II. DEL:
PREGLED HIDROLOŠKIH RAZMER V LETU 2008

PART II:
REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2008

PODNEBNE ZNAČILNOSTI LETA 2008

Mag. Florjana Ulaga

Podnebje so leta 2008 zaznamovali neobičajno topla januar in februar, neobičajno hladen september, pomanjkanje padavin oktobra in večino novembra ter zelo izdatne padavine v decembru. Poletje so zaznamovala števila močna neurja. Povprečna letna temperatura zraka je bila v vsej državi nad dolgoletnim povprečjem.

Podrobneje so podnebne značilnosti leta 2008 opisane v mesečnih biltenih Agencije RS za okolje.

Padavine

V letu 2008 je bilo, razen na vzhodnem in jugozahodnem delu, v večjem delu Slovenije preseženo dolgoletno povprečje padavin (sliki 1 in 2). Presežek je bil največji v severozahodni Sloveniji. Največ padavin so namerili na Kredarici, 2180 mm. V pretežnem delu države je padavin najbolj primanjkovalo v začetku leta in septembra (slika 3). Januar in februar sta bila povsod podpovprečno namočena, v Murski Soboti je primanjkljaj znašal celo 87 %. Padavine v marcu in aprilu so v večjem delu presegale obdobno povprečje, maja in junija pa je bila količina padavin ponovno podpovprečna. Julij je bil v večjem delu države nadpovprečno namočen. Močna neurja so povzročala poplave in zemeljske plazove ter gospodarsko škodo, tudi na gozdovih. Na Goriškem je julijski presežek znašal kar 130 %. Izjemno malo padavin je bilo izmerjenih julija v Portorožu, kjer je bil primanjkljaj 42-odstoten glede na dolgoletno povprečje. V avgustu je v povprečju padla običajna količina padavin, september pa je bil izredno suh, kar je povzročilo daljše obdobje nizkih voda slovenskih rek. V osrednji Sloveniji in na Obali je primanjkljaj znašal več kot 70 %. Tudi oktober je bil, razen v visokogorju, zelo suh, kar je povzročilo še dodatno upadanje pretokov rek. Obdobje s podpovprečno količino padavin se je nadaljevalo v november; nadpovprečno padavin je novembra padlo le v jugozahodnem delu države. Decembra so bile padavine povsod po državi nad dolgoletnim povprečjem.

2008 CLIMATE CONDITIONS

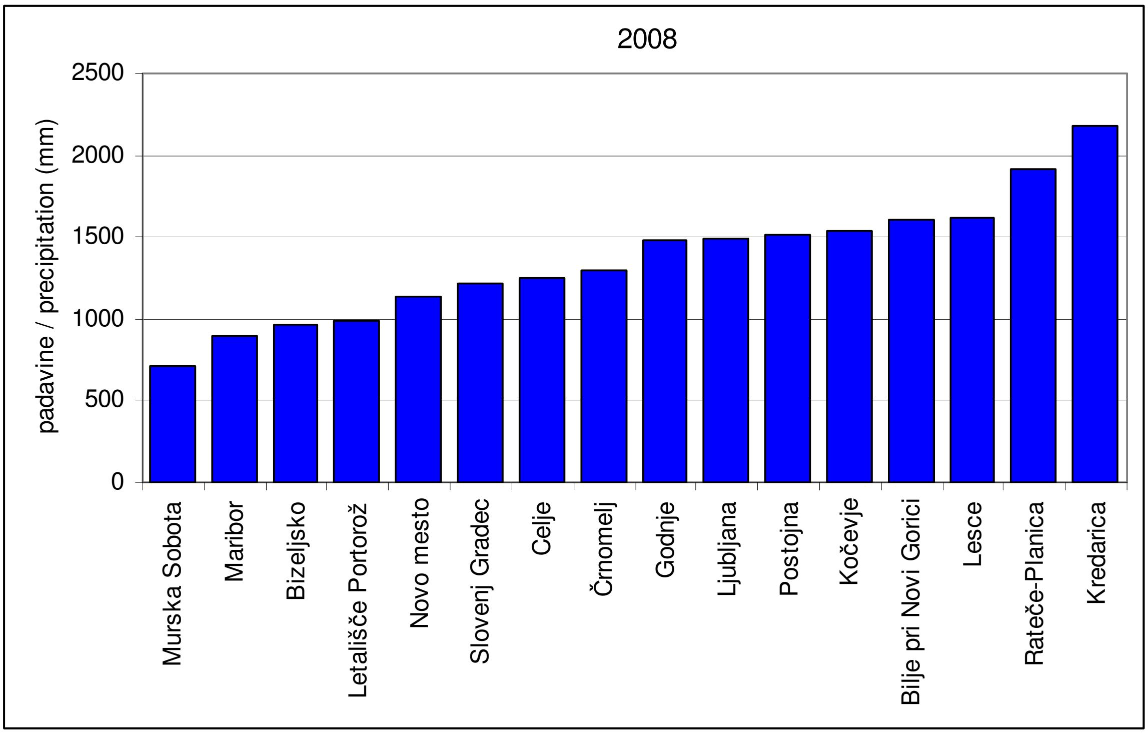
Florjana Ulaga, MSc

The climate in the year 2008 was marked by an unusually warm January and February, uncharacteristically cold September, precipitation shortage in October and most of November and substantial precipitation in December. The summer was marked by several severe thunderstorms. The annual mean air temperature was above the multi-annual average across the country.

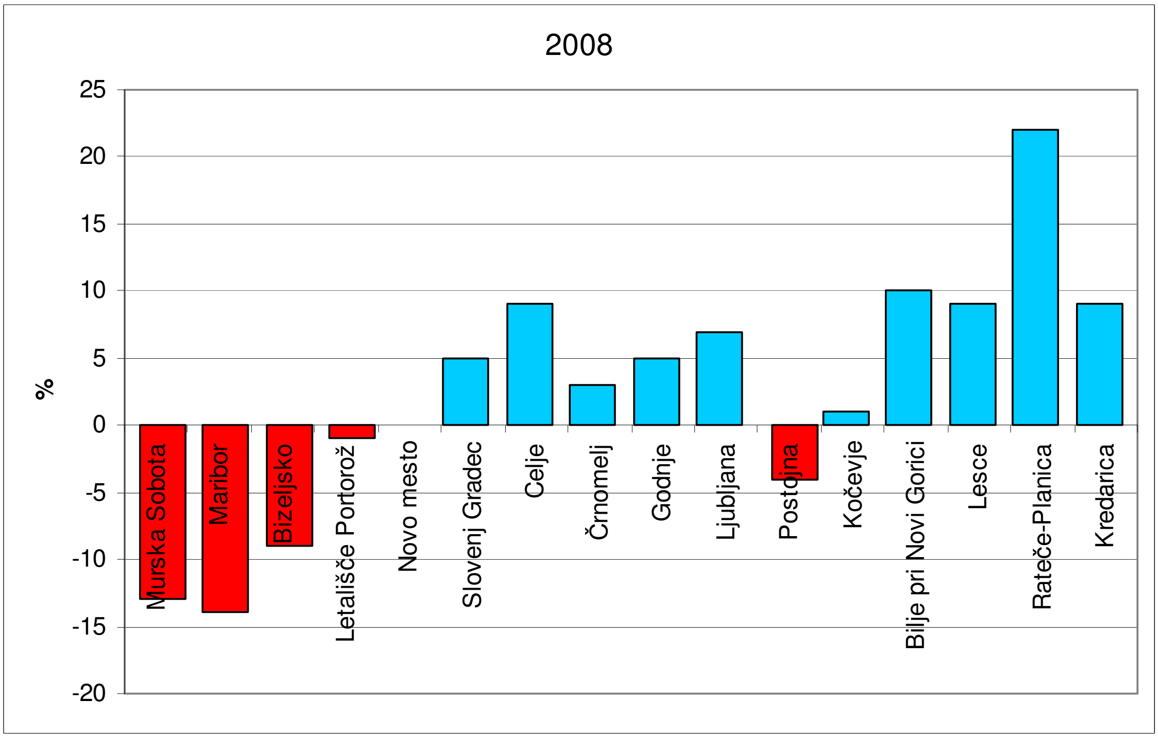
The climate conditions in the year 2008 are described in detail in the monthly bulletin of the Environmental Agency of the Republic of Slovenia.

Precipitation

In most parts of Slovenia, save for the eastern and south-western part, the multi-annual average of precipitation (Figure 1 and 2) was exceeded in 2008. The precipitation surplus was the largest in north-western Slovenia. The greatest precipitation values were recorded on Kredarica, 2180 mm. In most of the country a precipitation deficit was recorded at the beginning of the year and in September (Figure 3). January and February recorded below average precipitation across the country, with the deficit even reaching 87% in Murska Sobota. Precipitation in March and April in most parts exceeded the periodical average, while the precipitation level yet again dropped below the average in May and June. July recorded above-average precipitation in most parts of the country. Severe thunderstorms caused floods and landslides and great economic damage to the forests too. The July surplus in Goriško (Gorica area) amounted to 130%. Extremely low precipitation was recorded in July in Portorož, where the deficit stood at 42% compared to the multi-annual period average. August was average in terms of precipitation while September was extremely dry resulting in a longer period of low water levels in Slovenian rivers. The central part of Slovenia and the Coast recorded a deficit exceeding 70%. Even October was, save for the high mountain area, very dry, which caused an additional decline in the river discharges. The period of below-average precipitation continued into November, with the only above-average precipitation levels recorded in the south-western part of the country. In December, precipitation was above the multi-annual period across the country.



Slika 1: Višina padavin 2008 na izbranih postajah
Figure 1: The precipitation level in 2008 at the selected stations



Slika 2: Odstopanje višine padavin v letu 2008 od povprečja obdobja 1961–1990 na izbranih postajah
Figure 2: Precipitation level discrepancy in 2008 from the 1961-1990 reference period average at the selected stations

Slika 3: Mesečna višina padavin v letu 2008 v primerjavi s povprečjem obdobja 1961–1990 in odklon mesečnih padavin od obdobnega povprečja

Figure 3: Monthly volume of precipitation in 2008 compared to the multi-annual 1961–1990 reference period and the monthly precipitation deviation from the periodical average

Izredni padavinski dogodki

Leto 2008 si bomo zapomnili predvsem po izrazitih julijskih neurjih in izdatnih decembrskih padavinah. Julija so v večjem delu države divjala neurja, ki so povzročala poplave, zemeljske plazove in škodo na kmetijskih in gozdnih površinah. Delež padavin je bil močno presežen v osrednjem delu zahodne Slovenije ter v osrednjem delu države. Največ padavin so julija namerili v Kamniški Bistrici (311 mm), presežek dolgoletnega povprečja pa je bil največji v Biljah pri Novi Gorici (129 %).

Decembra je bilo dolgoletno povprečje padavin preseženo v vsej državi. Med 10. in 11. decembrom je Slovenijo zajelo močno deževje. Največ padavin je padlo v jugozahodnem delu – v porečju reke Reke, v zgornjem Posočju in na Goriškem. V Ilirski Bistrici so v decembru namerili 372 mm padavin, kar presega obdobno povprečje kar za 215 %. Reka Reka je močno poplavljala. Glede na sredozemski pretočni režim je bil padavinski in s tem pretočni višek decembra 2008 zelo izrazit. Tudi v osrednji Sloveniji je bila količina decembrskih padavin močno povečana, v Ljubljani so namerili 225 mm, kar presega obdobno povprečje za 123 %. V južnem delu države je bilo padavin nekoliko manj, a je bil presežek še vedno več kot 70 %. Najmanjše odstopanje padavin od dolgoletnega povprečja je bilo v vzhodni Sloveniji. Obilne padavine so povzročale poplave, ki so zaradi nizkih temperatur in izdatne namočenosti zunaj vegetacijske dobe dolgo vztrajale ter se na kraških poljih Notranjske zadržale celo do novega leta.

Extreme precipitation events

The year 2008 shall be remembered mainly for the severe thunderstorms in July and heavy precipitation in December. Thunderstorms raged in July in most parts of the country causing floods, landslides and damage to the rural and forest areas. The precipitation levels were greatly exceeded in the central part of western Slovenia and in central Slovenia. The highest levels were recorded in Kamniška Bistrica (311 mm) in July while the multi-annual average was exceeded by the highest amount in Bilje pri Novi Gorici (129%).

The multi-annual average of precipitation was exceeded across the country in December. Slovenia was hit by heavy rain between 10 December and 11 December. The largest share fell in the south-western part – in the river basin of the Reka River, in the upper part of Posočje and in Goriško. 372 mm of precipitation was recorded in Illirska Bistrica in December, exceeding the periodical average by no less than 215%. The Reka River flooded extensively. With regard to the Mediterranean discharge regime, the precipitation and consequently the discharge surplus was very noticeable in December 2008. Even in central Slovenia the volume of precipitation greatly increased in December (225 mm recorded in Ljubljana), exceeding the periodical average by 123%. The southern part of the country had slightly less precipitation, with the surplus still reaching more than 70%. The smallest precipitation deviation from the multi-annual average was recorded in eastern Slovenia. Extensive rainfall caused floods which, due to low temperatures and noticeably water-drenched land outside the vegetation period, persisted in the area for quite some time, even remaining on the karstic fields of Notranjska until the New Year.

Meritev visoke vode Reke v Trnovem 12. decembra 2008 (foto: Arhiv ARSO)
Measuring the high water level of the Reka River in Trnovo on 12 December 2008 (Photo: EARS Archives)

Preglednica 1: Višina decembrskih padavin in odstopanje od obdobnega povprečja
Table 1: December precipitation levels and deviation from the periodical average

Postaja	Padavine *Precipitation (mm)*	Odstopanje od povprečja *Precipitation anomaly %*
Ilirska Bistrica	372	215
Bilje	291	147
Ljubljana	225	123
Portorož	161	99
Novo mesto	132	79
Kredarica	205	71
Murska Sobota	59	32

Temperatura zraka

Tako kot za padavine velja tudi za temperature – razlike med pokrajinami so lahko v posameznih mesecih velike. Povprečna temperatura leta 2008 je bila nad dolgoletnim povprečjem, saj je bilo povsod po državi topleje od dolgoletnega povprečja (slika 5). V Ljubljani je povprečna letna temperatura znašala 11,6 °C, v Murski Soboti 11,2 °C, na Kredarici –0,6 °C, na Obali pa 14 °C.

