VERIFICATION OF THE SEECOF–28 WINTER 2022/2023 CLIMATE OUTLOOK AND SEASONAL BULLETIN FOR THE TERRITORY OF SERBIA

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Temperature

The SEECOF-28 outlook for the winter 2022/2023 in Serbia indicated normal- to above-normal temperature in Serbia with 40% probability relative to the 1981–2010 climatological base period (*Figure* A).

Climatological monitoring showed that the winter 2022/2023 was warm in entire Serbia, with above-normal temperature based on the tercile method (*Figure* B). The outlook for a warm winter was partly correct, considering that the equal probabilities for warm and average winter temperature were predicted.

OUTLOOK – WINTER **2022/2023**

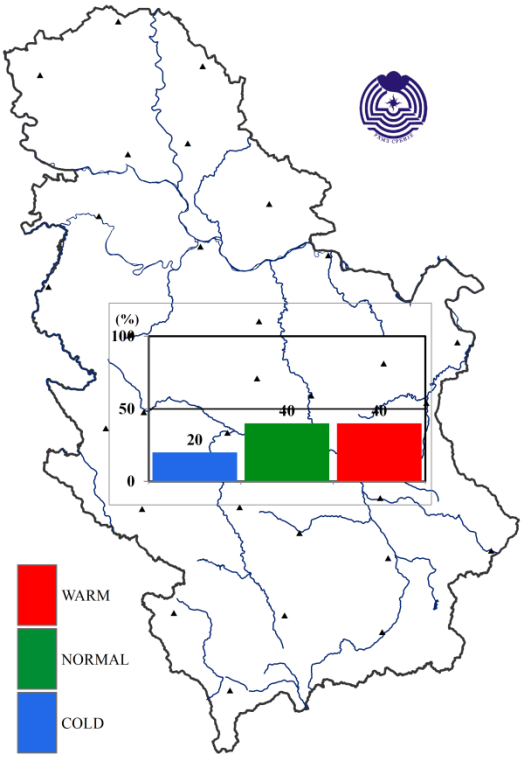

Figure A. SEECOF-28 - winter temperature outlook

MONITORING – WINTER **2022/2023**

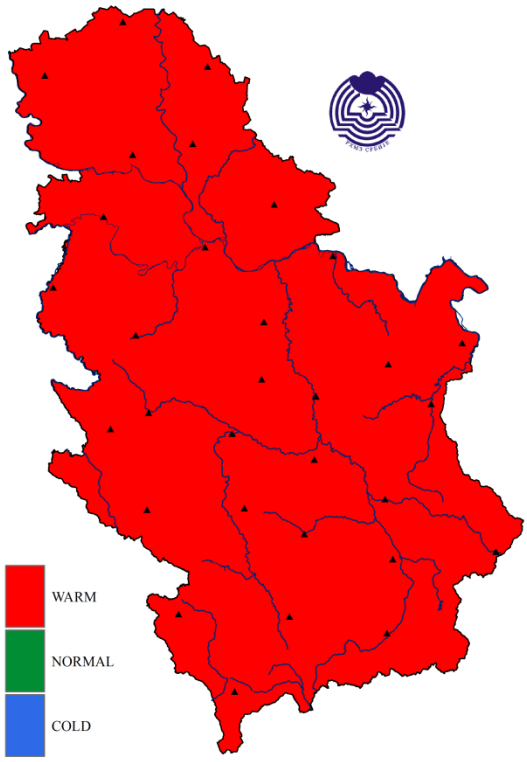

Figure B. Monitoring of the winter temperature using tercile method compared to the 1981-2010 base period

Precipitation

According to the SEECOF-28 outlook for the winter 2022/2023, approximately equal probabilities for below, near or above normal precipitation were indicated for Serbia, relative to the 1981–2010 climatological base period (*Figure* C), hence climatology (average seasonal precipitation) was suggested.

Based on the climatological monitoring of precipitation, the winter of 2022/2023 was wet in most of Serbia whilst average precipitation sums were recorded in some parts of eastern, central and southeastern Serbia (*Figure* D). The outlook for the average winter precipitation sums was correct for some parts of Serbia.

OUTLOOK – WINTER **2022/2023**

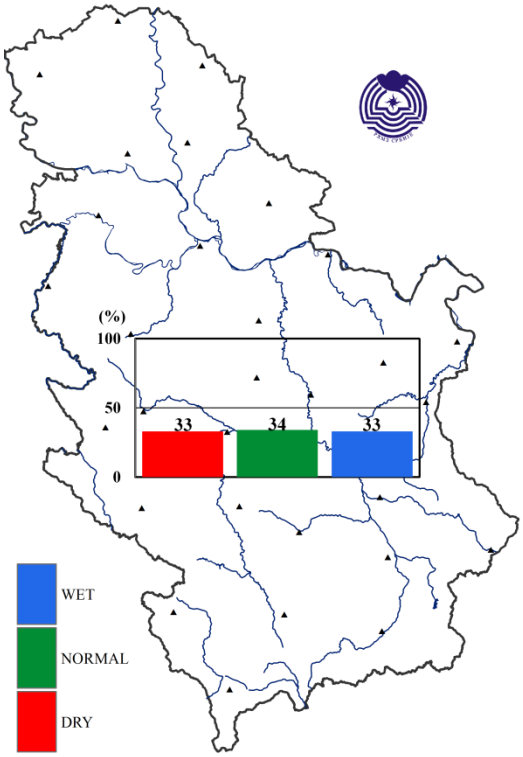

Figure C. SEECOF-28 - winter precipitation outlook

MONITORING – WINTER **2022/2023**

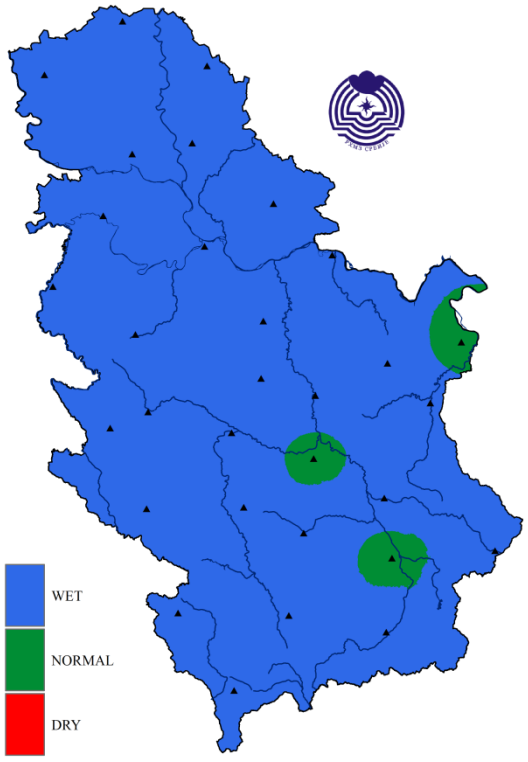

Figure D. Monitoring of the winter precipitation using tercile method compared to the 1981-2010 base period

Winter 2022/2023			**Air Temperature (°C)**			
Station	Rank*	Rank**	33	50	66	Observed value
Belgrade (1887-2023)	2	2	1.5	2.4	3.0	5.9
Palić (1945-2023)	2	2	-0.1	0.5	1.5	3.9
Sombor (1941-2023)	2	2	0.0	0.9	1.8	4.1
Novi Sad (1948-2023)	2	2	0.4	1.1	1.8	4.7
Zrenjanin (1943-2023)	2	2	0.3	1.0	1.8	4.7
Kikinda (1948-2023)	2	2	0.1	0.9	1.7	4.4
Banatski Karlovac (1985-2023)	1	1	0.7	1.4	2.0	4.6
Loznica (1952-2023)	3	3	0.7	1.8	2.5	5.0
Sremska Mitrovica (1925-2023)	3	2	0.4	0.9	1.6	4.2
Valjevo (1926-2023)	4	3	0.7	1.3	2.2	4.7
Kragujevac (1925-2023)	3	2	0.9	1.5	2.3	5.1
Smederevska Palanka (1939-2023)	3	2	0.7	1.5	2.1	4.9
Veliko Gradište (1926-2023)	3	2	0.4	1.0	1.6	4.1
Crni Vrh (1966-2023)	5	5	-3.6	-3.2	-2.1	-0.1
Negotin (1927-2023)	3	3	0.7	1.1	1.8	4.5
Zlatibor (1950-2023)	6	5	-2.2	-1.8	-0.8	1.2
Sjenica (1946-2023)	2	1	-3.4	-2.5	-2.0	0.6
Pozega (1952-2023)	2	2	-1.3	-0.7	0.3	2.5
Kraljevo (1926-2023)	2	2	0.5	1.1	2.1	4.5
Kopaonik (1949-2023)	4	3	-5.0	-4.6	-3.8	-1.7
Kursumlija (1952-2023)	3	3	0.3	1.0	1.5	3.9
Krusevac (1927-2023)	4	3	0.7	1.1	1.9	4.4

Cuprija (1948-2023)	1	1	0.4	1.2	1.7	4.5
Nis (1925-2023)	2	1	1.1	1.6	2.3	5.1
Leskovac (1948-2023)	5	3	0.3	0.9	1.7	4.1
Zajecar (1929-2023)	2	2	0.0	0.4	1.1	3.5
Dimitrovgrad (1945-2023)	2	1	-0.5	0.0	1.1	3.8
Vranje (1926-2023)	2	1	0.3	1.0	1.7	4.2

*Rank –period of stations work (warmest season)
**Rank – 1981-2023 period (warmest season)

Winter 2022/2023			**Precipitation sums (mm)**			
Station	Rank*	Rank**	33	50	66	Observed Value
Belgrade (1887-2023)	8	4	129.8	152.3	158.3	218.3
Palić (1936-2023)	28	15	90.1	104.4	121.5	130.1
Sombor (1931-2023)	16	6	104.2	114.8	123.0	164.8
Novi Sad (1945-2023)	13	4	109.9	119.1	133.5	168.3
Zrenjanin (1925-2023)	15	4	106.5	115.7	127.0	164.1
Kikinda (1925-2023)	14	5	98.0	105.5	121.2	162.8
Banatski Karlovac (1946-2023)	8	2	108.3	122.7	132.5	194.8
Loznica (1925-2023)	3	2	166.4	171.6	201.4	281.1
Sremska Mitrovica (1925-2023)	10	2	103.0	115.9	130.1	192.7
Valjevo (1926-2023)	9	5	149.5	157.6	173.3	224.1
Kragujevac (1925-2023)	33	15	113.0	120.0	134.0	148.2
Smederevska Palanka (1926-2023)	6	5	121.8	132.7	157.6	201.4
Veliko Gradište (1926-2023)	6	2	120.8	147.9	161.3	227.6

