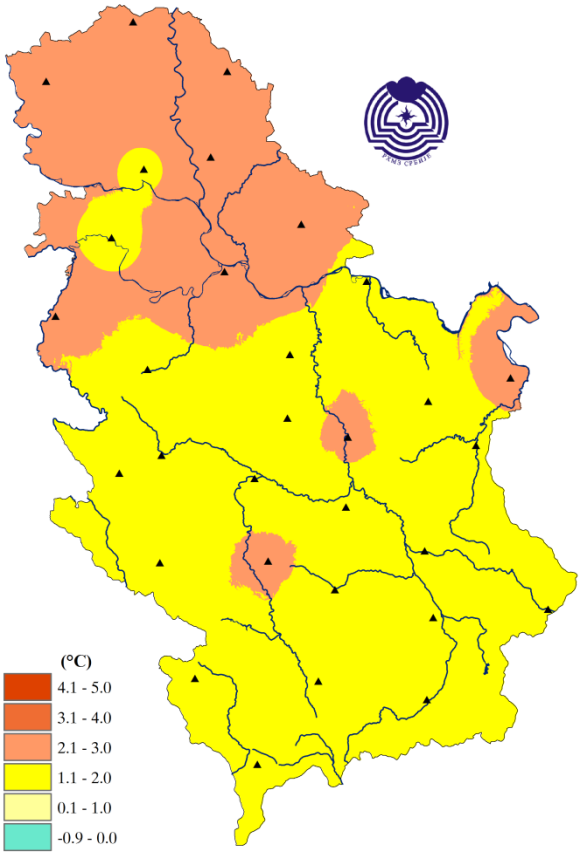

Figure 31. Seasonal mean air temperature anomaly relative to the 1961-1990 base period

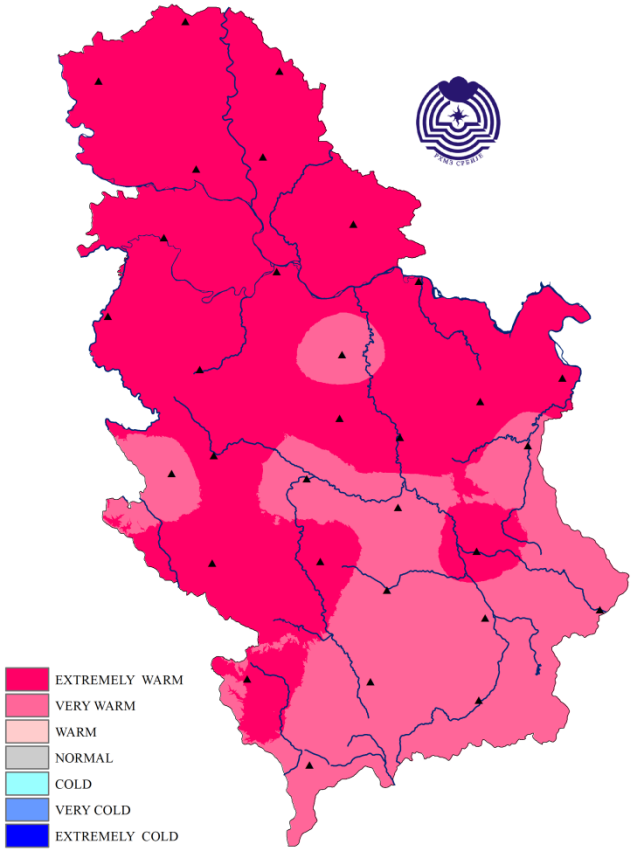

Figure 32. Assessment of the air temperature in Serbia using percentile method relative to the 1961-1990 base period

Precipitation

Summer precipitation sums were above the average relative to the normal for the 1961-1990 base period in most of Serbia. Relative to the normal, precipitation sums ranged from 94% in Vranje to 192% in Kraljevo (*Figure 33*).