Odkloni mesečnega povprečja temperature so bili, razen septembra, opazno nad dolgoletnim povprečjem. Največji odklon je bil januarja v Murski Soboti (4,1 °C), najhladnejši v primerjavi z dolgoletnim povprečjem pa je bil september na Kredarici (slika 4).

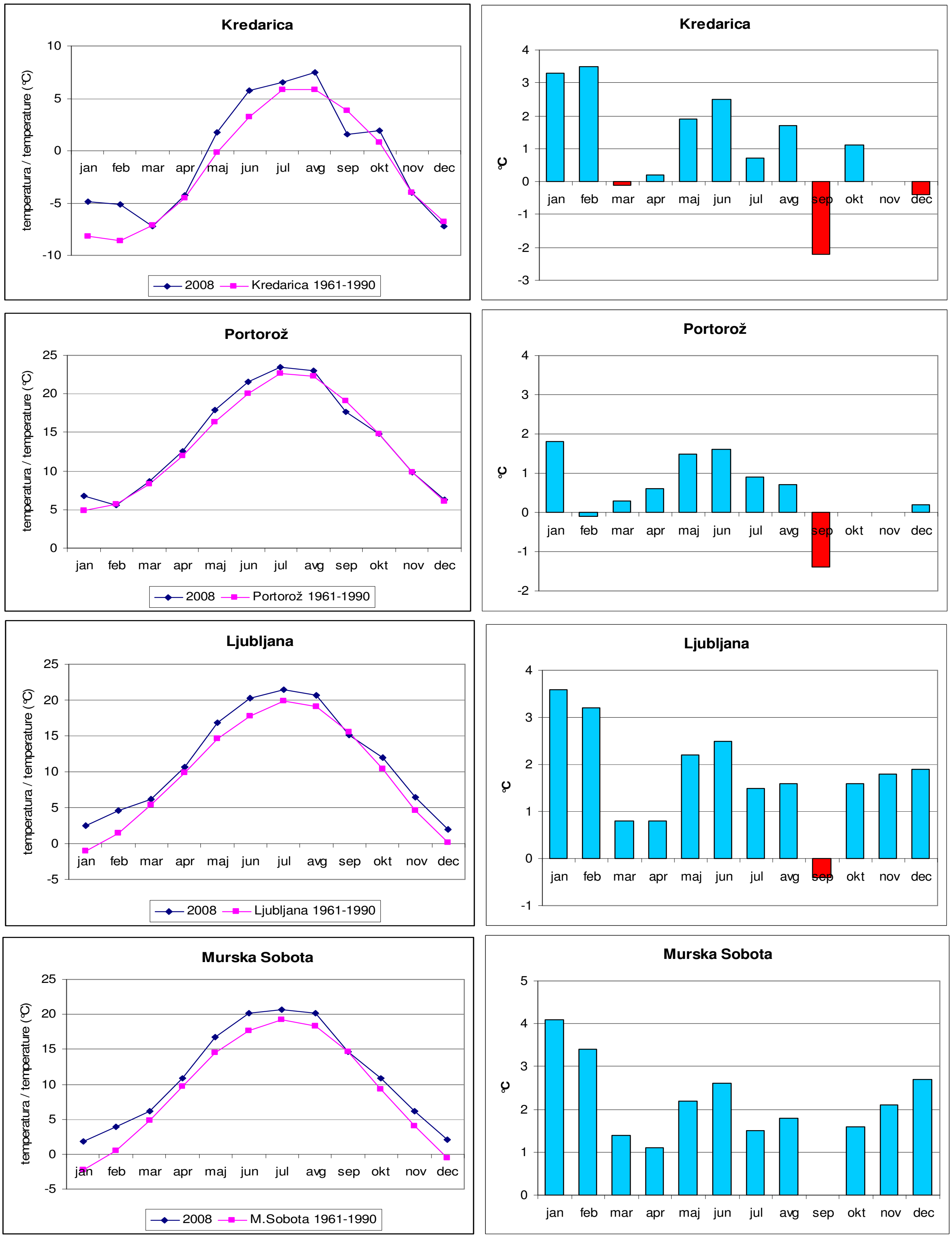
Čeprav v zadnjem desetletju opažamo naraščanje temperatur zraka, je leto 2008 po najnižji in najvišji izmerjeni temperaturi močno zaostajalo za rekordnimi vrednostmi v zadnjih desetletjih. Najnižji absolutni minimum je bil v Ljubljani leta 1956 (–23,3 °C), v letu 2008 pa se je temperatura spustila le na –7,7 °C. Najvišji absolutni maksimum je bil v Ljubljani leta 1950 (38,8 °C), v letu 2008 pa se je temperatura povzpela na 32,7 °C. Pri trajanju sončnega obsevanja, podobno kot pri temperaturah, v dolgoletnem obdobju opazimo trend naraščanja. Leto 2008 je bilo v Ljubljani že dvanajsto zapored z nadpovprečnim trajanjem sončnega obsevanja; sonce je sijalo 1824 ur, kar je 7 % več od dolgoletnega povprečja. Tudi v Murski Soboti je sonce sijalo nadpovprečno dolgo, na Obali povprečno in na Kredarici podpovprečno.

Air temperature

The same applies for temperatures as for precipitation – the differences between the regions can be great in individual months. The 2008 average temperature was above the multi-annual average, as it was warmer than the multi-annual average across the country (Figure 5). The average annual temperature recorded for Ljubljana amounted to 11.6°C, Murska Sobota 11.2°C, Kredarica -0.6°C, and 14°C on the Coast.

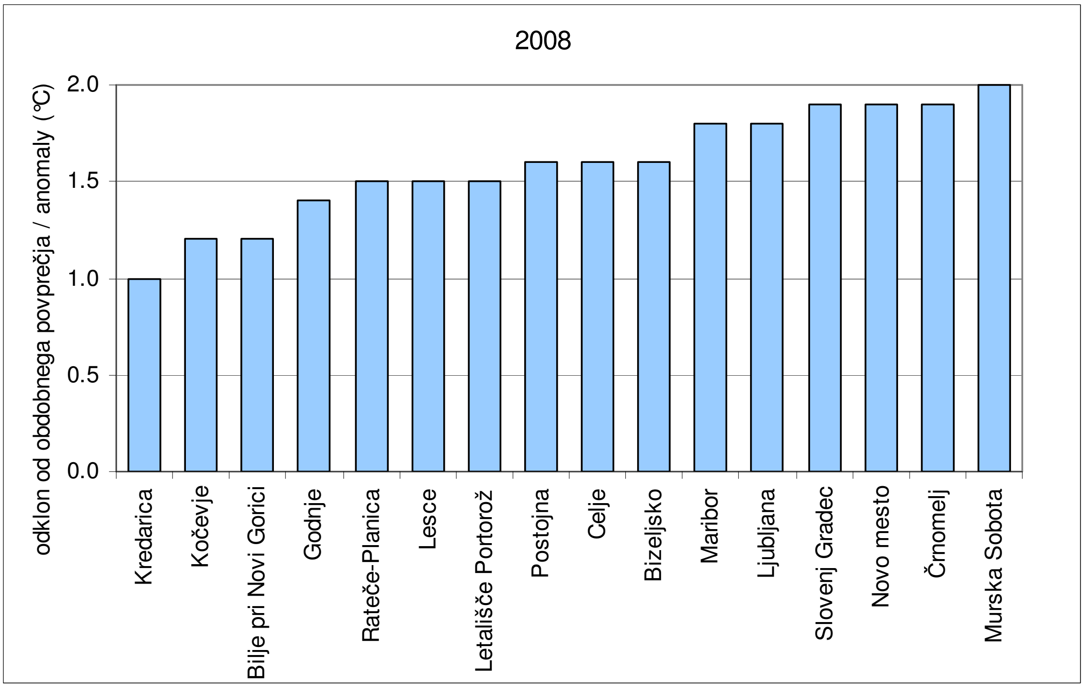
The monthly average temperature deviations, save for September, were significantly above the multi-annual average. The greatest deviation was recorded in January in Murska Sobota (4.1°C), while the coldest month compared to the multi-annual average was recorded in September on Kredarica (Figure 4).

Even though we have noticed an increasing air temperature tendency in the past decade, the year 2008 was lagging behind the record values from the past decades in terms of the lowest and highest recorded temperature. The lowest absolute minimum was recorded in 1956 in Ljubljana (-23.3°C), while the temperature dropped to a mere -7.7°C in the year 2008. The highest absolute maximum recorded in Ljubljana in 1950 stood at 38.8°C, while the temperature rose to 32.7°C in 2008. The increased duration of solar radiation, just like with temperature tendencies, has been evident during the multi-annual period. The year 2008 has been the twelfth consecutive year with above-average duration of solar radiation in Ljubljana, recording 1,824 hours of sunlight, representing 7% more than the multi-annual average. Even in Murska Sobota the sun shone longer on average. Average and below-average duration of sun exposure was recorded on the Coast and on Kredarica, respectively.



Slika 5: Povprečna mesečna temperatura zraka v letu 2008 v primerjavi s povprečjem obdobja 1961–1990 in mesečni odkloni temperature v letu 2008 od povprečja obdobja 1961–1990

Figure 5: Average monthly air temperature in 2008 compared to the 1961–1990 reference period average and monthly temperature deviation in 2008 from the 1961–1990 reference period average



Slika 4: Odklon povprečne letne temperature zraka od povprečja obdobja 1961–1990 na izbranih postajah
Figure 4: Average annual air temperature deviation from the 1961–1990 reference period average at the selected stations

Decembrske padavine in poplava na Planinskem polju (foto: Florjana Ulaga)
December precipitation and flooding of Planinsko polje (photo: Florjana Ulaga)

A. POVRŠINSKE VODE

VODOSTAJI IN PRETOKI REK

Igor Strojan

Opis hidrološkega stanja v letu 2008 je narejen na podlagi analize preverjenih podatkov petnajstih izbranih reprezentativnih vodomernih postaj. Te so nekako enakomerno porazdeljene po celotnem območju države. Izbor vključuje tako večje kot manjše vodotoke, reke s hudourniškim in kraškim značajem ter tudi reke, kjer je naravni režim spremenjen zaradi obratovanja hidroelektrarn. Primerjave pretokov z obdobnimi vrednostmi se nanašajo na priporočen dolgoletni niz podatkov Svetovne meteorološke organizacije (WMO) 1971–2000, kar omogoča mednarodno primerjavo hidroloških stanj. Poglavje o mesečnih deležih letnih pretokov in pretočnih režimih obravnava odstopanja od splošno znanih pretočnih režimov posameznih rek, ki so sicer v Sloveniji dokaj raznoliki. Značilen primer je na primer pretočni režim reke Mure, ki se napaja v avstrijskem visokogorju in je zato njena vodnatost v nasprotju z večino ostalih rek, katerih vodnatosti so največje spomladi in jeseni, največja v poletnem obdobju. V zadnjem poglavju, kjer je opisan kronološki pregled razmer na rekah v posameznih mesecih leta, je opis razmer povzet iz prispevkov o pretokih rek, ki so objavljeni v mesečnih biltenih Agencije Republike Slovenije za okolje (http://www.arso.gov.si/). Fotografije so večinoma delo sodelavcev ARSO, ki opravljajo dodatne hidrološke meritve ali vzdržujejo merilno opremo na vodomernih postajah.

V povprečju je bila leta 2008 vodnatost rek zelo podobna povprečni vodnatosti v dolgoletnem primerjalnem obdobju. Značilni za to leto so manjša odstopanja od dolgoletnih povprečij vodnatosti vse do septembra, hidrološko sušna jesen in zelo vodnat december, v katerem so reke tudi močno poplavljale. Celoletna vodnatost je bila geografsko dokaj neenakomerno porazdeljena. V zahodni polovici države je bila vodnatost večja kot v vzhodni (slika 2). Povprečni letni pretoki so bili v severozahodnem delu države največji, v severovzhodnem pa najmanjši. Tako je na reki Soči v Solkanu preteklo 20 % vode več kot navadno, na Ledavi v Polani pa kar 48 % manj kot navadno. Nadpovprečno vodnata je bila tudi Sava v večjem delu svojega toka.