Crni Vrh (1966-2023)	14	13	127.6	143.8	170.7	184.8
Negotin (1941-2023)	26	17	105.9	137.3	186.9	177.8
Zlatibor (1950-2023)	4	3	204.3	225.1	237.8	314.5
Sjenica (1925-2023)	1	1	140.9	151.4	177.6	296.4
Pozega (1925-2023)	9	2	124.3	147.5	157.6	213.8
Kraljevo (1926-2022)	33	17	126.9	137.3	156.8	163.3
Kopaonik (1949-2023)	4	4	158.1	204.0	232.1	312
Kursumlija (1925-2023)	12	5	123.5	150.9	174.5	214.7
Krusevac (1925-2023)	39	21	115.1	133.2	155.6	144.1
Cuprija (1947-2023)	19	12	127.5	148.1	163.1	190.5
Nis (1925-2023)	26	14	117.7	137.1	150.6	160.5
Leskovac (1925-2023)	34	22	127.3	150.4	161.8	151.8
Zajecar (1925-2023)	33	18	103.7	136.3	146.6	148.3
Dimitrovgrad (1926-2023)	21	13	111.6	120.4	143.9	167
Vranje (1926-2023)	22	10	111.7	126.9	137.1	173.3

*Rank –period of stations work (highest seasonal precipitation)
**Rank – 1981-2023 period (highest seasonal precipitation)

Country	Seasonal temperature DJF		Seasonal precipitation DJF		High Impact Events
	Observed	SEECOF-28 climate outlook for temperature	Observed	SEECOF-28 climate outlook for precipitation	
Serbia (1)	Above normal in entire Serbia	**Normal - to above-normal** (20, 40, 40) in entire Serbia	Above normal in most of Serbia	**No predictive signal** (33, 34, 33) in entire Serbia	❖ ***3rd warmest winter for Serbia since 1951, WARMEST ON RECORD for Cuprija and Banatski Karlovac, 2nd warmest for Belgrade since 1888, Sombor, Novi Sad, Zrenjanin, Kikinda, Kraljevo, Pozega, Sjenica, Nis, Zajecar, Dimitrovgrad, Vranje and Palic*** ❖ ***First winter without ice days in Novi Sad and Zajecar*** ❖ ***Record low number of frost days in Sombor, Banatski Karlovac, Belgrade, Valjevo, Kragujecac, Smederevska Palanka, Pozega, Negotin and Palic*** ❖ ***8th wettest winter for Serbia since 1951, WETTEST ON RECORD for Sjenica since 1926, 3rd wettest for Loznica since 1926*** ❖ ***Maximum daily precipitation sums exceded in Veliko Gradiste and Kopaonik, where for the first time since the record-keeping one day with precipitation sum above 50 mm was registered during winter*** ❖ ***Record low snow depth in Kraljevo and Kursumlija*** ❖ ***Kopaonik observed record few days with snow cover***

Analysis of the winter season 2022/2023 for Serbia relative to the 1991-2020 base period

Warm and wet winter (*Figure 1*) with mean seasonal air temperature significantly above the normal[1] and precipitation sums above the average.

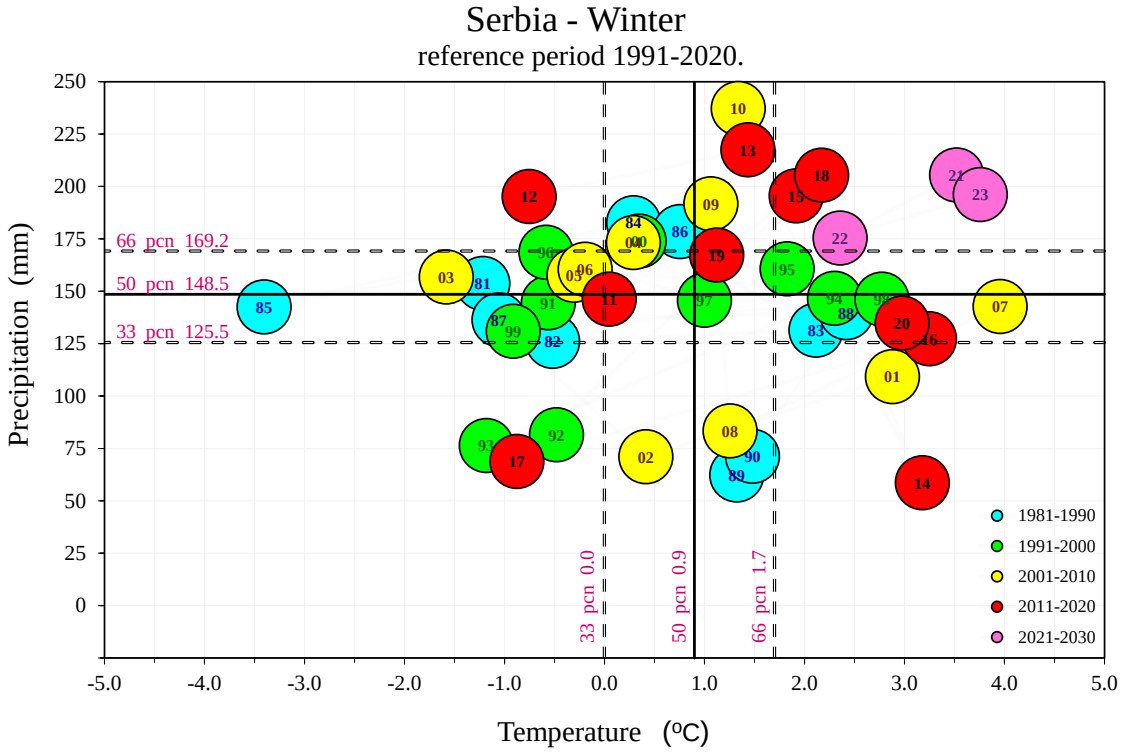

Figure 1. Assessment of mean air temperature and precipitation for winter in Serbia based on the accompanying terciles relative to the 1991-2020 base period

Temperature

Winter of 2022/2023 ranks as **the 3rd warmest for Serbia** (*Figure 2*) since 1951. It was the **warmest on record for Cuprija** (since 1949, *Figure 3*) **and Banatski Karlovac** (since 1986), and **2nd warmest for Belgrade since 1888,** as well as for **Sombor, Novi Sad, Zrenjanin, Kikinda, Kraljevo, Pozega, Sjenica, Nis, Zajecar, Dimitrovgrad, Vranje and Palic**.

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

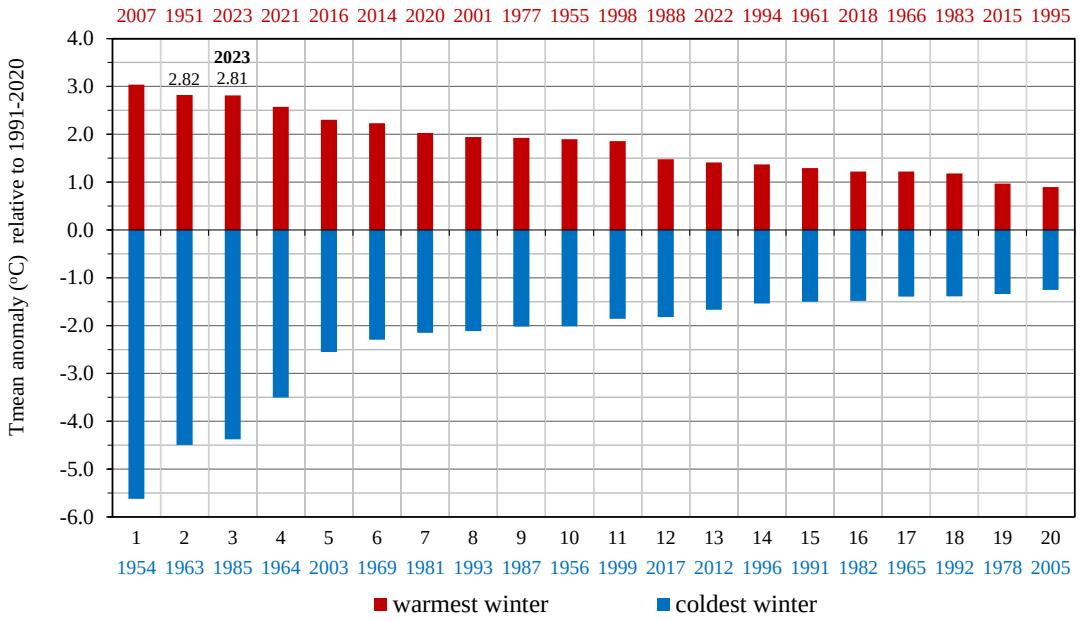

Figure 2. Rank of twenty warmest and coldest winter seasons in Serbia for the 1951-2023 period

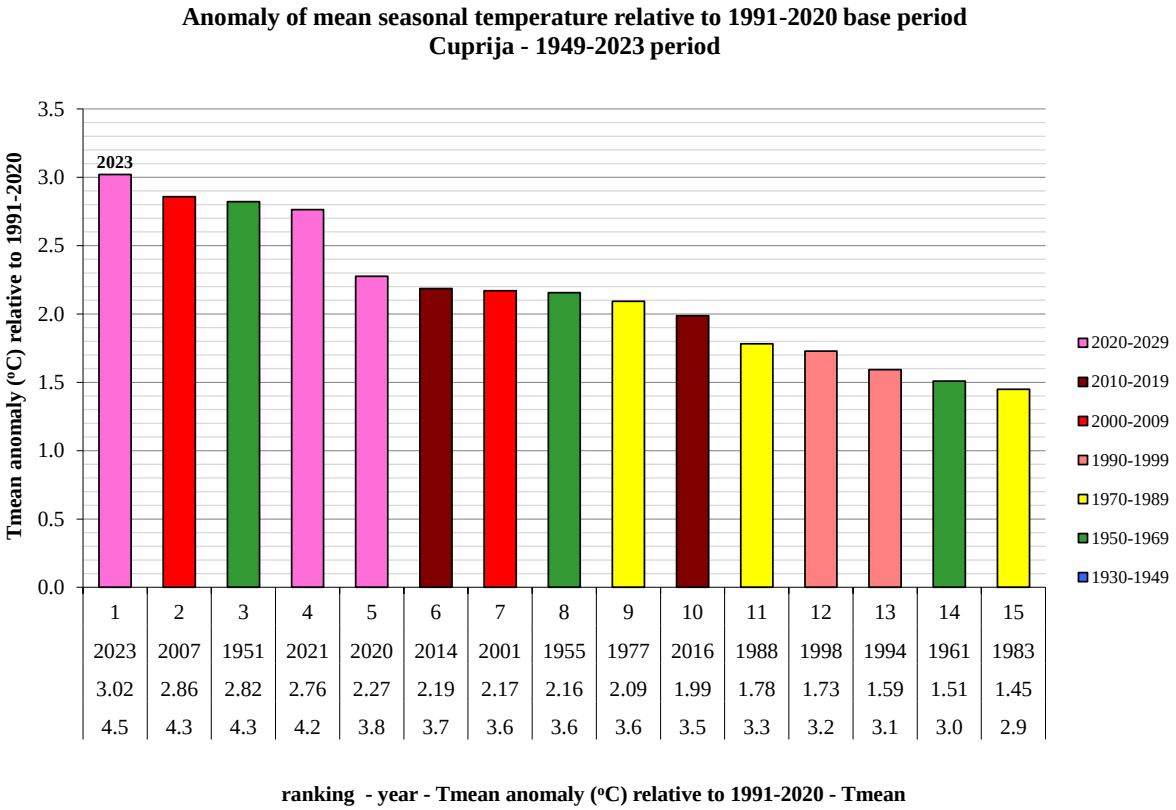

Figure 3. Rank of the warmest winters in Cupria for the 1949-2023 period

Mean winter air temperature in Serbia was 3.8 °C, +2.8 °C above the normal. Mean winter air temperature in Belgrade was 5.9 °C, +3.0 °C above the normal (*Figure 4*).