Based on the percentile method, summer precipitation sums were in the category of extremely rainy and very rainy in northern, western and some central parts of the country, whereas in the remainder of the country it was in the rainy and normal category (*Figure 34*).

Based on the tercile method, precipitation sums were above the average in most of Serbia, apart from Banatski Karlovac, Loznica, Belgrade, Cuprija, Nis, Zajecar and Vranje where precipitation sums were within the average.

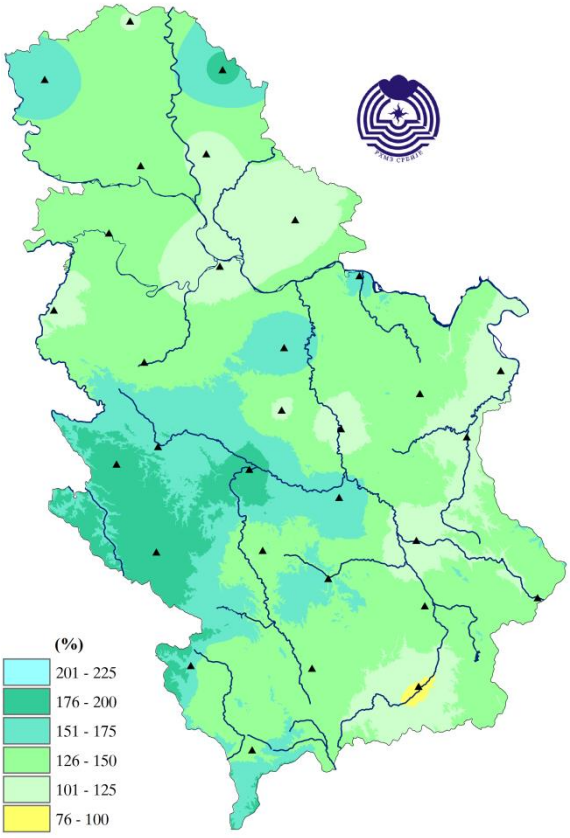

Figure 33. Spatial distribution of precipitation sums expressed in the percentages of normal compared to the 1961-1990 base period

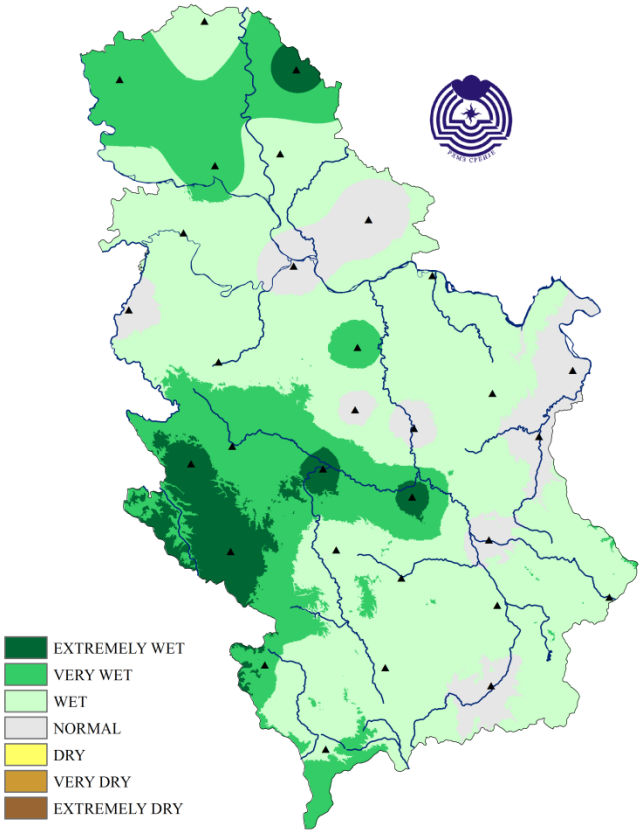

Figure 34. Assessment of the precipitation sums using percentile method relative to the 1961-1900 base period