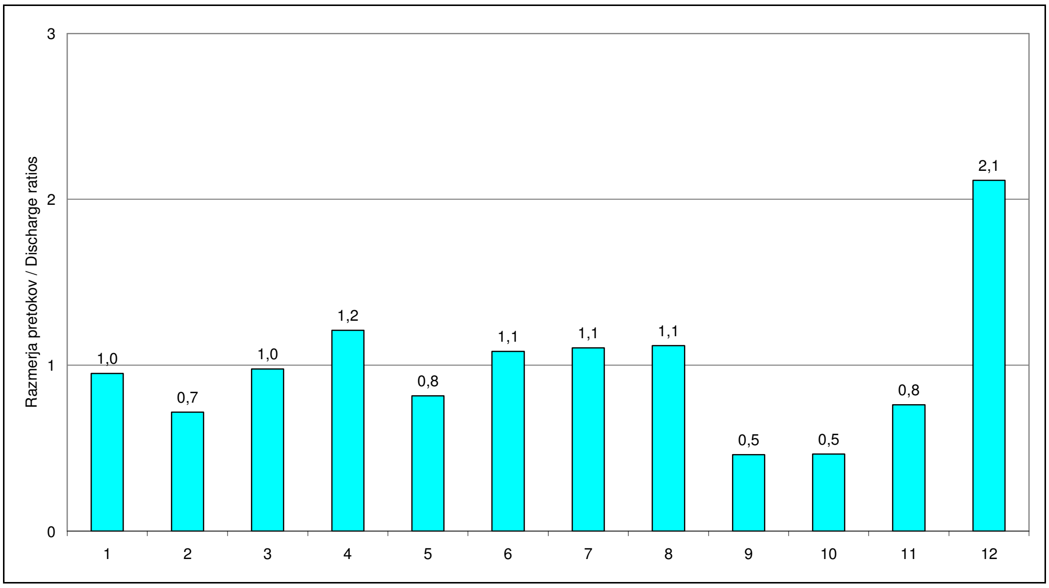
A. SURFACE WATERS

WATER LEVELS AND RIVER DISCHARGES

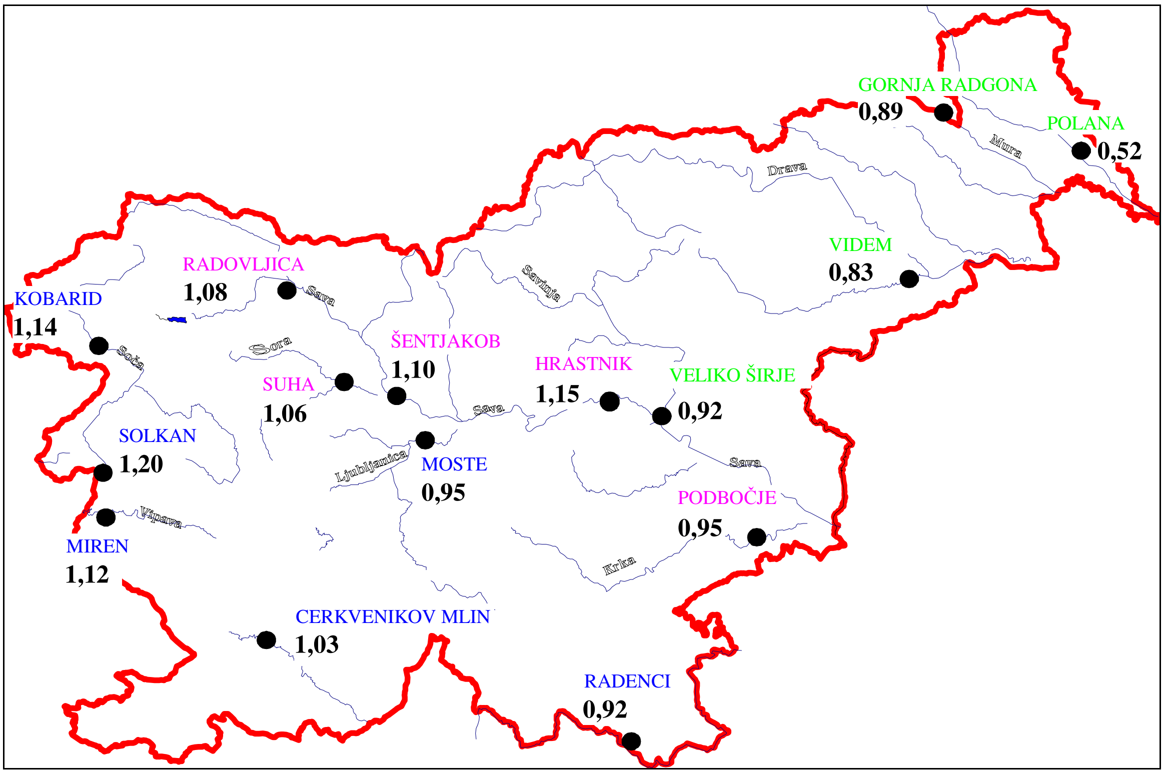
Igor Strojan

The description of hydrological conditions for 2008 was prepared on the basis of data analysis for 15 selected representative water gauging stations, more or less evenly distributed on the entire territory of the Republic of Slovenia. The selection includes major and minor streams, rivers with torrential and karstic character, as well as rivers for which the natural regime was changed due to the operation of hydroelectric power plants. The comparison of discharges with periodical values refers to the recommended multi-annual reference period (1971–2000) of data provided by the World Meteorological Organisation (WMO), enabling the international comparison of hydrological conditions. The chapter on monthly shares of annual discharges and discharge regimes discusses deviations from generally known discharge regimes of individual rivers which are otherwise quite diverse in Slovenia. A characteristic example is the discharge regime of the Mura River, which is fed in the Austrian high mountain range, and thus its water level is the highest in the summer period, in contrast to the majority of other rivers of which water levels are the highest in spring and autumn. In the last chapter containing the chronological overview of conditions on rivers in individual months of the year, the description of the conditions is summarised from pieces (articles) on river discharges published in the monthly bulletins of the Environmental Agency of the Republic of Slovenia (http://www.arso.gov.si) The photographs are mainly the work of ARSO colleagues performing additional hydrological measurements or maintaining the gauging equipment at the water gauging stations.

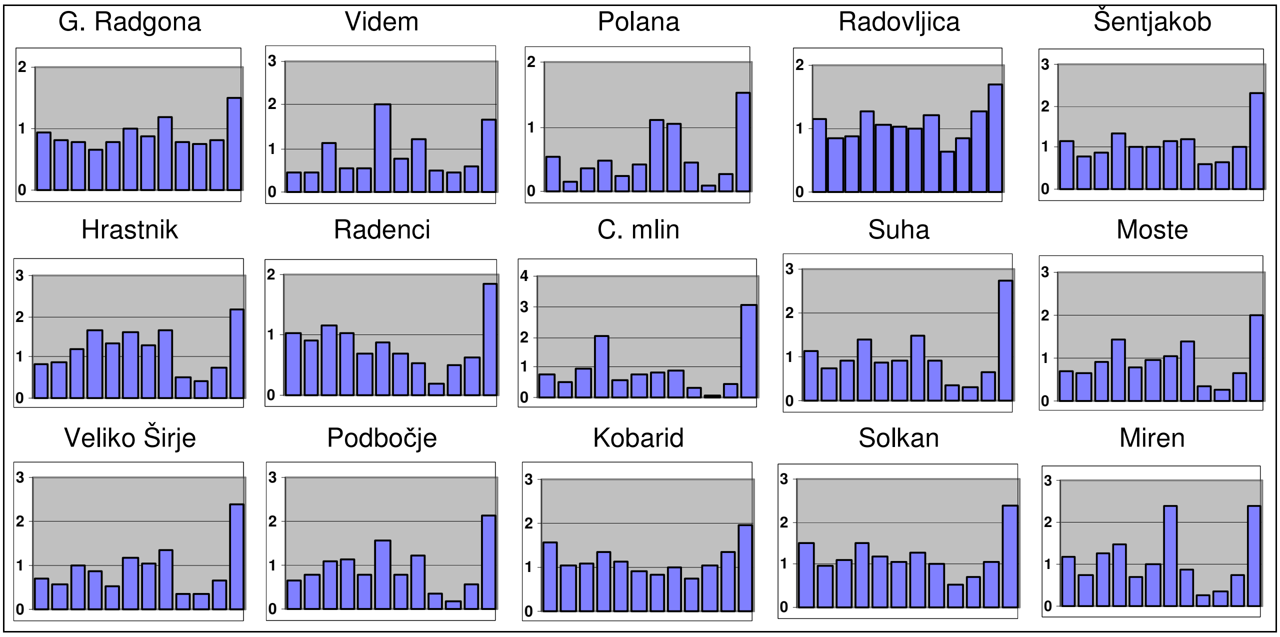
The average annual river stage in 2008 was very similar to the average stage during the multi-annual reference period. The year 2008 was characterised by minor deviations from the multi-annual water level averages up to September, the hydrological drought in autumn and abundant river stages in December, when the rivers flooded extensively. The river stage through the year was geographically distributed quite unevenly. The western half of the country recorded higher river levels compared to its eastern part (Figure 2). The average annual discharges in the north-western part of the country were the highest, while the north-eastern part recorded the lowest levels. Thus, the river discharges were 20% higher on average in Solkan on the Soča River, while recording 48% lower values on average in Polana on the Ledava River. Sava also reached above-average river stage levels in the majority of its stream.



Slika 1: Razmerja med srednjimi mesečnimi pretoki v letu 2008 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah (glej sliko 2).
Figure 1: Ratios between mean monthly discharges in 2008 and periodical mean monthly discharges Ratios are calculated as an average of ratios at selected stations (see Figure 2)

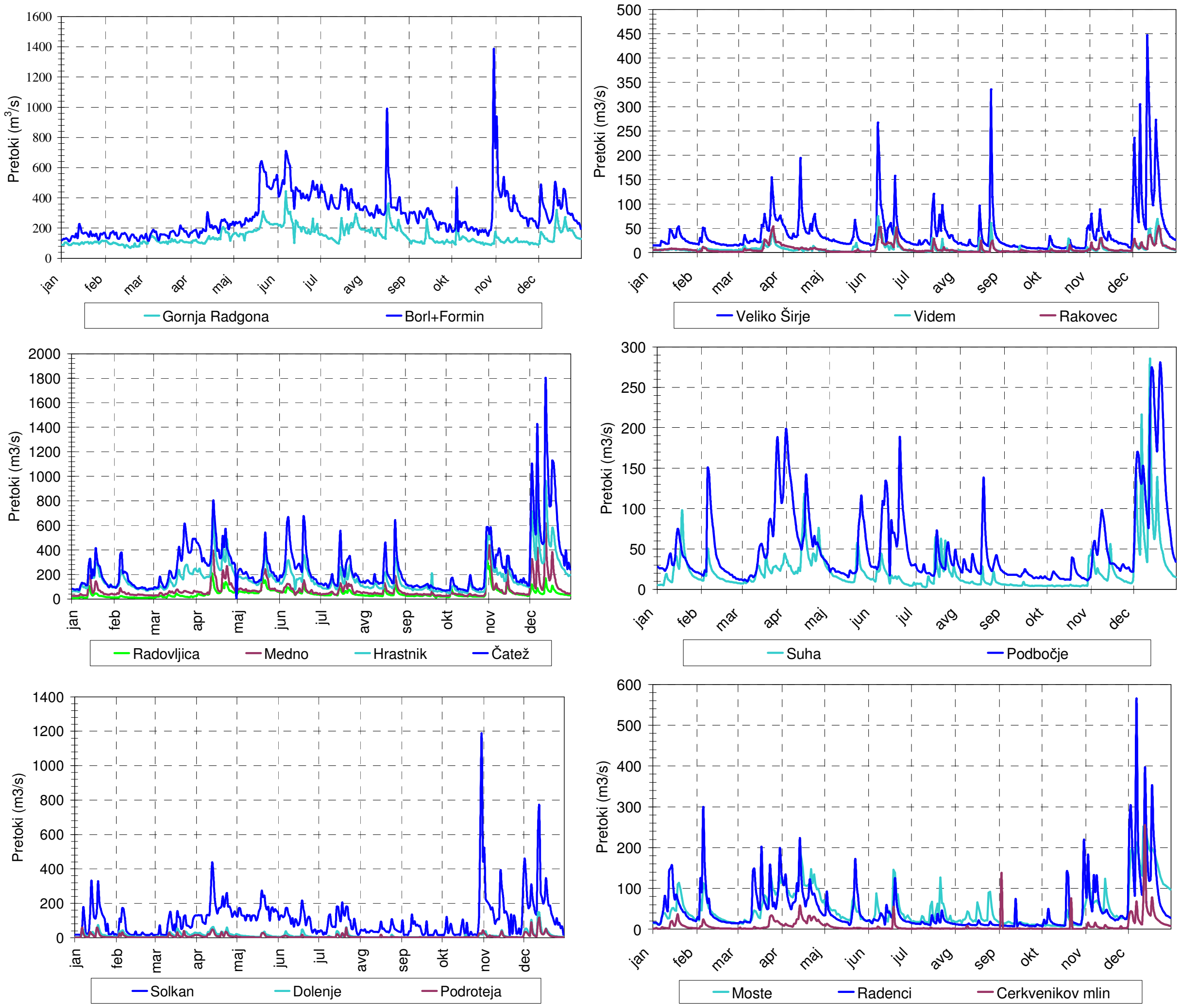


Slika 2: Razmerja med srednjimi letnimi pretoki leta 2008 in srednjimi letnimi pretoki v dolgoletnem obdobju 1971–2000 na slovenskih rekah
Figure 2: Ratios between the mean annual discharges in 2008 and mean annual discharges in the multi-annual period (1971-2000) on Slovenian rivers



Slika 3: Razmerja med srednjimi mesečnimi pretoki rek v letu 2008 in obdobju 1971–2000. Vrednost razmerja 1 pomeni, da je bil v določenem mesecu leta 2008 srednji mesečni pretok enak povprečju srednjih mesečnih pretokov v dolgoletnem obdobju.

Figure 3: Ratios between mean monthly discharges of rivers in 2008 and the reference period (1971-2000). Ratio value 1 means that the mean monthly discharge of a certain month in 2008 is equivalent to the average mean monthly discharges during the multi-annual period.



Slika 4: Pretoki rek v letu 2008

Figure 4: River discharges in 2008

Primerjava karakterističnih pretokov z dolgoletnim obdobjem

Največji pretoki so bili 10 % manjši kot v dolgoletnem primerjalnem obdobju (slika 5 in preglednica 1). Visokovodni konici na Reki in na Soči v zgornjem toku sta bili največji. Najnižje visokovodne konice so bile na Ledavi v Polani. Pretoki so bili v veliki večini največji decembra. Na Soči so bili pretoki največji konec oktobra, na Muri in Dravinji pa avgusta.

Srednji letni pretoki rek so v povprečju le malo odstopali od dolgoletnih povprečij. Najmanjši pretoki v letu so bili 4 % manjši od povprečnih najmanjših pretokov iz dolgoletnega primerjalnega obdobja. Najmanjši je bil pretok 24. oktobra na Ledavi v Polani, ki je bil 42 % manjši od povprečja najmanjših obdobnih pretokov. Pretoki rek so bili sicer večinoma najmanjši oktobra. Sava v Radovljici in Šentjakobu in Soča v Solkanu sta imeli najmanjše pretoke v prvih dneh leta 2008.

Mesečni deleži letnih pretokov leta 2008 in pretočni režimi

Mesečni deleži letnih pretokov vse do jeseni niso mnogo odstopali od mesečnih deležev pretokov v obdobju 1971–2000. Septembra, oktobra in novembra so bili deleži mesečnih pretokov občutno manjši kot navadno. Decembra, ko so bile reke zelo vodnate, je bil mesečni delež pretokov leta 2008 enkrat večji kot v dolgoletnem obdobju (slika 6).