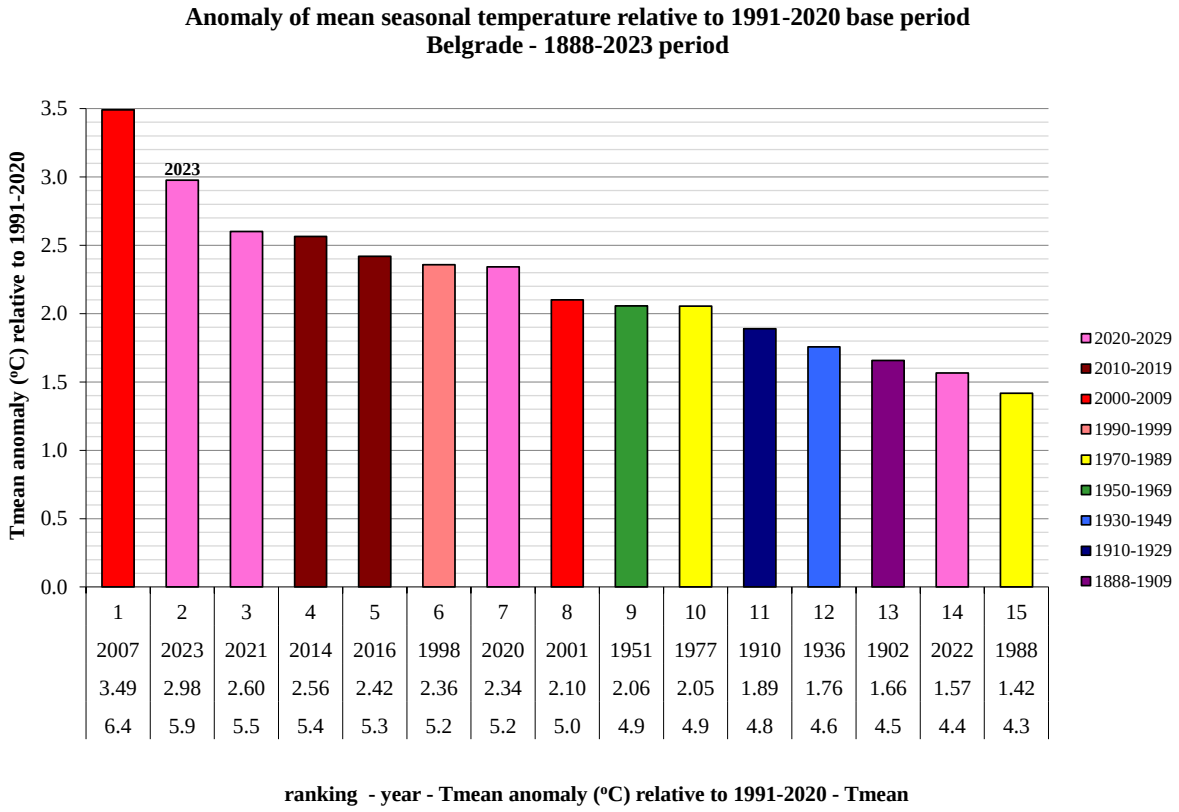

Figure 4. Rank of the warmest winters in Belgrade for the 1888-2023 period

Mean seasonal air temperature during winter ranged from 2.5 ºC in Pozega to 5.9 ºC in Belgrade, and on the mountains from –1.7 ºC at Kopaonik to 1.2 ºC at Zlatibor (*Figure 5*).

Departure of the mean seasonal air temperature from the normal during winter, ranged from +2.6 ºC in Pozega and Veliko Gradiste to +3.2 ºC in Zrenjanin and Dimitrovgrad, and in the upland from +2.4 ºC at Kopaonik, Zlatibor and Crni Vrh to +3.1 ºC in Sjenica (*Figure 6*).

Based on the percentile method, mean seasonal air temperature in winter was in the following categories: extremely warm in most of Serbia, very warm in Sombor, Loznica, Valjevo, Negotin, Zajecar as well as Kopaonik and Zlatbor, and warm category only at Crni Vrh (*Figure 7).*

Based on the tercile method, mean seasonal air temperature in winter was in the warm category in entire Serbia (*Figure 8*).

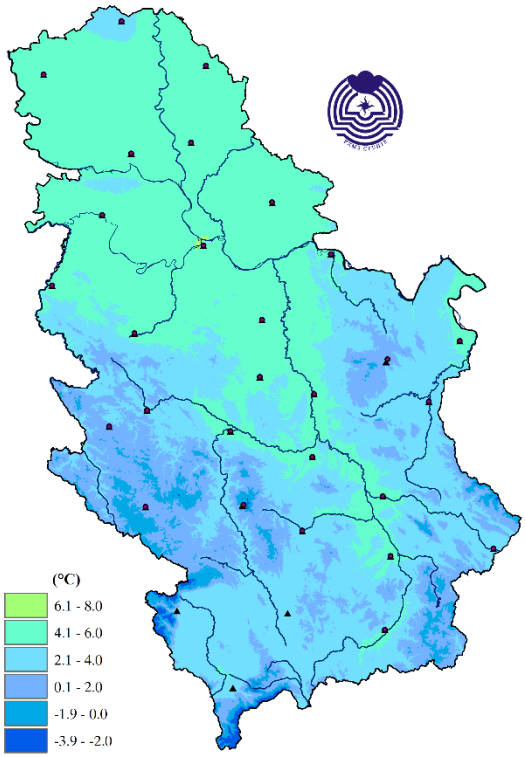

Figure 5. Spatial distribution of mean winter air temperature

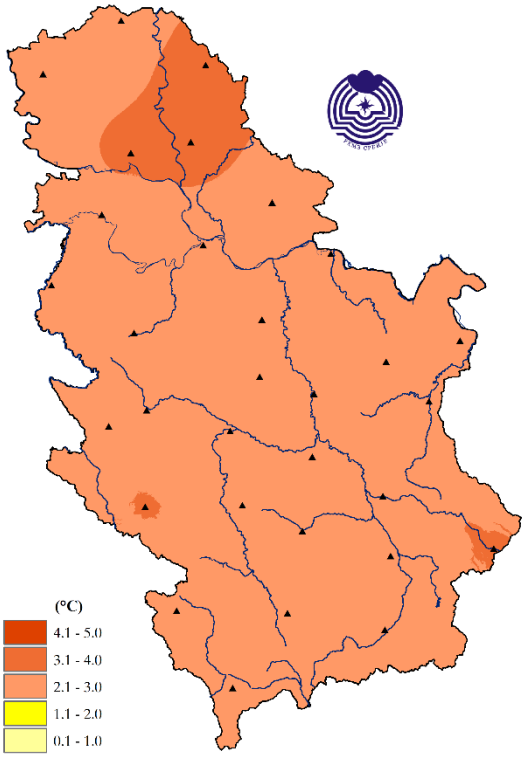

Figure 6. Spatial distribution of mean winter air temperature anomaly from the normal

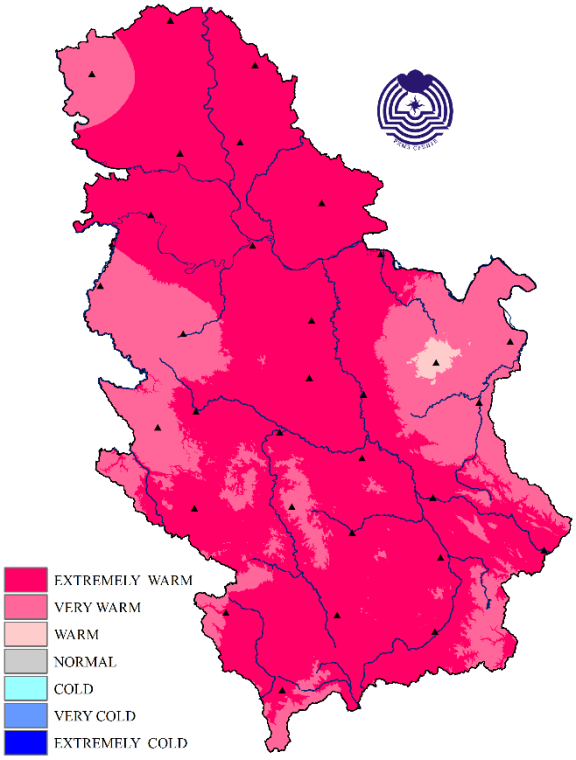

Figure 7. Spatial distribution of mean winter air temperature according to the percentile method

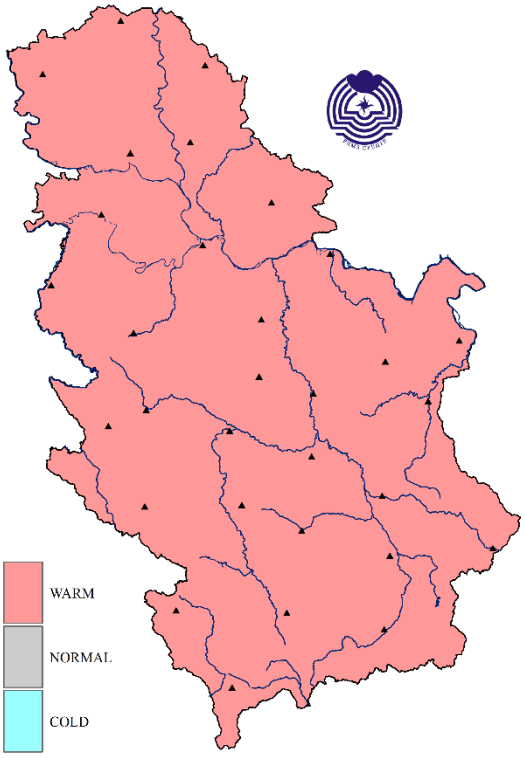

Figure 8. Spatial distribution of mean winter air temperature according to the tercile method

The highest winter temperature of 22.2 ºC was measured in Kragujevac on December 16.

Number of ice days, with the maximum daily air temperature below 0 ºC, was below the average, three to 18 days across the entire country. **For the first time since record-keeping began, Novi Sad and Zajecar experienced winter without ice days.** Ice days were not registered at 11 main meteorological stations. The highest number of ice days, total of four days, was observed in Pozega, and on the mountains their number ranged between 13 in Sjenica and 41 days at Crni Vrh (*Figure 9*).

The lowest winter air temperature of –22.7 ºC was measured in Sjenica on February 9.

Number of frost day, with the minimum daily air temperature below 0 ºC, ranged from 12 in Belgrade to 49 days in Pozega, and on the mountains from 56 at Zlatibor to 78 days at Kopaonik. **Record few frost days were registered in Sombor, Banatski Karlovac, Belgrade, Valjevo, Kragujevac, Smederevska Palanka, Pozega, Negotin and Palic.** Number of frost days was 14 to 31 days below the winter average, on the mountains from six to 15 days below the average (*Figure 10*).

In the lowland, there were up to three days with severe frost, with minimum daily air temperature below –10 ºC, two to seven days below the average. On the mountains, from six days at Zlatibor (at the beginning of February, *Figure 11*) and Crni Vrh up to 12 days in Sjenica, six to 16 days below the winter average.

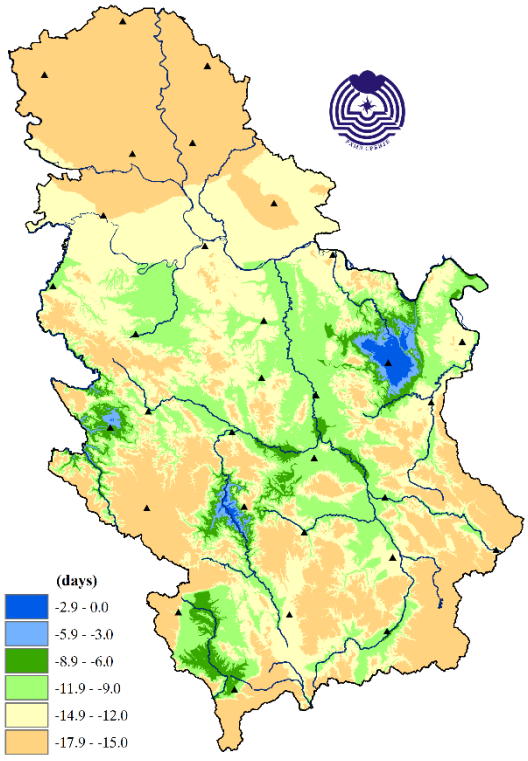

Figure 9. Deviation of the number of ice days from the normal

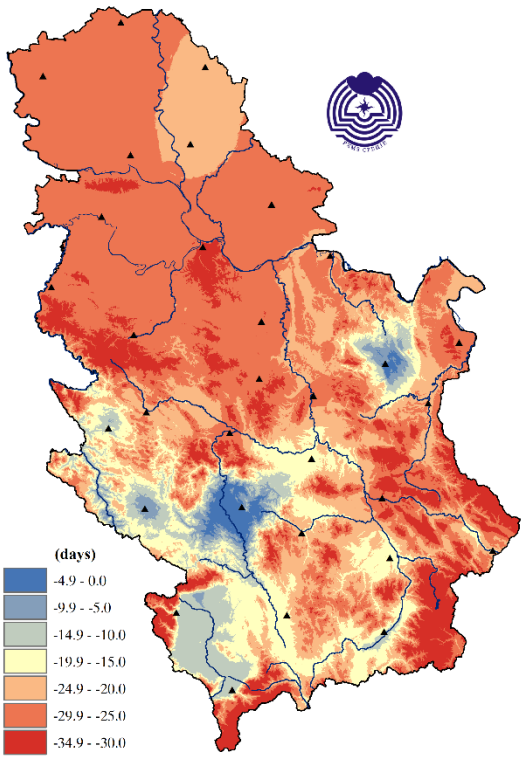

Figure 10. Deviation of the number of frost days from the normal

Warmer periods in Belgrade, with air temperature above the multiannual average, were recorded at the end of the first decade, in the middle of and during the third decade of December, in the first decade and at the end of the second decade of January, and at the end of second decade and beginning of the third decade of February. Colder periods, with air temperature below the multiannual average, were registered in the middle of December, at the end of the first and beginning of the second decade of February (*Figure 12*).

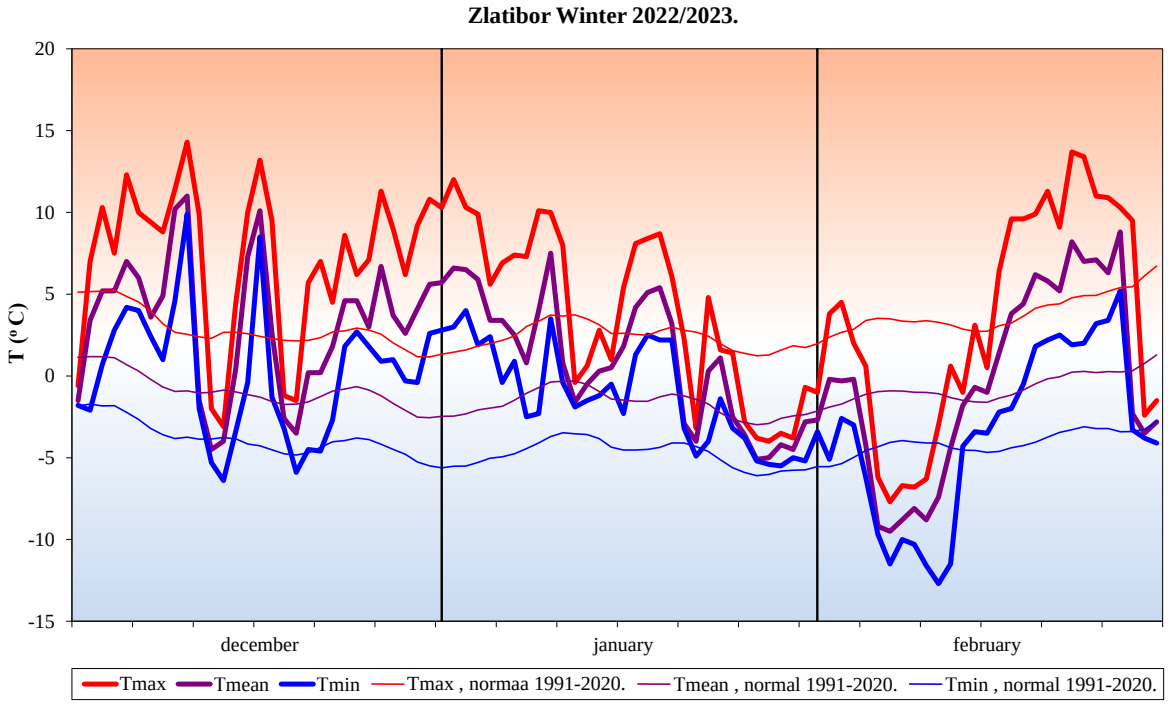

Figure 11. Three–month course of the mean, maximum and minimum daily air temperature at Zlatibor

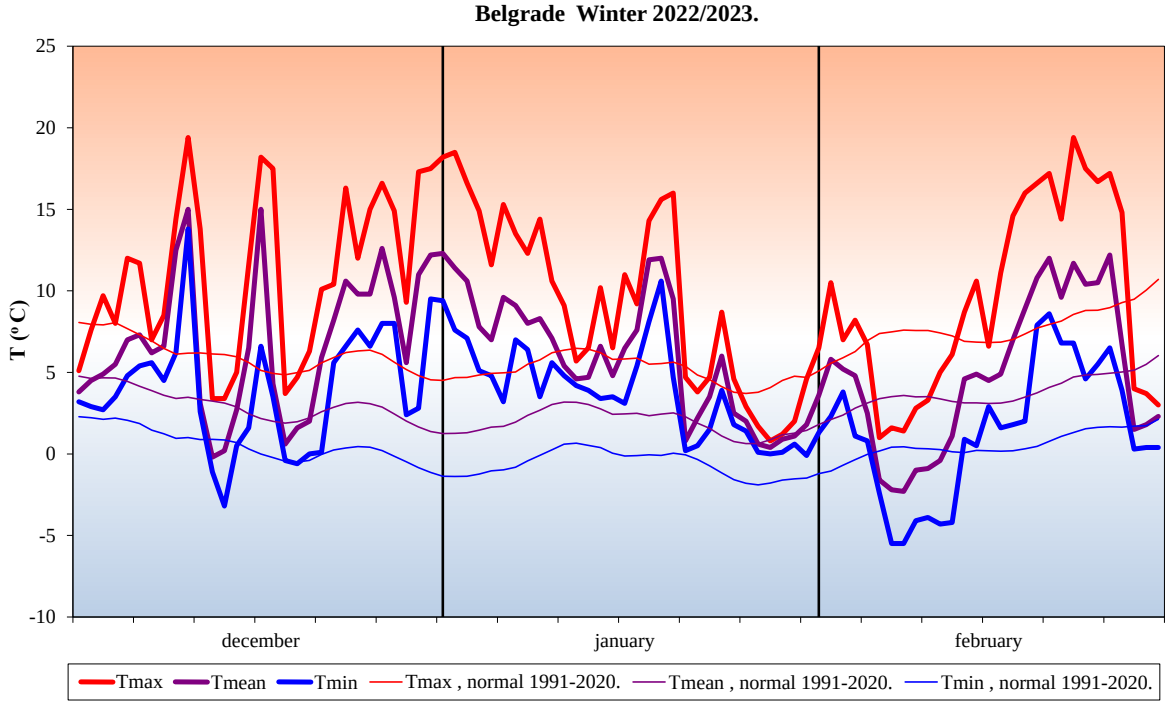

Figure 12. Three–month course of the mean, maximum and minimum daily air temperature in Belgrade

Cold wave / heat wave

In winter 2022/23, three heat waves [2] were recorded. The onset of the first heat wave was registered in the southern areas lasting from December 7 to 11. The second heat wave affected the entire country apart from Pozega and Vranje, lasting from December 29 to January 3. However, in Sombor and Palic it began on December 23 and lasted even until January 8 in certain northern and eastern areas. The third heat wave affected some parts of northern and western Serbia in the period from February 16 to 24. Cold wave[3] was recorded on Kopaonik only, from February 5 to 9 (*Table 1*).