Odstopanje od ustaljenega letnega pretočnega režima je bilo najmanjše na Muri v Gornji Radgoni, Soči v Kobaridu in Savi v Radovljici. Presežki in primanjkljaji v posameznih mesecih na Muri niso bili večji kot 6 % na Soči, na Savi pa ne večji kot 7 %. V posameznih mesecih sta najbolj odstopala mesečna presežka in primanjkljaja na reki Reki na vodomerni postaji Cerkvenikov mlin. Oktobra je bil primanjkljaj 10 %, decembra pa presežek 25 % (slika 7).

Comparison of characteristic discharges with the multi-annual reference period

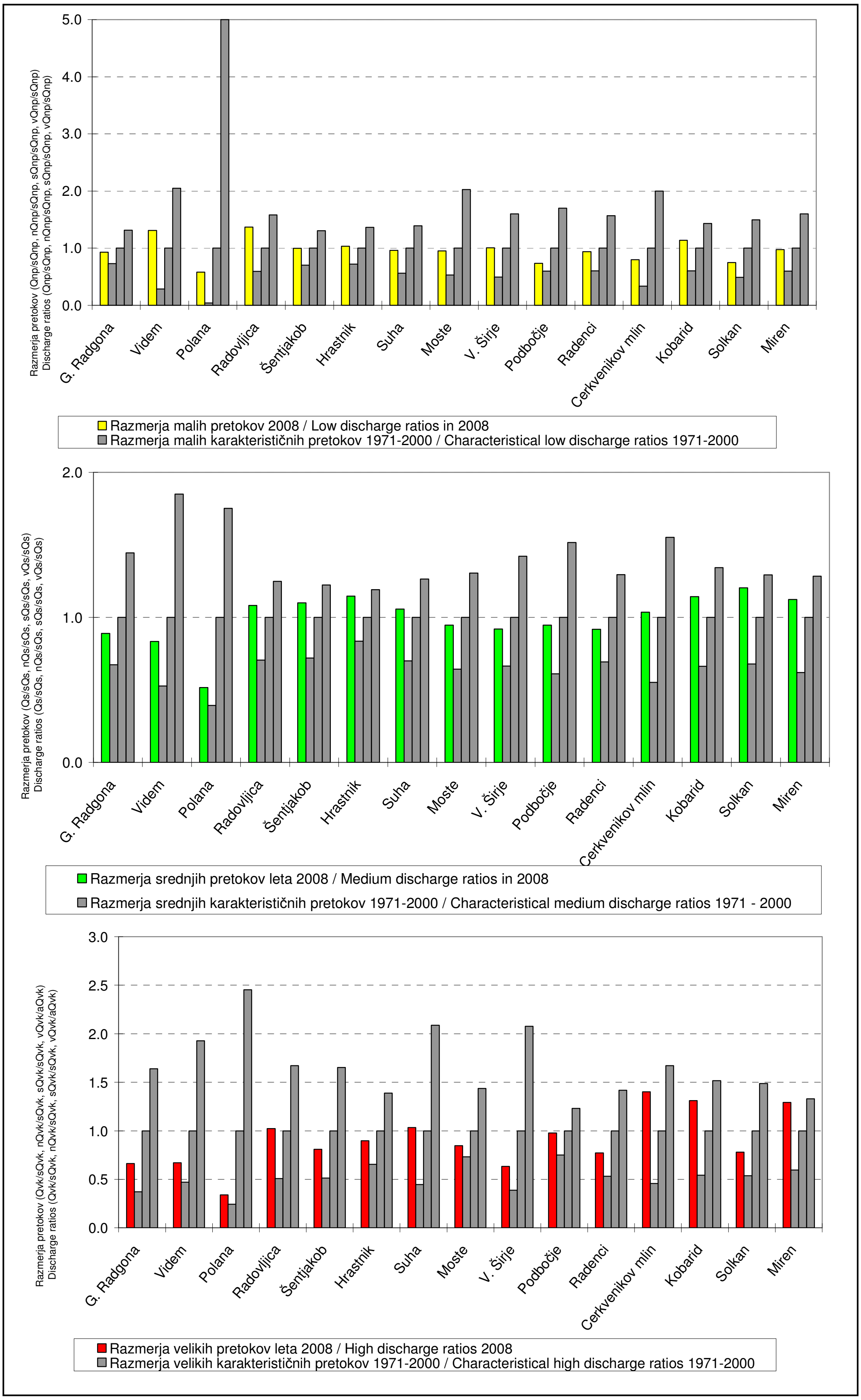
All of the highest discharges were 10% lower compared to the multi-annual reference period (Figure 5 and Table 1). High-water peaks on the Reka and Soča rivers were the highest in the upper reach. The lowest high-water peaks were recorded in Polana on the Ledava River. Discharges were the highest in December for the majority of the rivers. The highest discharges on the Soča River were recorded at the end of October, while the Mura and Dravinja rivers had high discharges in August.

The mean annual river discharges on average only slightly deviated from the multi-annual average. The lowest annual discharges were 4% lower compared to the average lowest discharges of the multi-annual reference period. The lowest discharge was recorded on 24 October in Polana on the Ledava River, 42% lower than the average lowest periodical discharges. The river discharges were generally the lowest in October. The discharges in Radovoljica on the Sava River and in Solkan on the Soča River were lowest during the first days of the year (2008).

Monthly shares of annual discharges in 2008 and discharge regimes

Up until autumn, the monthly shares of annual discharges did not significantly deviate from the monthly shares recorded in the 1971-2000 reference period. In September, October and November the shares of monthly discharges were significantly lower than usual. In December, with the rivers at a high water level, the monthly share of discharges in 2008 was twice as high as during the multi-annual period (Figure 6).

Derogations from the usual annual discharge regime were the lowest in Gornja Radgona on the Mura River, in Kobarid on the Soča River and in Radovljica on the Sava River. The surpluses and shortages in individual months on the Mura River were no higher than 6% on the Soča River and no higher than 7% on the Sava River. The monthly surpluses and shortages in individual months deviated the most on the Reka River at the Cervenikov mlin water gauging station. In October there was a 10% shortage, while in December a 25% surplus was recorded (Figure 7).

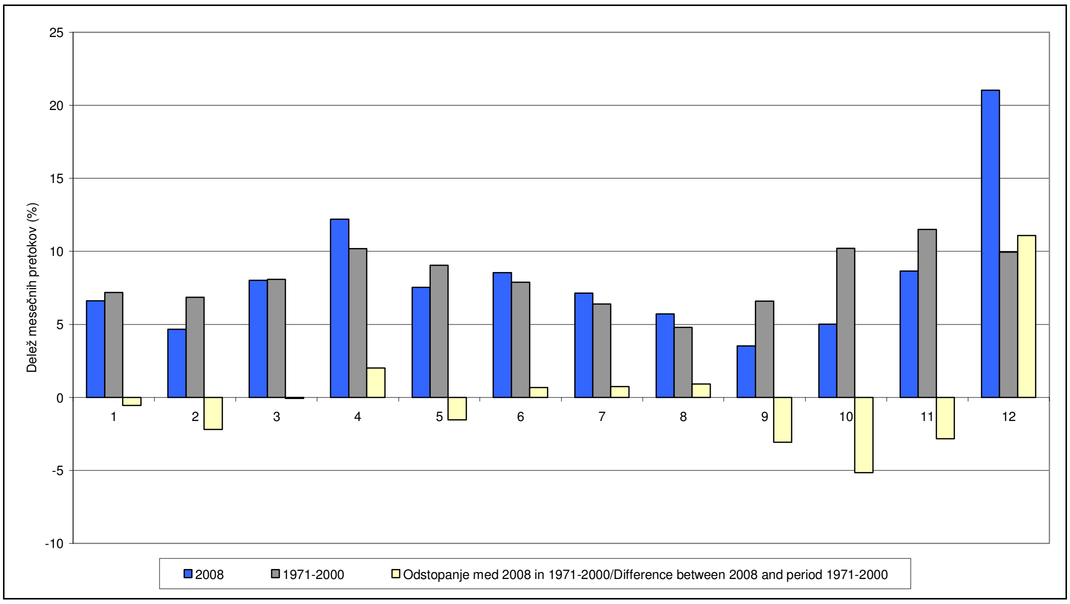


Slika 5: Razmerja malih, srednjih in velikih pretokov v letu 2008 ter razmerja karakterističnih pretokov obdobja 1971–2000. Vrednosti so podane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.
Figure 5: Ratios of low, mean and high discharges in 2008 and ratios of characteristic discharges during the reference period (1971–2000). Values are relative with regard to the average values of low, mean and high periodical discharges

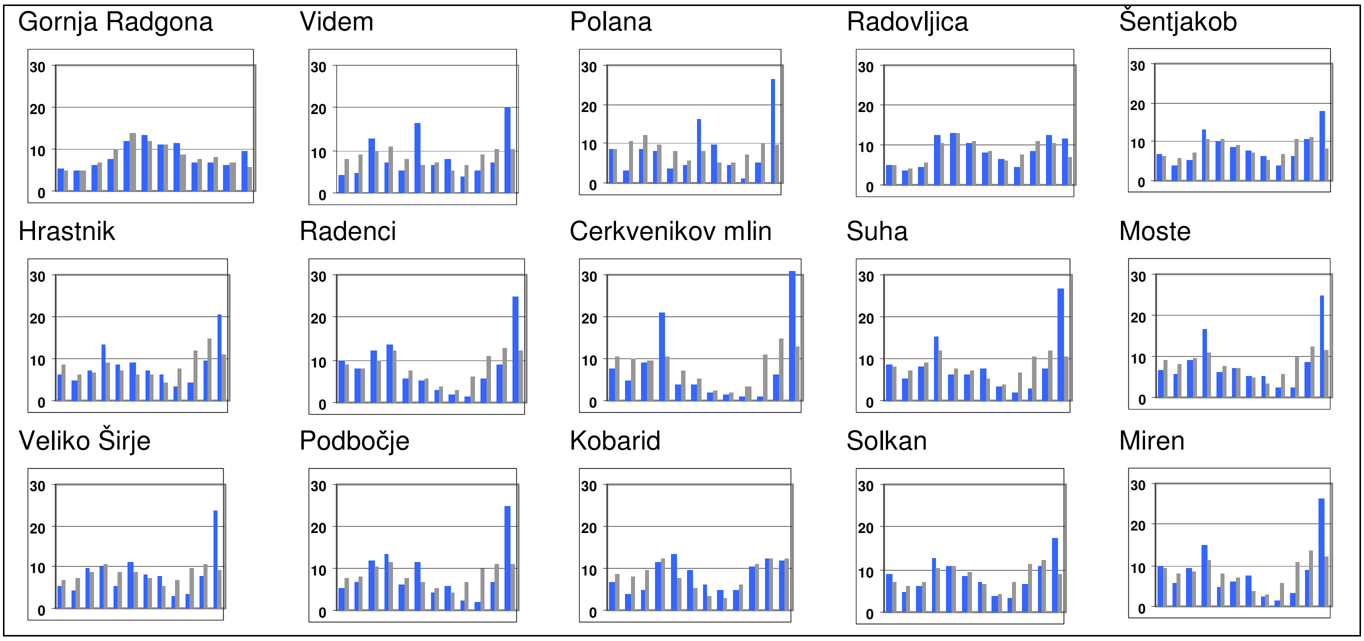
Preglednica 1: Značilni pretoki v letu 2008 in obdobju 1971–2000
Table 1: Characteristic discharges in 2008 and during the reference period (1971-2000)

Reka	Postaja	2008			1971 - 2000	
River	*Station*	Qnp		nQnp	sQnp	vQnp
		m^3/s	Dan	m^3/s	m^3/s	m^3/s
Mura	G. Radgona	69,0	18.2.	45,3	62,1	81,7
Drava	Borl+Formin	112	6.1.	78,9	164	299
Dravinja	Videm	1,3	21.9.	0,6	2,1	4,3
Savinja	Veliko Širje	7,7	1.10.	4,7	9,5	15,2
Sotla	Rakovec	1,0	31.5.	0,1	0,9	1,8
Sava	Radovljica	8,0	1.1.	5,0	8,4	13,3
Sava	Medno	25,0	16.10.	19,1	27,1	35,3
Sava	Hrastnik	48,0	3.10.	32,8	45,6	62,2
Sava	Čatež	67,1	15.10.	50,8	73,0	102
Sora	Suha	2,5	7.7.	2,14	3,8	5,3
Krka	Podbočje	10,0	4.3.	6,2	10,4	17,7
Kolpa	Radenci	7,4	10.9.	3,5	5,8	9,1
Ljubljanica	Moste	6,8	15.10.	4,1	7,7	15,6
Soča	Solkan	15,0	25.2.	9,6	19,6	29,3
Vipava	Dolenje	1,8	29.9.	1,5	1,8	2,2
Idrijca	Podroteja	1,6	27.2.	0,8	1,5	2,2
N. Reka	Cerkvenikov m.	0,7	23.10.	0,2	0,6	1,2
		Qs		nQs	sQs	vQs
Mura	G. Radgona	145		103	153	221
Drava	Borl+Formin	286		164	284	483
Dravinja	Videm	8,0		5,9	11,2	20,7
Savinja	Veliko Širje	40,6		29,2	44	62,5
Sotla	Rakovec	7,8		5,1	9,3	13,1
Sava	Radovljica	44,3		30,4	43,1	53,8
Sava	Medno	76,0		61,2	85,1	104
Sava	Hrastnik	176		132	158	188
Sava	Čatež	255		183	272	359
Sora	Suha	22,3		13,5	19,3	24,4
Krka	Podbočje	50,9		31,7	51,9	78,6
Kolpa	Radenci	50,8		35,1	50,7	65,6
Ljubljanica	Moste	53,1		35,7	55,6	72,5
Soča	Solkan	107		60,9	89,8	116
Vipava	Dolenje	14,2		8,9	12,1	15,2
Idrijca	Podroteja	8,5		6,4	8,2	10,4
N. Reka	Cerkvenikov m.	8,6		4,2	7,8	12,1
		Qvk		nQvk	sQvk	vQvk
Mura	G. Radgona	443	6.6.	273	735	1205
Drava	Borl+Formin	1383	30.10.	251	640	2292
Dravinja	Videm	265	6.6.	71,1	151	291
Savinja	Veliko Širje	1400	11.12.	278	717	1490
Sotla	Rakovec	54,6	19.12.	52,0	155	264
Sava	Radovljica	583	30.10.	208	411	687
Sava	Medno	615	12.12.	442	861	1422
Sava	Hrastnik	1008	6.12.	786	1202	1668
Sava	Čatež	1777	12.12.	1005	2034	3267
Sora	Suha	285	12.12.	147	329	687
Krka	Podbočje	280	19.12.	217	289	356
Kolpa	Radenci	564	6.12.	355	669	949
Ljubljanica	Moste	252	11.12.	206	282	405
Soča	Solkan	1187	30.10.	747	1391	2066
Vipava	Dolenje	147	11.12.	78,0	152	192
Idrijca	Podroteja	116	12.12.	96,0	184	304
N. Reka	Cerkvenikov m.	255	12.12.	83,3	182	305