Table 1.

HEAT WAVES IN SRBIA - WINTER 2022/2023

(reference period 1991-2020)

DECEMBER

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
ПАЛИЋ																							VW	EW	VW	EW	EW		VW	VW	EW
SOMBOR																							VW	VW	EW	EW	VW		EW	VW	EW
KIKINDA																													VW	VW	EW
ZRENJANIN																													VW	VW	EW
NOVI SAD																													EW	VW	EW
SR. MITROVICA																													VW	VW	EW
BEOGRAD																													EW	EW	EW
LOZNICA																													VW	EW	EW
VALJEVO																													VW	EW	EW
V. GRADISTE																													VW	EW	EW
SM. PALANKA																													EW	EW	EW
KRAGUJEVAC																													VW	EW	EW
KRALJEVO																														VW	VW
POZEGA																															
ZLATIBOR																													VW	VW	VW
CUPRIJA																													VW	EW	EW
KRUSEVAC																													VW	EW	EW
NEGOTIN																														VW	EW
ZAJECAR																														EW	EW
CRNI VRH																													VW	EW	EW
KOPAONIK																														VW	EW
SJENICA																														EW	EW
NIS							VW	VW	VW	EW	VW																		VW	VW	VW
VRANJE							VW	VW	VW	EW	EW																				
DIMITROVGRAD																														VW	VW
LESKOVAC																													VW	VW	VW
KURSUMLIJA							VW	VW	VW	EW	VW																		VW	VW	EW
B. KARLOVAC																													EW	EW	EW

JANUARY

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
ПАЛИЋ	EW	EW																													
SOMBOR	EW	EW																													
KIKINDA	EW	EW																													
ZRENJANIN	EW	EW	EW	VW	VW	VW	VW																								
NOVI SAD	EW	EW	VW	VW	VW																										
SR. MITROVICA	EW	EW	EW	VW	VW	VW	VW	VW																							
BEOGRAD	EW	EW	VW																												
LOZNICA	EW	VW	VW																												
VALJEVO	EW	VW	EW																												
V. GRADISTE	EW	EW	EW																												
SM. PALANKA	EW	EW	EW																												
KRAGUJEVAC	EW	EW	EW																												
KRALJEVO	VW	VW	EW																												
POZEGA																															
ZLATIBOR	EW	VW	VW																												
CUPRIJA	EW	EW	EW																												
KRUSEVAC	EW	VW	EW																												
NEGOTIN	EW	EW	EW	VW	EW	VW																									
ZAJECAR	EW	EW	EW																												
CRNI VRH	EW	EW	EW																												
KOPAONIK	EW	EW	EW																												
SJENICA	EW	VW	EW																												
NIS	VW	VW	EW																												
VRANJE																															
DIMITROVGRAD	EW	EW	EW																												
LESKOVAC	VW	EW	VW																												
KURSUMLIJA	EW	VW	EW																												
B. KARLOVAC	EW	EW	EW																												

FEBRUARY

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
ПАЛИЋ																	VW	VW	VW	VW	EW	VW	VW	VW				
SOMBOR																	VW	VW	VW	VW	EW	VW	VW	VW				
KIKINDA																												
ZRENJANIN																												
NOVI SAD																	VW	VW	VW	VW	EW	VW	VW	VW				
SR. MITROVICA																	VW	VW	VW	VW	EW	VW	VW	VW				
BEOGRAD																												
LOZNICA																	VW	VW	VW	VW	EW	VW	VW	VW				
VALJEVO																VW	VW	VW	VW	VW	EW	VW						
V. GRADISTE																												
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VRANJE																												
DIMITROVGRAD																												
LESKOVAC																												
KURSUMLIJA																												
B. KARLOVAC																												

EW	EXTREMELY WARM
VW	VERY WARM
VC	VERY COLD
EC	EXTREMELY COLD

[2] Heat wave, according to the percentile method, is a period of minimum five days with maximum daily air temperature is in the very warm and extremely warm categories

[3] Cold wave, according to the percentile method, is a period of minimum five days with minimum daily air temperature is in the very cold and extremely cold categories

Precipitation

Winter 2022/2023 was **the 8th wettest winter for Serbia** (*Figure 13*) since 1951 and **the wettest for Sjenica** since 1926 (*Figure 14).* Sjenica with precipitation sum of 296.4 mm exceeded the previous record of 272.5 mm from 2021. It was the third wettest winter for Loznica since 1926 (*Figure 15).*

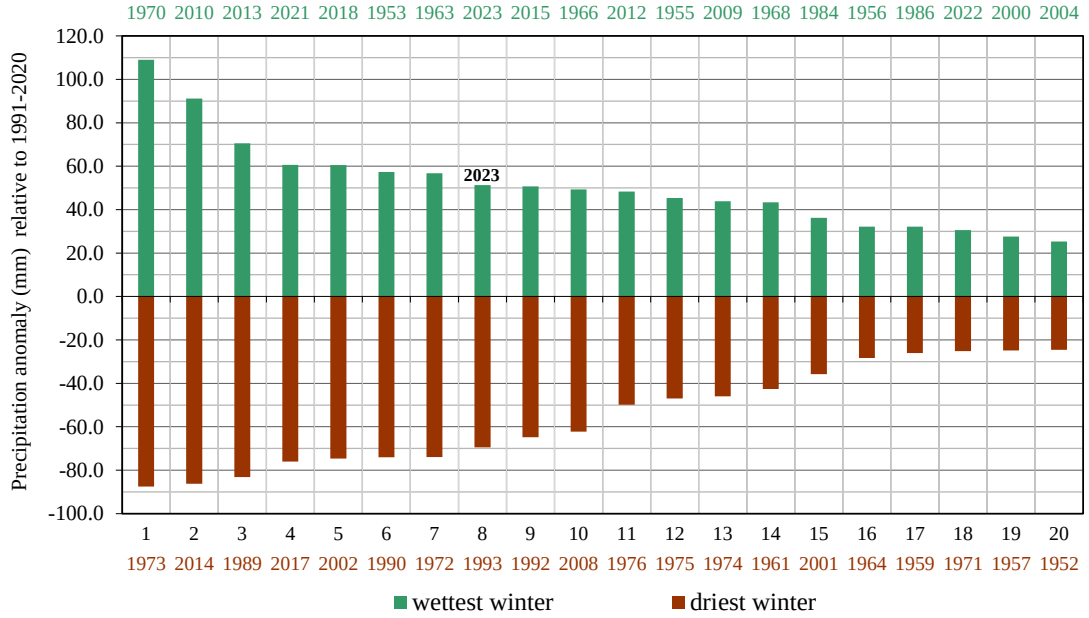

Figure 13. Rank of the wettest and driest winter seasons for Serbia for the 1951-2023 period

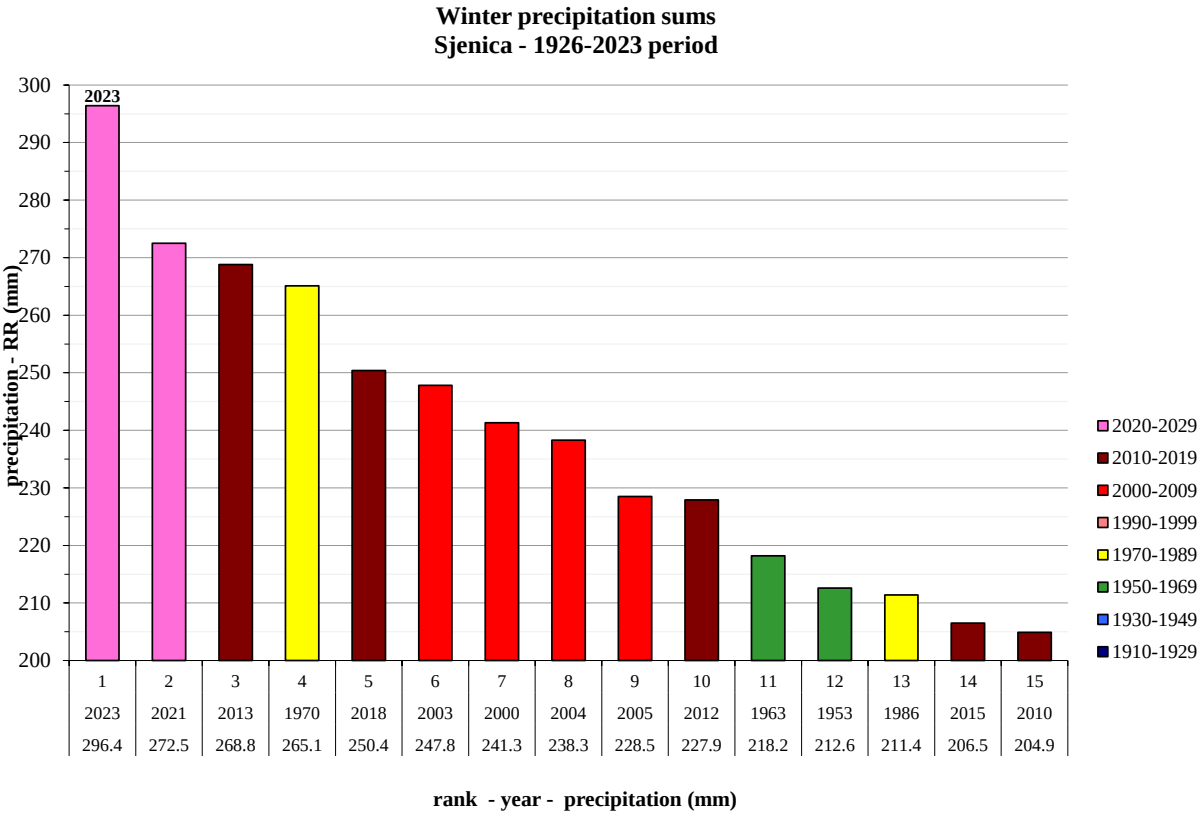

Figure 14. Rank of the wettest winters in Sjenica

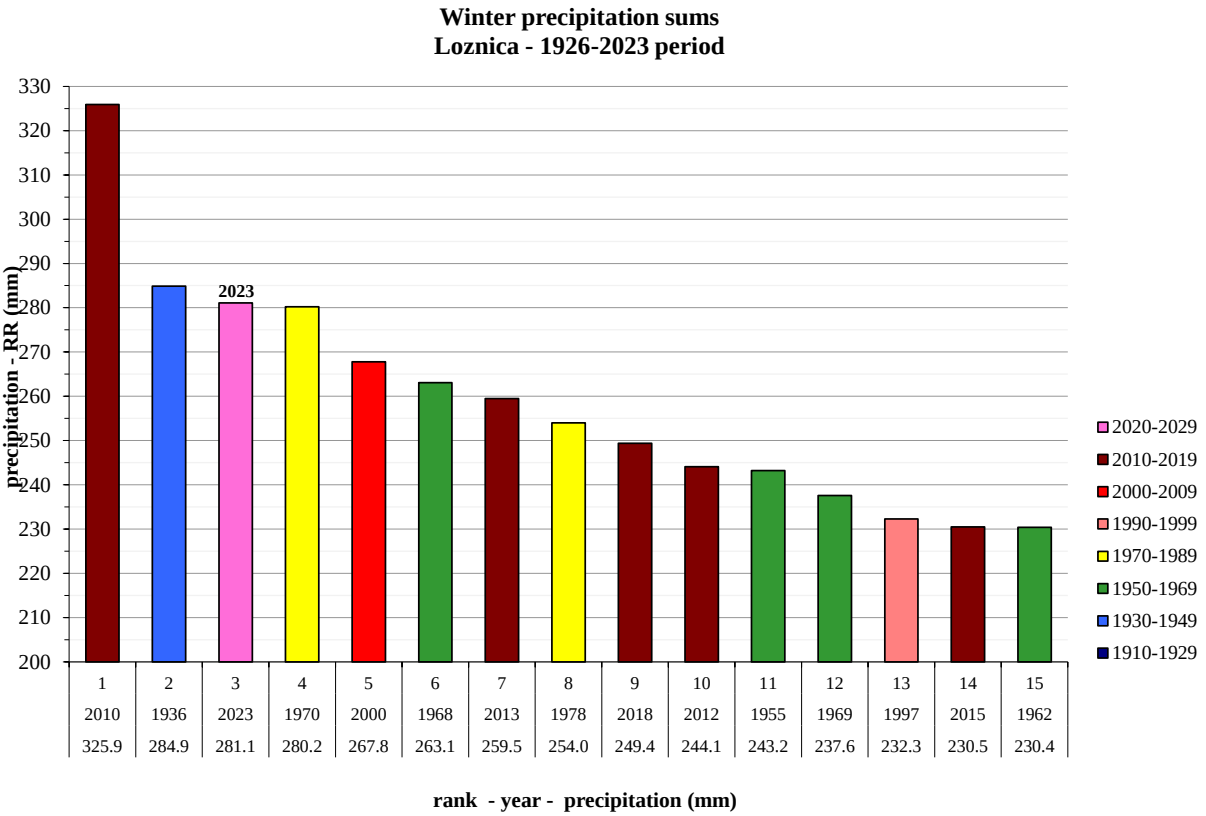

Figure 15. Rank of the wettest winters in Loznica

Figures 16, 17 and 18 show cumulative precipitation sums for Sjenica, Belgrade and Kopaonik in winter, per months relative to the average cumulative precipitation sums.

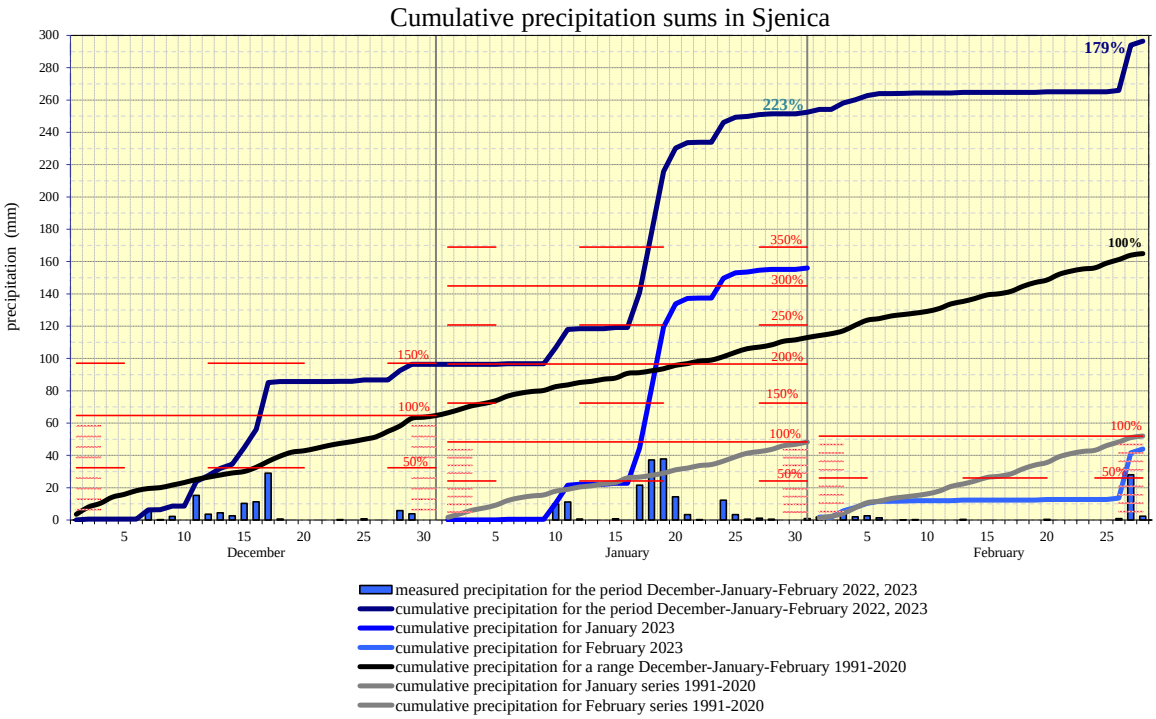

Figure 16. Cumulative precipitation sums for Sjenica

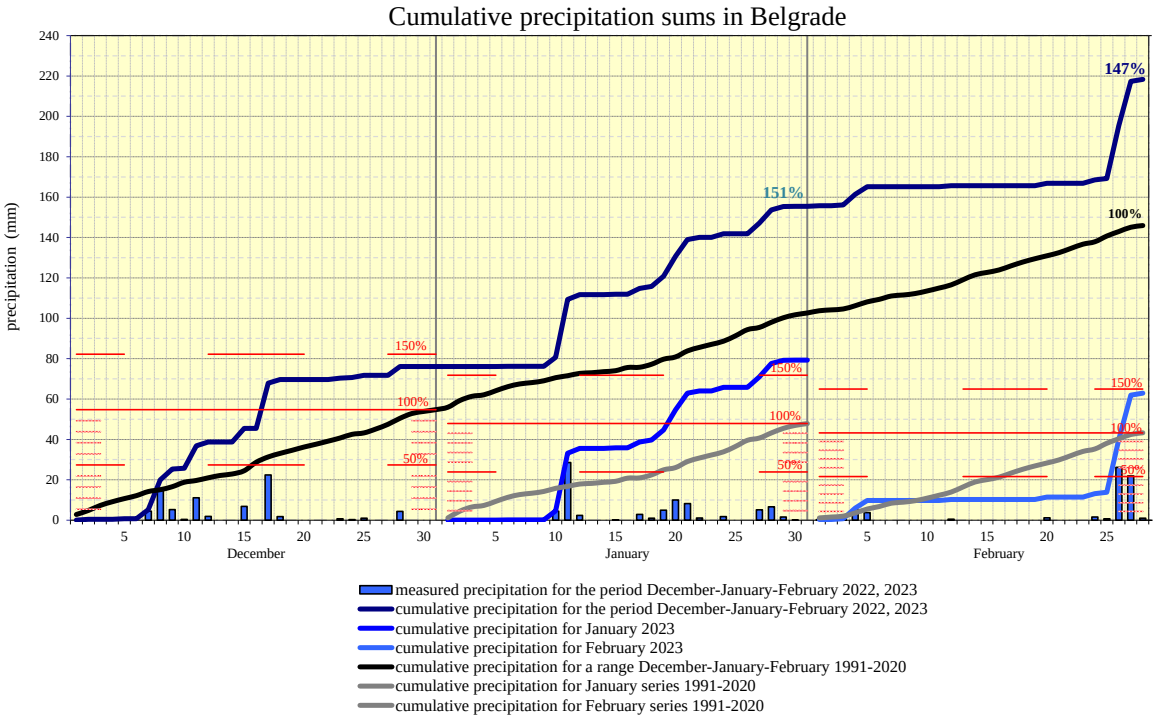

Figure 17. Cumulative precipitation sums for Belgrade

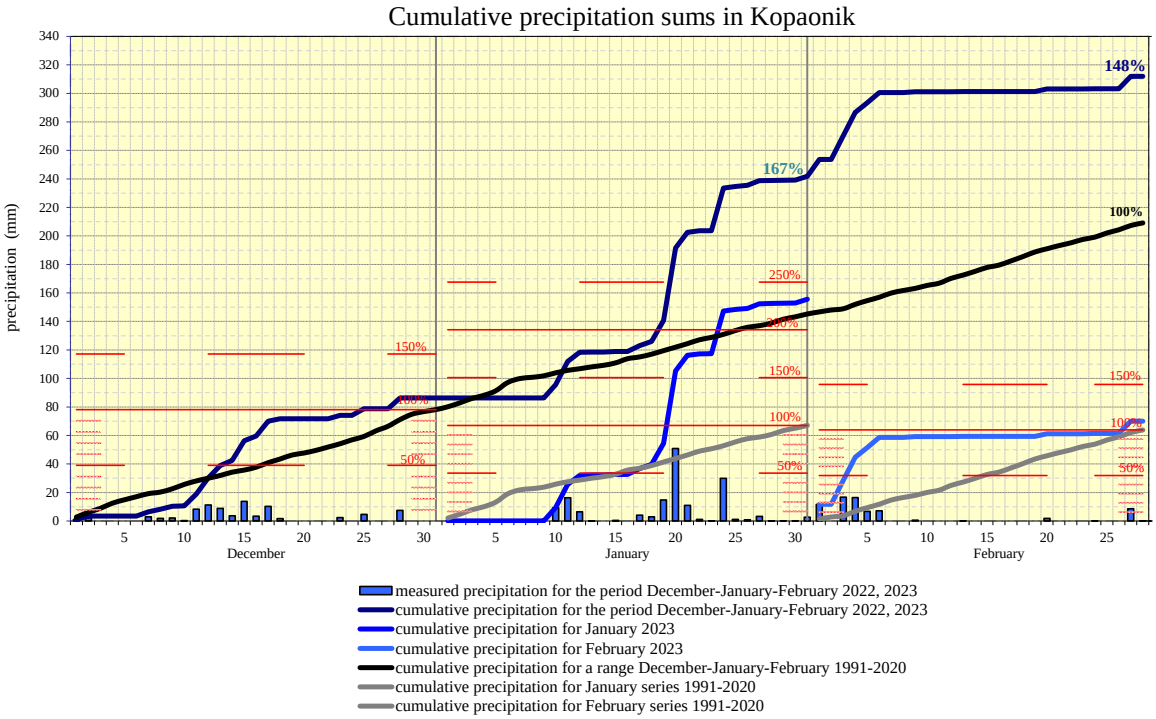

Figure 18. Cumulative precipitation sums for Kopaonik

Winter precipitation totals were above the average in most of Serbia. Precipitation sums ranged from 130.1 mm on Palic to 281.1 mm in Loznica, and in the upland from 184.8 mm at Crni Vrh to 314.5 mm at Zlatibor (*Figure 19*). Precipitation totals in the percentage of normal (*Figure 20)* ranged from 100% in Leskovac to 167% in Veliko Gradiste, and in the upland from 118% at Crni Vrh to 179% in Sjenica (*Figure 16).*