Qnp najmanjši pretok v letu – dnevno povprečje / *minimum annual discharge – daily average*
sQs srednji pretok v obdobju */ mean discharge during the reference period*
nQnp najmanjši mali pretok v obdobju */ the minimum low discharge during the reference period*
vQs največji srednji pretok v obdobju */ maximum mean discharge during the reference period*
sQnp srednji mali pretok v obdobju */ mean low discharge during the reference period*
Qvk največji pretok v letu – konica / *maximum annual discharge – peak*
vQnp največji mali pretok v obdobju */ maximum low discharge during the reference period*
nQvk najmanjši veliki pretok v obdobju / *minimum high discharge during the reference period*
Qs srednji pretok v letu – dnevno povprečje / *mean annual discharge – daily average*
sQvk srednji veliki pretok v obdobju */ mean high discharge during the reference period*
nQs najmanjši srednji pretok v obdobju / *minimum mean discharge during the reference period*
vQvk največji veliki pretok v obdobju / *maximum high discharge during the reference period*



Slika 6: Mesečni deleži letnih pretokov v odstotkih v letu 2008 in obdobju 1971–2000 na obravnavanih postajah (glej sliko 2). Na grafu je podano tudi odstopanje mesečnih deležev pretokov v letu 2008 od mesečnih deležev v obdobju 1971–2000.
Figure 6: Monthly share of annual discharges in percentages in 2008 and in the 1971-2000 reference period at the observed stations (see Figure 2). This graph also shows deviations of monthly discharge shares in 2008 from monthly shares in the reference period (1971-2000.)



Slika 7: Deleži mesečnih pretokov v letu 2008 (modri stolpci) in v obdobju 1971–2000 (sivi stolpci) kot ponazoritev odstopanj od ustaljenih režimov pretokov rek na izbranih reprezentativnih lokacijah v letu 2008.
Figure 7: Shares of monthly discharges in 2008 (blue columns) and in the 1971-2000 reference period (grey columns) to illustrate deviation from the normal river discharge regimes at selected representative locations in 2008.

Kronološki pregled hidroloških razmer na rekah v posameznih mesecih leta

Po treh hidrološko suhih mesecih se je povprečna mesečna vodnatost **januarja** 2008 povečala, a je bila še vedno 10 % manjša kot v dolgoletnem primerjalnem obdobju. Tokrat so bili pretoki večji kot navadno v zahodnem delu države. **Februarja**

Chronological overview of hydrological conditions on rivers in individual months of the year

The average monthly water level increased in **January** 2008 following three hydrologically dry months but still remained 10% lower compared to the multi-annual reference period. In this period je bila vodnatost rek še vedno manjša kot navadno. Srednji mesečni pretoki so bili v povprečju 30 % manjši kot v dolgoletnem februarskem obdobju. **Marca** so pretoki slovenskih rek le malo odstopali od povprečnih marčevskih pretokov v dolgoletnem primerjalnem obdobju. Vodnatost rek se je povečala **aprila**, ko so bili pretoki slovenskih rek v povprečju 20 % večji kot navadno. **Maja** so bili pretoki rek v prvi polovici meseca majhni, kasneje so se povečali. V celoti so bili pretoki maja 17 % manjši kot navadno. Sledilo je povečanje vodnatosti rek v **juniju**, ko so bili srednji mesečni pretoki rek v povprečju 20 % večji kot običajno. Relativno največji pretoki so bili junija zabeleženi v vzhodnem delu države, na Sotli, Dravinji, Dravi in spodnji Savi. Nekoliko nadpovprečno vodnata sta bila tudi zahod in jugozahod države. Reke osrednje Slovenije so bile povprečne, reke kraškega dela države pa precej podpovprečne. Tudi **julija** je bila vodnatost rek večja od dolgoletnega povprečja. Vodnatost rek je bila večja v zahodnem delu države. V **avgustu** so bili pretoki rek po Sloveniji podobni dolgoletnemu primerjalnemu obdobju. Relativno najmanjši pretok je bil zabeležen na Kolpi, največji pa na Savi. **Septembra** je po rekah pretekla polovica manj vode kot v dolgoletnem primerjalnem obdobju. Srednji mesečni pretoki Vipave, Idrijce, Sore, Kolpe in Savinje so bili enaki ali manjši od tretjine srednjih mesečnih pretokov v dolgoletnem obdobju. Najbolj vodnati sta bili reki Mura in Drava. **Oktobra** se je majhna vodnatost rek nadaljevala. Pretoki rek so bili zopet polovico manjši kot navadno. Od povprečja so izstopali pretoki Mure, Drave in Save v zgornjem toku. V južnem delu države so bili pretoki večinoma tretjino manjši od tistih iz dolgoletnega obdobja. Tudi **novembra** je bila vodnatost slovenskih manjša kot v dolgoletnem povprečju, tokrat za 30 %. Najbolj vodnati sta bili reki Soča in Sava v zgornjem in srednjem toku. Povečanja pretokov so bila v novembru majhna. Pretoki so se v drugem delu meseca večinoma zmanjševali vse do zadnjih dni, **decembra** pa so se zelo povečali. V povprečju so bili dvakrat večji kot v dolgoletnem primerjalnem obdobju. Izredno vodnati sta bili prvi dve dekadi meseca, ko so se pretoki kar štirikrat povečali. Najbolj vodnati sta bili reki Reka na vodomerni postaji Cerkvenikov mlin in Sora v Suhi, katerih srednji mesečni pretok je bil trikrat večji kot v primerjalnem obdobju. V severovzhodnem delu države, kjer je bila vodnatost manjša, so bili pretoki še vedno do 50 % večji kot navadno v decembru. Reke so poplavljale od 10. do 14. decembra, ko je padlo od 100 do več kot 200 mm dežja. Največ dežja je padlo na območju Ilirske Bistrice. Na višini od 700 do 1000 m je snežilo, kar je bistveno zmanjševalo območja odtekanja vode v reke. Poplavljale so

the discharges were higher than usual in the western part of the country. In **February**, the river stage was still below the usual level. The mean monthly discharges were 30% lower on average compared to the multi-annual February period. In **March**, the discharges of Slovenian rivers only marginally deviated from the average March discharges recorded in the multi-annual reference period. The river stages increased in **April** when the Slovenian river discharges were 20% higher than usual on average. In the first half of **May** the river discharges were low, increasing later in the month. Collectively, the discharges in May were 17% lower than usual. An increase in river stage levels followed in **June** when the mean monthly river discharges were 20% higher than usual on average. In relative terms, the highest discharges were recorded in the eastern part of the country in June on the Sotla, Dravinja, Drava and lower Sava rivers. Slightly above-average water levels were also recorded in the western and south-western part of the country. Rivers running through the central part of Slovenia had average water levels, while rivers in the karstic region of Slovenia were significantly below-average in terms of water levels. **July** was marked with higher water abundance compared to the multi-annual average. River stages were higher in the western part of the country. The river discharges in **August** across Slovenia were similar to the discharges recorded during the multi-annual reference period. The relative minimum discharge was recorded on the Kolpa River, while the maximum discharge was recorded on the Sava River. 50% lower water flow in rivers was recorded in **September** compared to the multi-annual reference period. The mean monthly discharges of the Vipava, Idrijca, Sora, Kolpa and Savinja rivers were equal to or lower than a third of the mean monthly discharges recorded during the multi-annual period. The Mura and Drava rivers were the most water-abundant. The low water abundance of rivers continued through **October**. River discharges were again 50% lower than usual. The discharges of the Mura, Drava and Sava rivers in the upper reach stood out from the average. The southern part of the country recorded mainly 33% lower discharges compared to the multi-annual period average. **November** also recorded lower water abundance (by 30%) of Slovenian rivers compared to the multi-annual period. The Soča and Sava rivers in their upper and middle reaches were most water abundant. Discharge increases were very slight in November. Discharges mostly decreased in the second part of the month until its last days, picking up significantly in **December**. On average the discharges recorded were twice as high compared to the multi-annual reference period. The first two-thirds of the month were extremely abundant and reke Ljubljanica, Gradaščica, Reka, Vipava, Kolpa in Krka. Večinoma so bila poplavljena polja in odseki cest. Povratne dobe pretokov so bile večinoma dvoletne. Največji pretok Reke je imel 5- do 10-letno povratno dobo. Zaradi velike namočenosti tal se je sprožilo tudi nekaj zemeljskih plazov.

Podrobneje so hidrološke razmere na rekah v letu 2008 opisane v mesečnih biltenih Agencije RS za okolje.

the discharges increased fourfold. The Reka River at the Cerkvenikov mlin w.g.s. and the Sora River in Suha were the most abundant, recording a three times higher mean monthly discharge than in the reference period. In the north-eastern part of the country, where the water abundance was usually lower, the discharges were still 50% higher than usual in December. The rivers flooded from 10 December to 14 December, recording from 100 to over 200 mm of rainfall during this period. The majority of the rain fell in the area of Ilirska Bistrica. Snow fell at the altitude between 700 and 1,000 metres, significantly reducing the outflow areas into the rivers. The Ljubljanica, Gradaščica, Reka, Vipava, Kolpa and Krka rivers flooded. Mainly the fields and road sections were flooded. Mostly two-year return periods of discharges were recorded. The highest discharge of the Reka River had a 5-10 year return period. Several landslides occurred due to the heavily water-drenched land.

The hydrological conditions on rivers for 2008 are described in detail in monthly bulletins of the Environmental Agency of the Republic of Slovenia.

VISOKE VODE REK IN POPLAVE

Janez Polajnar

Visoke vode v letu 2008 so bile običajne. Pojavile so se pomladne in jesenske visoke vode, ko so reke poplavile po večini na območjih vsakoletnih poplav, poleti so poplavili hudourniki, morje je jeseni pogosto poplavljalo nižje dele obale. V letu 2008 največji pretoki rek niso presegli 10-letne povratne dobe, gladina morja pa je ob visoki plimi 1. decembra dosegla drugo najvišjo izmerjeno višino v opazovalnem obodbju zadnjih 50 let. Morje je takrat poplavilo dele obalnih mest in solin tudi na območjih, kjer poplave niso pogoste.

Leta 2008 je bilo zabeleženih skupno 54 pojavov visokih voda, ko so reke na vodomernih postajah presegle opozorilne pretoke, gladina morja na mareografski postaji opozorilne vodostaje ter ob tem poplavili. Največ visokih voda na vodotokih je bilo decembra (13), manj junija (6), avgusta jih je bilo 5, oktobra so bile 4, v marcu in juliju po 2, aprila in julija po 1. Morje je poplavilo nižje dele obale dvajsetkrat: sedemkrat decembra, po štirikrat novembra in oktobra, trikrat marca in po enkrat aprila in avgusta (slika 1). Najbolj obsežno poplavljanje morja je bilo 1. decembra, ko je gladina morja na mareografski postaji v Kopru dosegla drugo najvišjo višino v opazovalnem obdobju zadnjih 50 let.

Večje reke Ljubljanica, Krka, Vipava, Reka, Idrijca so poplavljale po večini na območjih vsakoletnih poplav. Obsežnejše poplave so bile zaradi poplavljanja morja le na slovenski obali. Morje je poplavilo dele obalnih mest, solin in prometnic na območjih, kjer poplave niso pogoste, ter povzročilo veliko materialno škodo. Poplave rek in morja so povzročile gmotno škodo na stanovanjskih in gospodarskih objektih, prometnicah, vodni infrastrukturi, kmetijskih površinah in na zavarovanih območjih solin.

V preglednici 1 so opisane reke in nekateri potoki, ki so poplavljali v letu 2008, ter poplavljanje morja ob slovenski obali. Poplavljanje manjših potokov in hudournikov v preglednici ni navedeno.

RIVER HIGH WATERS AND FLOODS

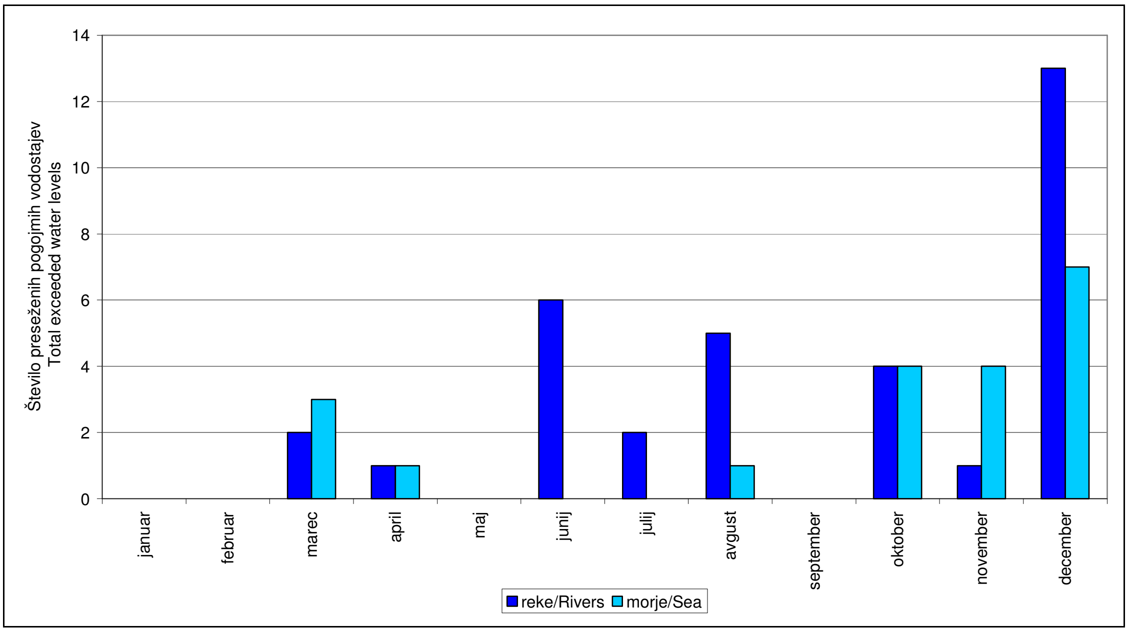
Janez Polajnar

In 2008 the high levels of water were usual. Spring and autumn high waters occurred when the rivers generally flooded the characteristic annual flooding areas. Torrents flooded during the summer, while the sea flooded the lower parts of the coast in autumn. In 2008, the highest river discharges did not exceed the 10-year return period and the sea level at high tide on 1 December reached the second highest recorded level during the observed period of the last 50 years. At that time, the sea flooded parts of the coastal towns and salines also in the areas where floods are not common.