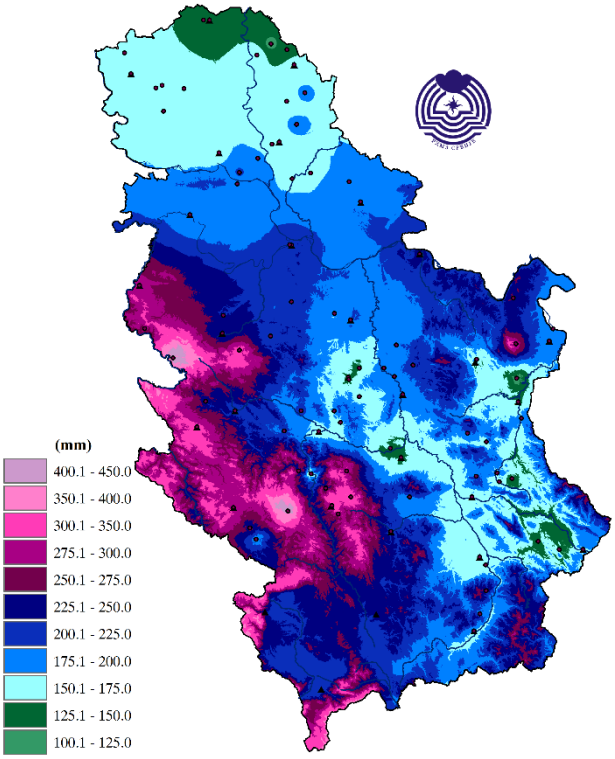

Figure 19. Spatial distribution of winter precipitation sums based on data from 28 Primary meteorological, 13 climatological and 53 rain gauge stations

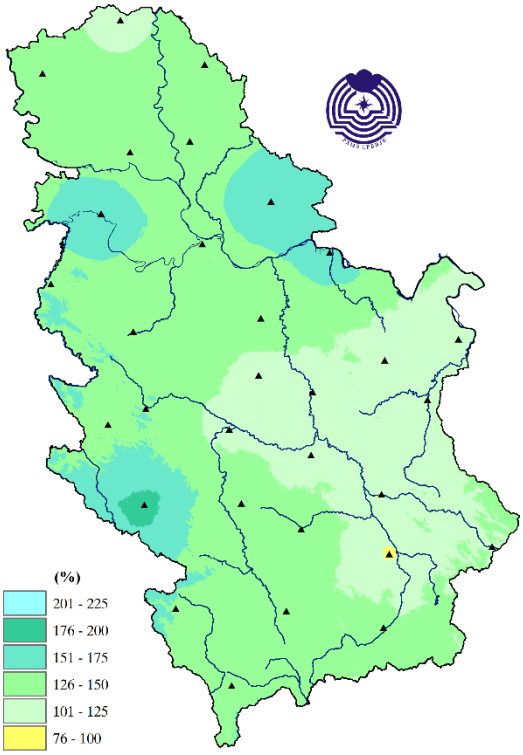

Figure 20. Spatial distribution of winter precipitation sums in percentage of normal

Based on the percentile method, winter precipitation sums were in the following categories: extremely rainy in parts of western and northweastern Serbia, very rainy and rainy in northern, western and some parts of central and southern regions, elsewhere it was normal (*Figure 21*).

Based on the tercile method, precipitation sums were in the rainy category in most of Serbia, and in normal category in northernmost, eastern, southeastern and some central areas (*Figure 22).*

The highest daily precipitation sum of 58 mm was observed at Zlatibor on February 27. Veliko Gradiste experienced record-breaking daily precipitation sum of 40.4 mm. **Record-breaking daily precipitation sums were observed in Veliko Gradiste** (December 17) and **Kopanik** (January 20, *Figure 18*), amounting to 40.4 mm and 50.9 mm, respectively. **For the first time since record-keeping, Kopaonik registered day with precipitation sum of 50 mm and above**.

In winter, number of days with precipitation of 0.1 mm and above, ranged from 36 days in Nis to 50 days in Loznica, and on the mountains from 46 days in Sjenica to 50 days at Crni Vrh. The observed number of days with precipitation was two to nine days above the winter average (*Figure 23)* in most of Serbia. **Days with precipitation of 20 mm and above,** were registered in whole Serbia, except Kragujevac, with **record-breaking number in Sjenica and Belgrade, five and four days respectively.**

Number of days with snow cover in the lowland ranged from two days in Veliko Gradiste and Palic to 16 days in Dimitrovgrad. In the hilly-mountainous regions, their number ranged from 45 days at Zlatibor to 66 days at **Kopaonik**, which is **record low number of days.** Number of days with snow cover was below the normal across entire Serbia, from 14 days

below the average in Vranje to 32 days below the average in Zajecar (*Figure 24*). On February 6, the highest snow depth of 115 cm was measured at Kopaonik. **Record low snow depth** of 2 cm and 6 cm was registered in **Kraljevo** (December 13) and **Kursumlija** (December 14), respectively.

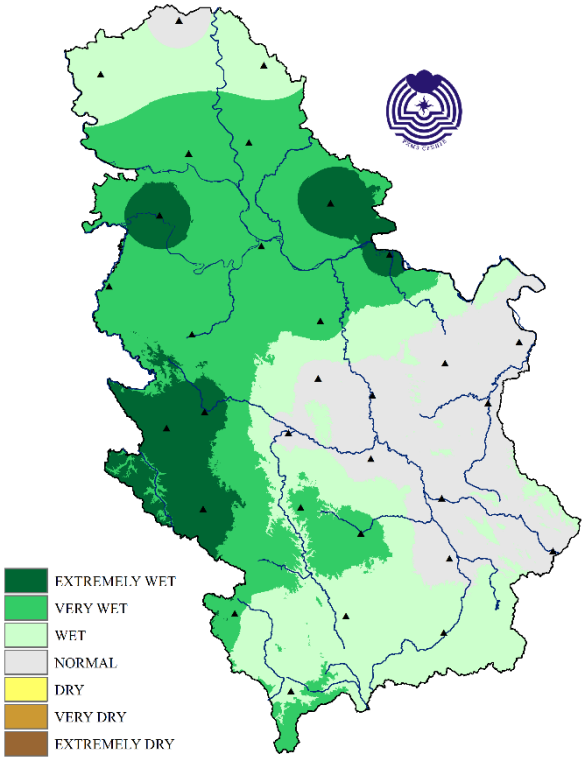

Figure 21. Winter precipitation sums according to the percentile method

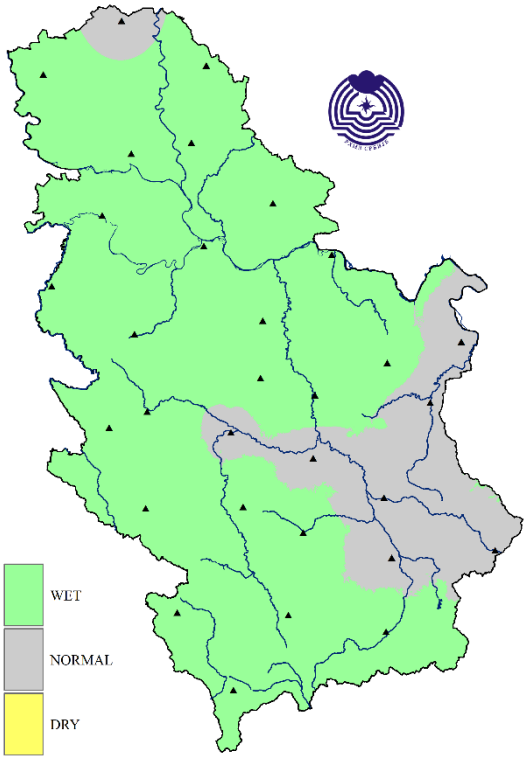

Figure 22. Winter precipitation sums according to the tercile method

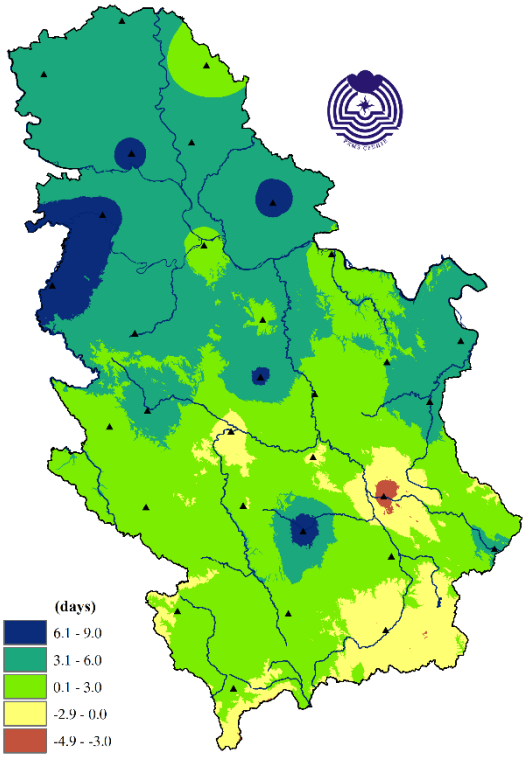

Figure 23. Deviation of number of days with precipitation of 0.1 mm and more from the normal

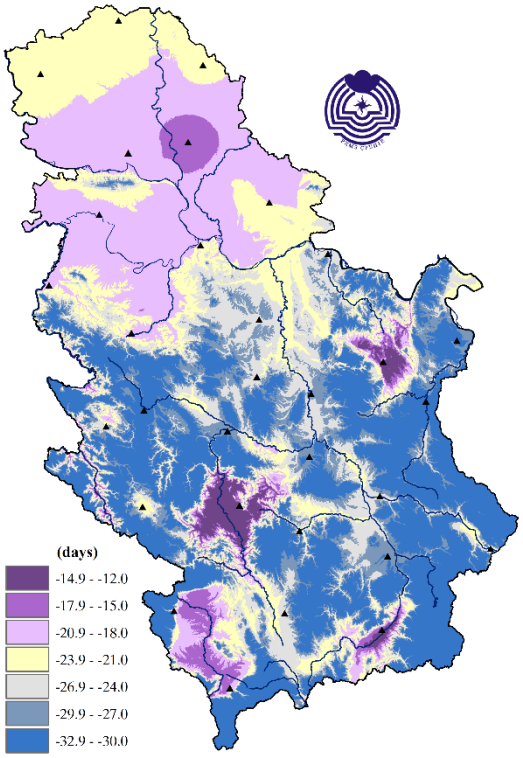

Figure 24. Deviation of number of days with snow cover from the normal

Sunshine duration (insolation)

In winter, sunshine duration ranged from 159.6 hours in Pozega to 311.4 hours in Belgrade (*Figure 25*).

Relative to the normal for the 1991-2020 base period, insolation ranged from 82% at Crni Vrh to 133% in Krusevac (*Figure 26*).

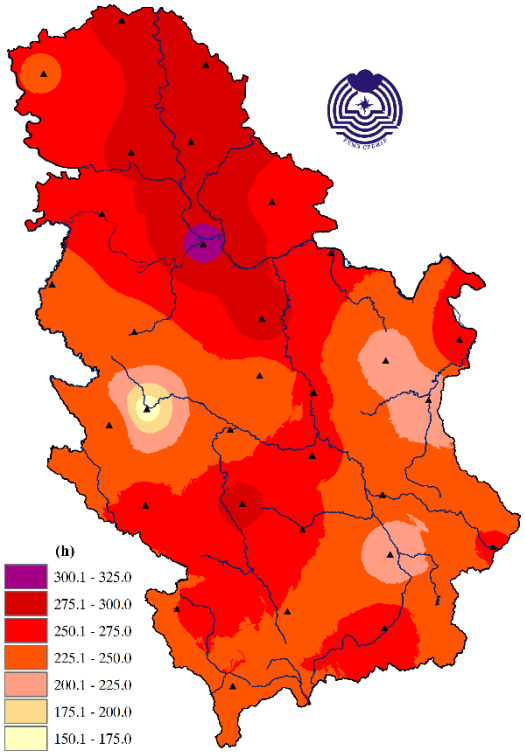

Figure 25. Insolation in hours

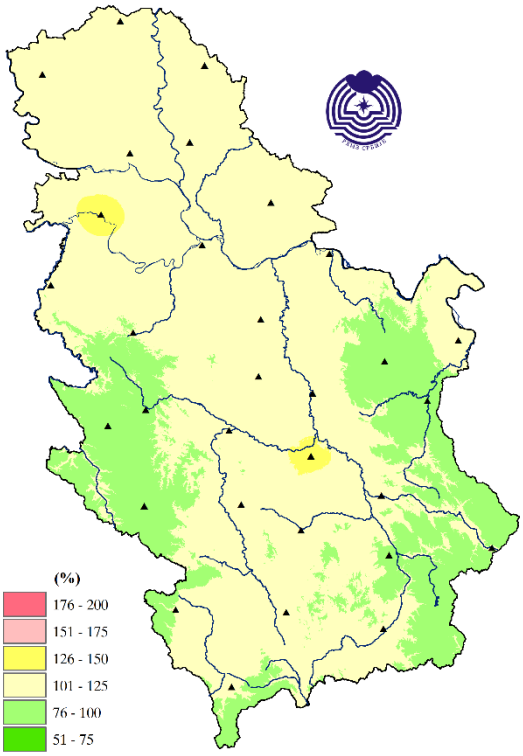

Figure 26. Insolation in percentage of normal

Analysis of the winter season 2022/2023 for Serbia relative to the 1961-1990 base period

Temperature

Departure of the mean air temperature from the normal, in winter for the 1961-1990 base period ranged from +3.0 ºC at Crni Vrh to +4.3 ºC in Zrenjanin (*Figure 27*).

Based on the percentile method, mean air temperature was in the extremely warm category in entire Serbia (*Figure 28*).

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

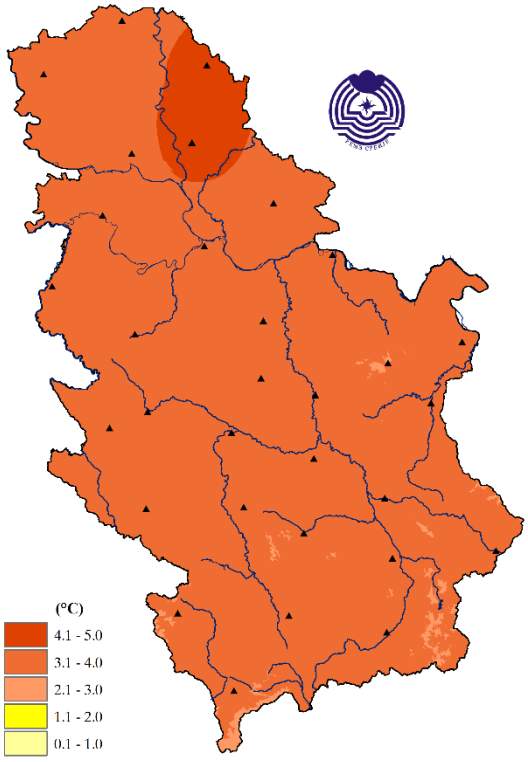

Figure 27. Spatial distribution of mean winter air temperature anomaly from the 1961-1990 normal

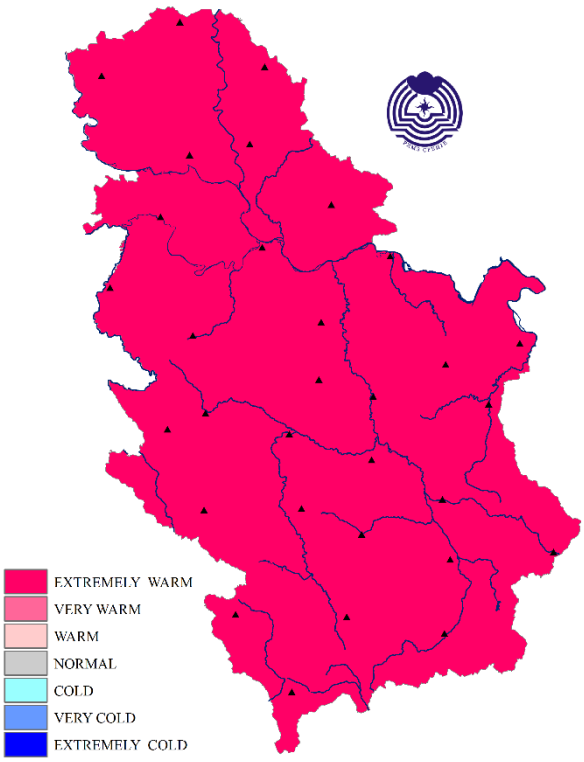

Figure 28. Spatial distribution of mean winter air temperature according to the percentile method

Precipitation

Winter precipitation sums were above the average in most of Serbia relative to the normal for the 1961-1990 base period. Precipitation sums in the percentages of normal ranged from 101% in Kraljevo to 213% in Sjenica (*Figure 29*).

Based on the percentile method, winter precipitation sums were in rainy category in most of Serbia, very rainy in western and some parts of northern and central Serbia, and extremely rainy in Loznica, Sjenica and Kopaonik (*Figure 30*).

Based on the tercile method, precipitation sums were in the rainy category in almost entire Serbia and normal category in Kragujevac, Kraljevo and Krusevac.

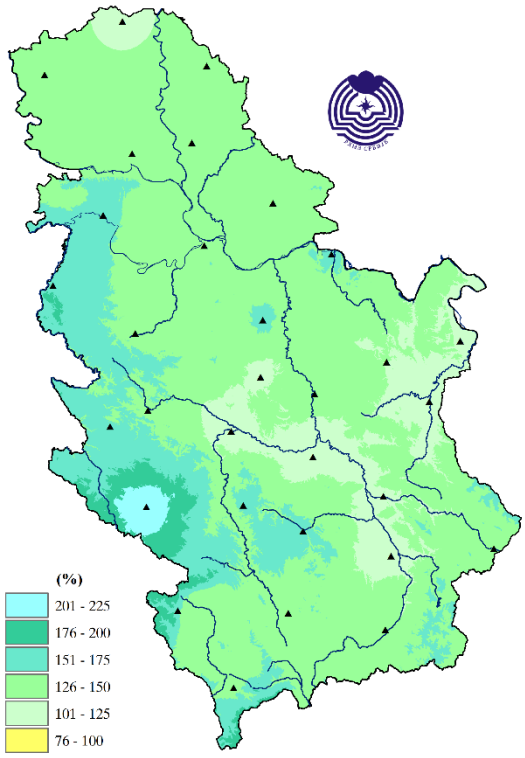

Figure 29. Spatial distribution of winter precipitation sums in percentage of the 1961-1990 normal

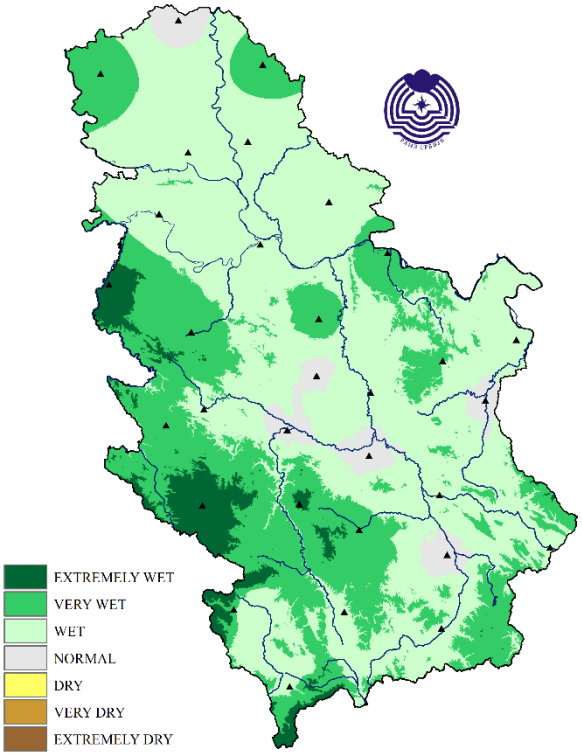

Figure 30. Winter precipitation sums according to the percentile method

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