In 2008, high waters were recorded on 54 occasions altogether when the rivers at water gauging stations exceeded critical discharge levels and the sea level at the mareographic station exceeded critical water levels and in most cases flooded. Most high waters occurred in December (13), fewer in June (6), 5 in August, 4 in October, 2 in March and July, and 1 in April and July. The sea flooded low-lying parts of the coast 20 times: 7 times in December, 4 times in November and October, 3 times in March and once in April and August (Figure 1). The most extensive floods of the sea occurred on 1 December when the sea level at the tide gauge Koper reached the second highest level during the observed period of the last 50 years.

Larger rivers; the Ljubljanica, Krka, Vipava, Reka and Idrijca flooded mostly in the areas of the usual annual floods. More extensive floods due to the sea flooding were recorded only on the Slovenian coast. The sea flooded parts of the coastal towns, salines and traffic routes in the areas where floods are not common causing significant material damage. River and sea flooding caused major material damage on residential and commercial buildings, traffic routes, water infrastructure, farmland and protected saline areas.

Table 1 demonstrates the rivers and streams which flooded in 2008 in addition to the sea flooding Slovenian coastal areas. The table does not show the flooding of smaller streams and torrents.



Slika 1: Število preseženih opozorilnih vodostajev slovenskih rek na opazovanih vodomernih postajah in gladin morja ob slovenski obali leta 2008

Figure 1: Number of exceeded critical water levels of Slovenian rivers at the observed water gauging stations and sea levels at the Slovenian coast in 2008

Visoke vode med 10. in 14. decembrom

Med 10. in 11. decembrom 2008 je Slovenijo zajelo močno deževje. Največ padavin je padlo v okolici Ilirske Bistrice, več kot 200 mm. Podobna količina padavin je padala v zahodnih Julijskih Alpah in zgornjem Posočju, kjer pa je del padavin padel kot sneg. Meja sneženja je bila med 700 in 1000 metri nadmorske višine. Na območju Škofjeloškega ter Idrijskega in Cerkljanskega hribovja je padlo okoli 120 mm, v okolici Ljubljane pa okoli 100 mm padavin. Zaradi obilnega deževja so močno narasle reke po vsej Sloveniji, le v vzhodni Sloveniji je vodnatost rek ostala nespremenjena.

Najmočneje je narasla Reka, ki je na vodomerni postaji Cerkvenikov mlin dosegla pretok s 5- do10-letno povratno dobo. Največji pretoki Gradaščice, Ljubljanice in Vipave so dosegli 2-letno povratno dobo. V noči z 10. na 11. december so močno narasle Soča s pritoki, Idrijca, Cerknica, Reka. Zjutraj 11. decembra sta Ljubljanica in Gradaščica že presegli opozorilne pretoke. Dež se je dopoldne okrepil in zajel območje osrednje Slovenije, dolenjskega krasa, porečje spodnje Save, Savinje, Krke in Kolpe. Že dopoldne okoli desete ure je Reka prestopila bregove sprva med Trpčanami in Ilirsko Bistrico in čez dan je poplavljala tudi v srednjem in spodnjem toku. Na vodomerni postaji v Cerkvenikovem mlinu je naslednji dan, 12. decembra, okoli pete ure zjutraj dosegla največji pretok, 257 m^3/s, kar je velik pretok s 5- do 10-

High waters between 10 December and 14 December

Slovenia was hit by heavy rain between 10 December and 11 December 2008. The greatest amount of rain fell in the area of Ilirska Bistrica – more than 200 mm. A similar volume of precipitation fell in the western Julian Alps and upper Posočje where part of the precipitation fell as snow. The snow-line was between 700 and 1000 metres in altitude. In the region of Škofjeloško, Idrijsko and Cerkljansko hribovje (hills) approx. 120 mm of precipitation was recorded while 100 mm fell in the surrounding area of Ljubljana. Due to the heavy rain the rivers across Slovenia rose rapidly. The water abundance of rivers remained unchanged only in the eastern part of Slovenia.

The most rapid water growth was recorded on the Reka River, which achieved a discharge with a 5 to 10-year return period at the w. g. s. Cerkvenikov mlin. The maximum discharges of the Gradaščica, Ljubljanica and Vipava rivers achieved a 2-year return period. During the night from 10 December to 11 December the water level of the Soča River together with its tributaries, the Idrijca River, Cerknica River and Reka River grew rapidly. In the morning of 11 December, the Ljubljanica and Gradaščica rivers already exceeded the critical discharge levels. Rainfall intensified in the morning and hit central Slovenia, the Dolenjska karstic area, the river basin of the lower Sava, Savinja, letno povratno dobo (slika 2). Čez dan 11. decembra so močneje narasle tudi druge reke: Sora, Idrijca, Savinja s pritoki, Dravinja, Mestinjščica in Sava v spodnjem toku, vendar so ostale v strugah.

V noči na 12. december je največji pretok dosegla tudi Ljubljanica v Mostah, 252 m^3/s, in se približala pretoku z dveletno povratno dobo. Poplavljala je na Ljubljanskem barju v nekoliko večjem obsegu kot običajno. Poleg Ljubljanice in Reke so v manjšem obsegu poplavile tudi Gradaščica, Vipava in Kolpa, 12. decembra pa tudi Krka v spodnjem toku. Največji pretok, 279 m^3/s, je Krka v Podbočju dosegla 13. decembra ob 17. uri. V naslednjih dneh se je vodnatost Krke prehodno nekoliko zmanjšala, 17. decembra pa je znova narasla in presegla prej omenjeni pretok. Poplavila je v spodnjem toku v okolici Kostanjevice.

V tem času so bile poplave na Ljubljanskem barju obsežnejše od običajnih. Območje v okolici zaselka Komin je bilo poplavljeno enajst dni, izdatno so bila poplavljena tudi kraška polja notranjskega krasa. Nekaj cest je bilo začasno neprevoznih, zaradi velike namočenosti so se ponekod trgali zemeljski plazovi.

Ob slovenski obali je bilo v tistih dneh povišano plimovanje morja. V dneh od 10. do 17. decembra je morje na mareografski postaji v Kopru kar 9-krat preseglo opozorilni vodostaj in 7-krat poplavilo nižje dele obale.

Krka and Kolpa rivers. At around 10 a.m. the Reka River breached its embankment at first between Trpčane and Ilirska Birstrica and during the day it flooded also in the mid and lower reach of the river. The next day, on 12 December, at around five in the morning, it reached its highest discharge level of 257 m^3/s, which is a high discharge level with a 5 to 10 year return period (Figure 2) at the w. g. s. Cerkvenikov mlin. Other rivers also grew excessively during the day on 11 December: The rivers Sora, Idrijca, Savinja with tributaries, Dravinja, Mestinjščica and Sava in its lower reach, but they remained in their riverbeds.

During the night from 11 December to 12 December, the maximum discharge of 252 m^3/s was achieved by the Ljubljanica River in Moste, approaching a discharge with a 2-year return period. It flooded Ljubljansko barje in a slightly wider area than usual. Besides the Ljubljanica and Reka rivers, minor floods were also caused by the Gradaščica, Vipava and Kolpa rivers and on 12 December also the Krka in its lower reach. The maximum discharge of 279 m^3/s was recorded at 5 p.m. on 13 December on the Krka River in Podbočje. In the following days the water level of the Krka River temporarily slightly subsided, again increasing and surpassing the aforementioned discharge on 17 December. It flooded in the lower reach in the Kostanjevica area.

In this period the flooding of Ljubljansko barje was more extensive than usual. The area surrounding the village of Komin was flooded for 11 days, while extensive floods also occurred on karstic fields of the Notranjska karst region. Some roads were temporarily impassable, and even landslides were triggered in some areas due to the significant drenching of the area.

The tides intensified during that period on the Slovenian coast. Between 10 December and 17 December the sea exceeded the critical water level level 9 times at the mareographic station in Koper which resulted in the flooding (7 times) of the low-lying coastal areas.

Preglednica 1: Visoke vode in njihovo razlitje leta 2008 (ARSO, CORS, razlitja manjših potokov in hudournikov niso upoštevana)
Table 1: High water levels and their spillage in 2008 (EARS, CORS, the spillage of smaller streams and torrents were not taken into account)

	jan	feb	mar	apr	maj	jun	jul	avg	sept	okt	nov	dec
Ljubljanica			x	x							x	x
Krka			x									x
Mislinja						x						
potok Bistrica Bistrica stream						x						
Mestinjščica						x		x				
hudourniki v Zasavju torrents in Zasavje						x		x				x
hudourniki v okolici Raven torrents in Ravne area						x						
Lahinja						x						
Ščavnica							x					
potok Češnjica Češnjica stream							x	x				
Gradaščica								x				
hudourniki v okolici Laškega torrents in Laško area								x				
Soča										x		
Savica										x		
Sava Bohinjka										x		
hudourniki v dolini Planice torrents in Planica valley										x		
potok Lijak Lijak stream												x
Gradaščica												x
Vipava												x
Gameljščica												x
Idrijca												x
Reka												x
Selška Sora												x
Bistrica												x
Dolenjski potok												x
Pivka												x
morje ob slovenski obali Sea at Slovenian coast			x x x	x				x		x x x x	x x x x	x x x x x x x

NIZKE VODE REK IN HIDROLOŠKA SUŠA

Dr. Mira Kobold

Leto 2008 je bilo nadpovprečno namočeno. Dolgoletno povprečje padavin je bilo v večjem delu Slovenije preseženo. Manj padavin od dolgoletnega povprečja je bilo v delu jugozahodne Slovenije ter v severovzhodni in vzhodni Sloveniji. Primanjkljaj na teh območjih je znašal do 15 %. Ker pa je bila porazdelitev padavin po mesecih neenakomerna, smo med letom večkrat beležili nizkovodne razmere. Najdaljše obdobje z malimi pretoki je bilo v večjem delu države v jesenskih mesecih, najbolj suha pa sta bila september in oktober.

Analiza mesečnih pretokov

V prvih treh mesecih leta so bili srednji mesečni pretoki (Qs) manjši od srednjih obdobnih pretokov (sQs), najmanjši mesečni pretoki (Qnp) pa manjši od srednjih malih obdobnih pretokov (sQnp). Le v zahodni Sloveniji so bili pretoki v mejah obdobnih vrednosti. Srednji mesečni aprilski pretoki so bili večinoma nad obdobnimi mesečnimi pretoki, od maja do avgusta pa večinoma v mejah obdobnih mesečnih pretokov (slika 1). Daljše nizkovodno stanje smo beležili od septembra do novembra, ko so bili srednji mesečni pretoki v mejah srednjih malih obdobnih pretokov, najmanjši mesečni pretoki pa so bili večinoma povsod manjši od srednjih malih obdobnih pretokov in so se ponekod približali najmanjšim obdobnim mesečnim pretokom. Hidrološko najbolj suha sta bila september in oktober. V decembru so padavine, ki so tudi do dvakrat presegle običajne decembrske padavine, povzročile močan porast pretokov, najbolj v porečju Dravinje, Savinje, Save v zgornjem toku in Reke.

Časovni potek srednjih dnevnih pretokov

Iz časovnega poteka srednjih dnevnih pretokov (slika 2) je razvidno, da so bila krajša obdobja z malimi pretoki v januarju, februarju in marcu ter maju in juniju, daljše obdobje z malimi pretoki pa je bilo od začetka septembra do konca oktobra. Pretoki niso nikjer dosegli najmanjših obdobnih pretokov.

RIVER LOW FLOWS AND HYDROLOGICAL DROUGHT

Mira Kobold, PhD

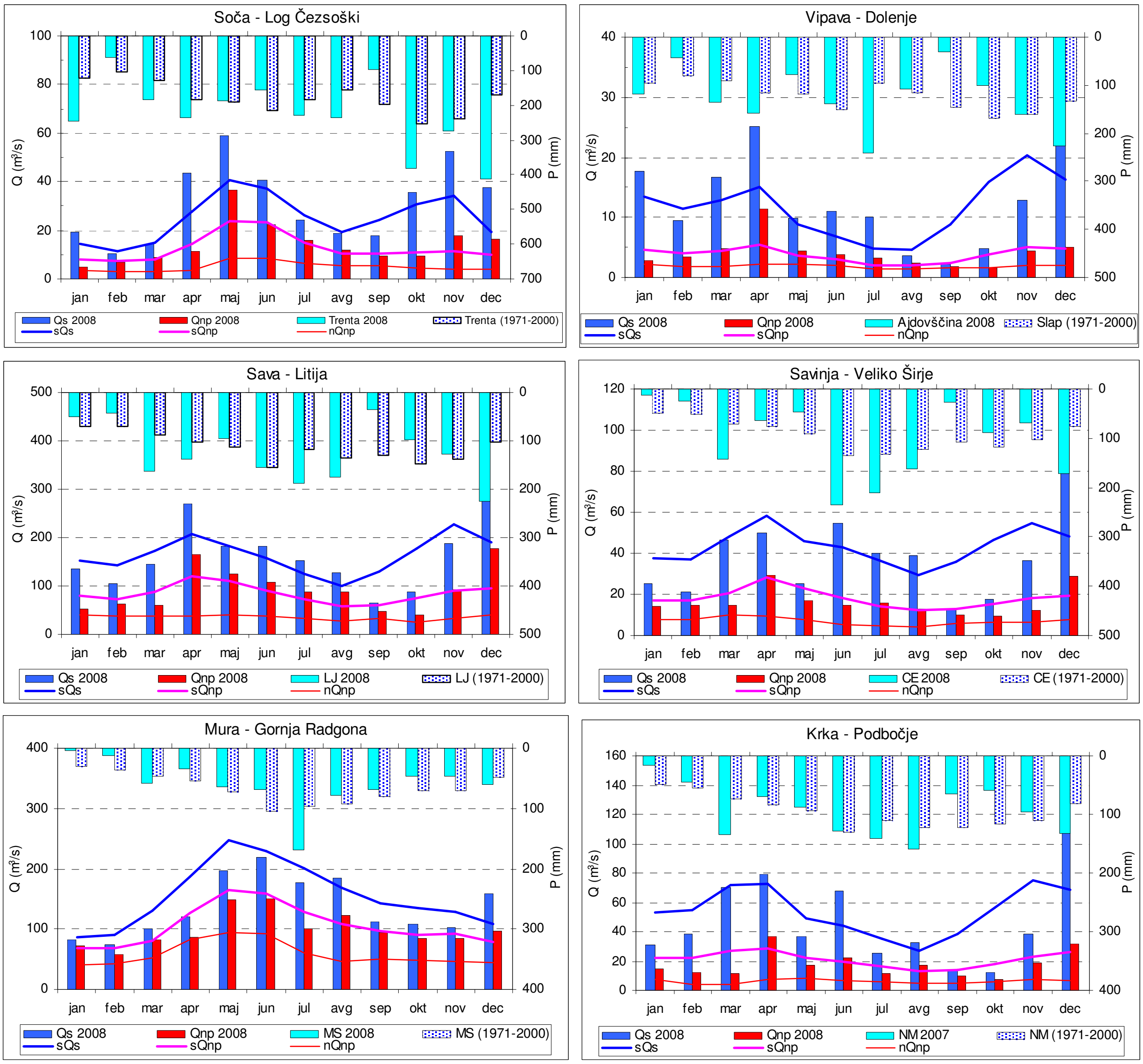
The year 2008 was an above-average water abundant year. The multi-annual average of precipitation was exceeded in most parts of Slovenia. Less precipitation than the multi-annual average was recorded in parts of south-western, north-eastern and eastern parts of Slovenia. A shortage of no more than 15% was recorded in these areas. As the precipitation by months was unevenly distributed we recorded low water conditions many times during the year. The longest period with low discharges occurred in the autumn months in most parts of the country, the driest of which were September and October.

Analysis of monthly discharges

In the first quarter of the year, the mean monthly discharges (Qs) were lower than the mean periodical discharges (sQs), and the minimum monthly discharges (Qnp) were lower than the mean low periodical discharges (sQnp). Only the western part of Slovenia recorded discharges within the limits of the periodical values. The mean monthly April discharges were mostly above the periodical monthly discharges, while mostly being within the limits of periodical monthly discharges from May until August (Figure 1). A longer period of low-water conditions occurred from September until November when the mean monthly discharges were within the limits of the mean low periodical discharges. The minimum monthly discharges were mainly lower throughout than the mean low periodical discharges and in some places almost reached the minimum periodical monthly discharge. September and October were the most hydrologically dry months. In December, the precipitation which exceeded the usual December precipitation, even up to double the level, caused a strong increase in the discharges, the most in the river basin of the Dravinja, Savinja, upper reach of Sava and Reka rivers.

Timeline of mean daily discharges

From the timeline of mean daily discharges (Figure 2) it is evident that shorter periods with low discharges occurred in January, February, March, May and June, while longer periods with low discharges were recorded from the start of September until the end of October. The discharges did not reach the minimum periodical discharges anywhere.

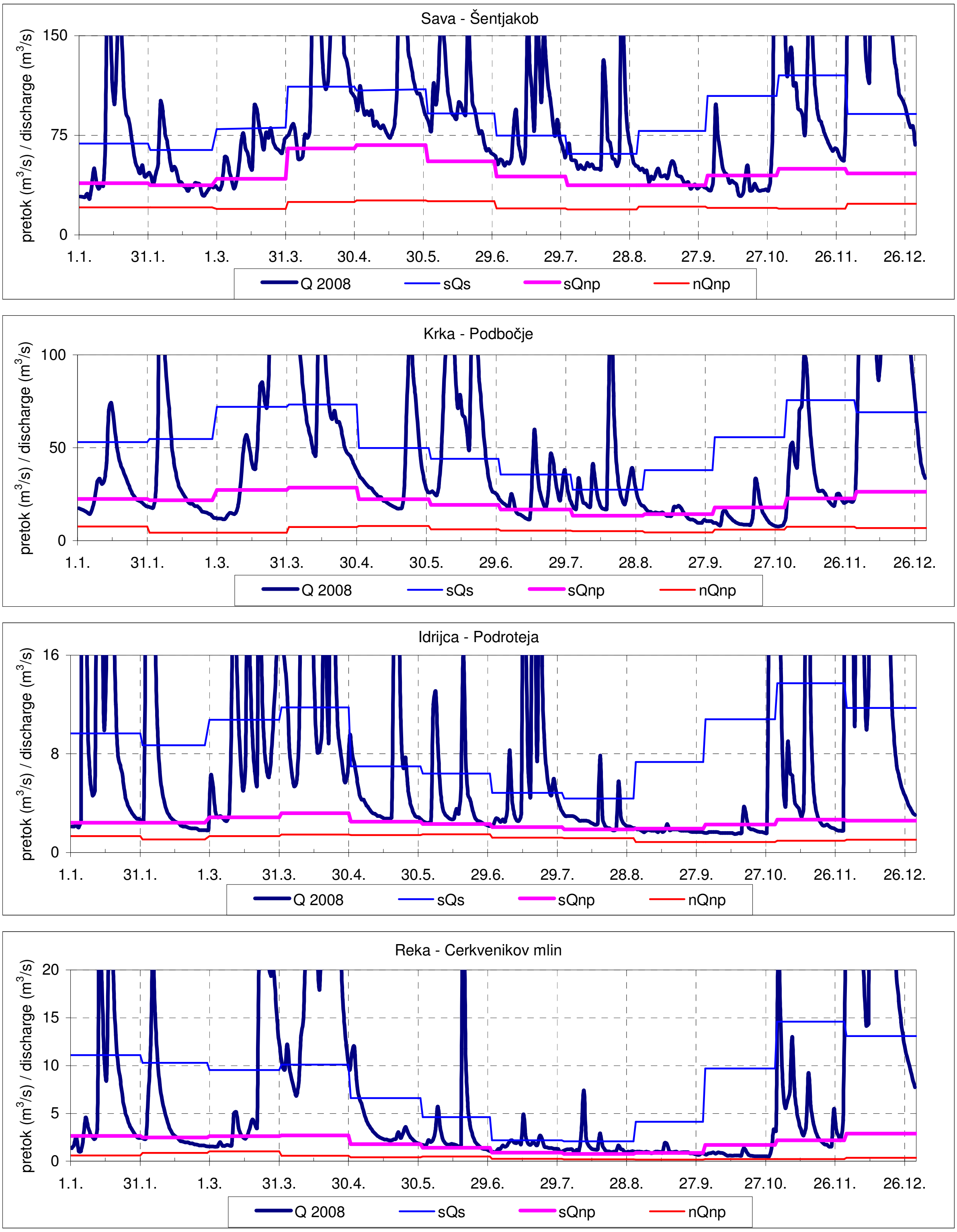


Slika 1: Srednji (Qs) in minimalni mesečni pretoki (Qnp) v letu 2008 ter obdobne mesečne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) mesečni pretoki, obdobne mesečne količine padavin obdobja 1971–2000 in mesečne količine padavin v letu 2008 z reprezentativnih padavinskih postaj.

Figure 1: Mean (Qs) and minimum monthly discharges (Qnp) in 2008 and periodical monthly values of discharges: mean periodical (sQs), mean low (sQnp) and minimum low (nQnp) monthly discharges, periodical monthly amount of precipitation in the reference period (1971-2000) and monthly amount of precipitation in 2008 from representative precipitation stations.

Prikaz vrednosti standardiziranega najmanjšega letnega pretoka je primerno orodje za ovrednotenje hidrološke suše (Dakova, 2004). Vrednost indeksa med 0 in –1 pomeni male pretoke, od –1 do –1,5 zmerno sušo, od –1,5 do –2 govorimo o hudi suši, indeks pod –2 pa pomeni ekstremno sušo. Indeks najmanjšega letnega 180-dnevnega pretoka je za leto 2008 (slika 3) po večini med 0 in –1, kar pomeni, da leto 2008 kljub nadpovprečni letni količini padavin domala po vsej Sloveniji uvrščamo med leta s pretežno malimi pretoki.

The demonstration of the value of the standardised minimum annual discharge is a suitable instrument for assessing hydrological drought (Dakova, 2004). The index value between 0 and -1 indicates low discharges, from -1 to -1.5 moderate drought, from -1.5 to -2 severe drought, while an index demonstrating a value below -2 indicates extreme drought. The index of the minimum annual 180-day discharge reached values between 0 and -1 in 2008 (Figure 3) indicating that 2008 was classified among years with mainly low discharges despite the above-average annual precipitation volume across Slovenia.

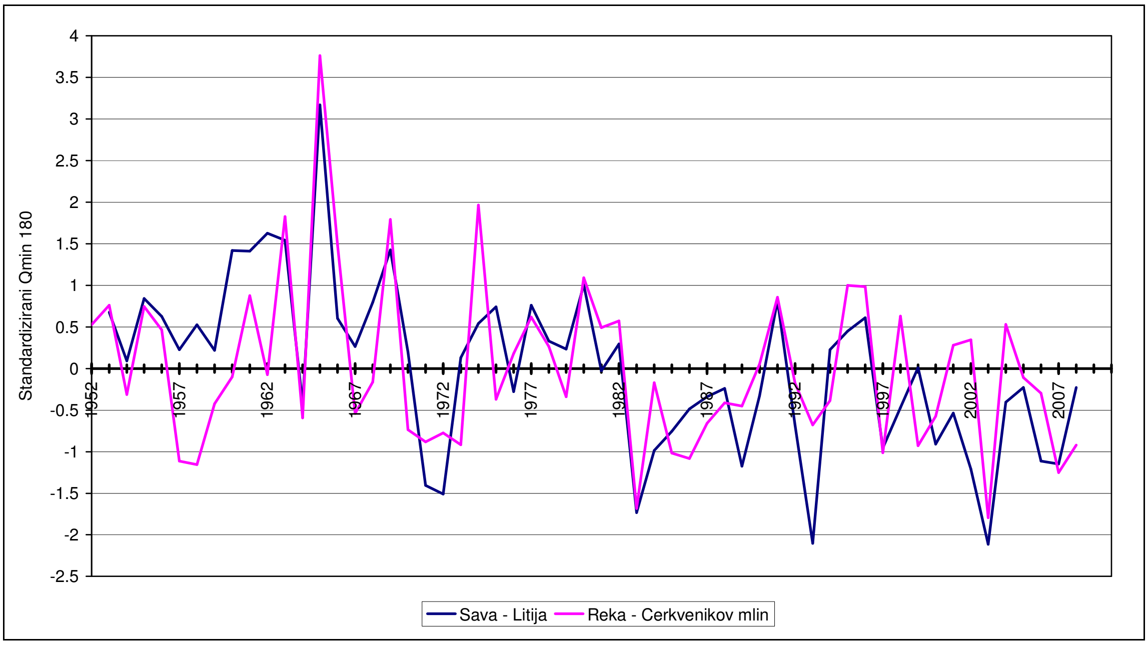


Slika 2: Srednji dnevni pretoki na izbranih vodomernih postajah za leto 2008 ter obdobne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) obdobni pretok.
Figure 2: Mean daily discharges at selected water gauging stations for 2008 and the periodical discharge values: mean periodical (sQs), mean low (sQnp) and minimum low (nQnp) periodical discharges.

Analize trendov pretokov kažejo, da se obdobja z malimi pretoki daljšajo in da je za reke v Sloveniji značilen upadajoč trend najmanjših letnih pretokov daljših trajanj (nad 30 dni), medtem ko za najmanjše letne srednje dnevne pretoke (Qnp) upadajoči trend ni značilen (Kobold in Ulaga, 2010). Za obdobje po letu 1980 so za slovenske vodotoke značilna dolga nizkovodna stanja in vse

The analyses of discharge trends demonstrate that the periods with low discharges are lengthening and that a declining trend of long periods (over 30 days) of minimum annual discharges is characteristic for rivers in Slovenia, while the declining trend is not characteristic for minimum annual mean daily discharges (Qnp) (Kobold and Ulaga, 2010). For the period after pogostejše suše, čeprav letna količina padavin v Sloveniji značilno še ne upada. Vse več padavin pade v obliki intenzivnih padavinskih dogodkov in dogaja se, da v istem letu beležimo tako hidrološko sušo kot poplave. To se je v letu 2008 zgodilo na porečju reke Reke, kjer smo nizkovodno stanje beležili od junija do oktobra, v decembru pa smo bili priča poplavam. Za porečje Reke je bila izdelana podrobnejša analiza hidroloških parametrov za leto 2008, saj je v jesenskih mesecih prišlo do izpraznjenja umetnih akumulacij Klivnik in Mola, ki sta namenjeni bogatenju reke Reke v času malih pretokov (Kobold in sod., 2009).

1980, long low water conditions and more frequent drought are characteristic for Slovenian watercourses, even though the annual precipitation volume in Slovenia has yet to decline. More and more precipitation appears in the form of intense precipitation events and it is not rare to record hydrological drought alongside flooding in the same year. This happened in 2008 in the Reka River basin where low water conditions were recorded from June to October while witnessing floods in December. A detailed analysis of hydrological parameters was prepared for the Reka River basin for 2008, as the emptying of artificial accumulations Klivnik and Mola intended for recharging the Reka River during low discharges (Kobold et al., 2009) occurred during the autumn months.



Slika 3: Časovna spremenljivost standardiziranega najmanjšega letnega 180-dnevnega pretoka za dve vodomerni postaji
Figure 3: Time changeability of the standardised minimum annual 180-day discharge for 2 water gauging stations

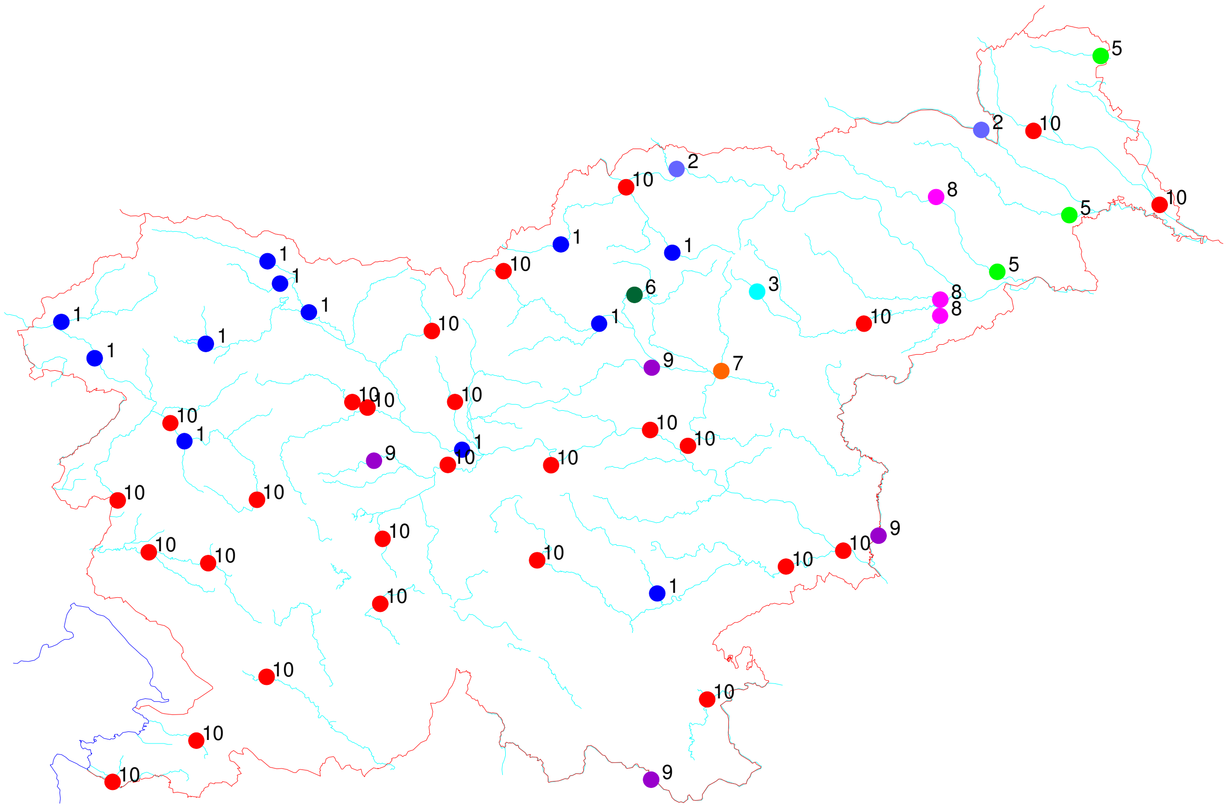
Izpraznjeni akumulaciji Klivnik in Mola v oktobru 2008 zaradi bogatenja reke Reke (foto: Špela Remec-Rekar)
The emptied accumulations Klivnik and Mola in October 2008 due to the recharging of the Reka River (photo: Špela Remec–Rekar)

Krajevna in časovna razporeditev najmanjših pretokov

Krajevna in časovna razporeditev najmanjših pretokov po državi je bila v letu 2008 različna (slika 4). V pretežnem delu Slovenije so bili najmanjši pretoki zabeleženi oktobra, le v povirju Save in Soče in ponekod v severni Sloveniji so bili najmanjši pretoki zabeleženi januarja, v severovzhodni Sloveniji pa večinoma maja in avgusta. Na Kolpi in Sotli smo najmanjše pretoke v letu 2008 zabeležili septembra.

Spatial and temporal distribution of the lowest discharges

The spatial and temporal distribution of the minimum discharges across the country was different in 2008 (Figure 4). The lowest discharges were recorded in October in the majority of Slovenia, in January only in the headwaters of the Sava and Soča and in some places in the northern part of Slovenia and mostly in May and August in the north-eastern part of the country. In 2008, the Kolpa and Sotla rivers had the lowest discharges in September.



Slika 4: Meseci, v katerih so bili na vodomernih postajah površinskih voda doseženi najmanjši srednji dnevni pretoki v letu 2008
Figure 4: Months in which the lowest mean daily discharges in 2008 were achieved at the surface water gauging stations

Viri / *Sources*

Dakova, S., 2004. Low flow and drought spatial analisys. Proceedings of BALWOIS conference, Ohrid, FY Republic of Macedonia.
Kobold, M., Ulaga, F. 2010. Okolje se spreminja (ur. T. Cegnar). ARSO.*The environment is changing, EARS.*
Kobold, M., in sod., 2009. Analiza hidroloških parametrov porečja Reke za leto 2008. Interna študija, ARSO. *Analysis of hydrological parameters of the Reka River basin for 2008«). Internal study, EARS.*

TEMPERATURE REK IN JEZER

Barbara Vodenik

Leta 2008 je bila povprečna temperatura izbranih rek 11,1 °C, kar je za 0,6 °C več kot v večletnem primerjalnem obdobju. Povprečna temperatura Blejskega jezera je znašala 13,1 °C, Bohinjskega pa 10,8 °C, kar je 0,1 °C oziroma 0,6 °C več kot v večletnem primerjalnem obdobju. Pri rekah je največje odstopanje od dolgoletnega povprečja opaziti pri Soči v Solkanu, ko so srednje mesečne temperature višje od dolgoletnega povprečja v maju za 2,0 °C, juniju za 3,1 °C in juliju za 3,8 °C. Na Savinji v Laškem so bile srednje mesečne temperature vse leto višje, in to za 1 do 2,5 °C.

Na Bohinjskem jezeru so bile srednje mesečne temperature v vsem letu 2008 višje kot v primerjalnem obdobju. Največje odstopanje je opaziti v februarju, marcu in juliju, ko so bile srednje mesečne temperature višje za 3,1 °C, 2,7 °C, in 2,3 °C. Odstopanja od večletnega povprečja Blejskega jezera so bila minimalna, saj se je največje odstopanje v aprilu razlikovalo od dolgoletnega povprečja le za 0,9 °C. Za izračun povprečja so upoštevani razpoložljivi nizi podatkov. Najdaljši nizi so od leta 1951.

Časovno spreminjanje temperatur rek

Temperaturna nihanja slovenskih rek na izbranih vodomernih postajah v letu 2008 so grafično prikazana na sliki 1. Temperature rek so se januarja spreminjale med 1,2 °C na Muri v Gornji Radgoni in Dravinji v Vidmu ter 9,4 °C na Vipavi v Dornberku. V prvi polovici januarja so temperature naraščale in dosegle najvišje vrednosti sredi meseca, v drugi polovici pa so se spet močno znižale. Konec januarja oziroma v začetku februarja je mogoče opaziti podoben potek temperature, le da je bilo znižanje, ki je sledilo sredi februarja, bolj izrazito. Padec temperature je najbolj očiten pri Soči in Savi, kjer se je temperatura znižala za 5,3 °C oziroma 4,9 °C. Soča, Sava in Savinja so takrat dosegle najnižje letne vrednosti (preglednica 2). Konec februarja in v marcu so temperature še znatno nihale, potem pa so se aprila in v prvi polovici maja reke postopoma segrevale. V poletnih mesecih je opaziti pogosta in izrazita temperaturna nihanja, kar je posledica hitrih sprememb temperature ozračja in poletnih neviht. Temperature večine izbranih rek (razen Vipave v Dornberku) so dosegle najvišje letne vrednosti v prvih dneh julija (preglednica 1). Sredi septembra so se

TEMPERATURES OF RIVERS AND LAKES

Barbara Vodenik

In 2008, the average temperature of the selected rivers was 11.1°C, which is 0.6°C higher than in the multi-annual reference period. The average temperatures of Lake Bled and Lake Bohinj were 13.1°C and 10.8°C, respectively, which is 0.1°C and 0.6°C higher than the multi-annual reference period. The largest deviation from the multi-annual average of rivers is evident on the Soča River on Solkan where the mean monthly temperatures were higher than the multi-annual average in May by 2.0°C, in June by 3.1°C and in July by 3.8°C. The mean monthly temperatures were higher all year round in Laško on the Savinja River, this by 1-2.5°C.

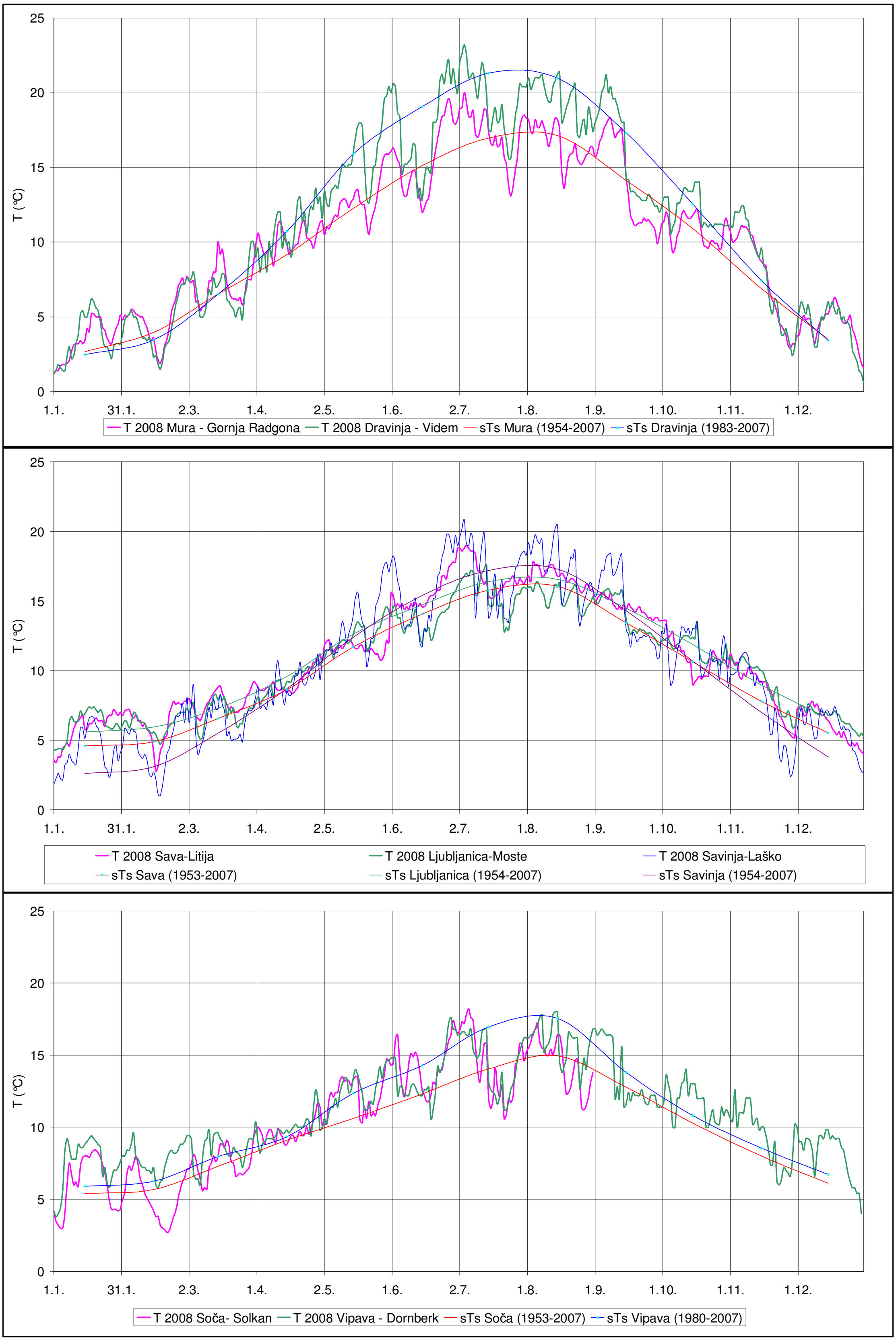
Lake Bohinj recorded higher mean monthly temperatures throughout 2008 than in the multi-annual reference period. The greatest deviation can be noticed in February, March and July when the mean monthly temperatures were higher by 3.1 °C, 2.7 °C, and 2.3 °C, respectively. The deviation from the multi-annual average of Lake Bled was minor as the greatest deviation was recorded in April deviating from the multi-annual average by a mere 0.9°C. In order to calculate the average value, the available data series were taken into account, the longest being from the year 1951.

Timeline of river temperature changes

The temperature fluctuations of Slovenian rivers at the selected water gauging stations in 2008 are graphically illustrated in Figure 1. In January, the river temperatures fluctuated between 1.2°C in Gornja Radgona on the Mura River and in Videm on the Dravinja River and 9.4°C in Dornberk on the Vipava River. In the first half of January, the temperatures rose reaching maximum levels mid-month, then again strongly declining in its second part. By the end of January or beginning of February a similar temperature trend can be noticed, except that the temperature decline that followed in February was more intense. The temperature drop is most evident on the Soča and Sava rivers where the temperature dropped by 5.3°C and 4.9°C, respectively. The Soča, Sava and Savinja rivers reached the lowest annual values during this time (Table 2). At the end of February and in March, temperatures still fluctuated significantly then the rivers gradually warmed up in April and the first half of May.

temperature večine opazovanih rek strmo znižale. Vzrok so bile ohladitev ozračja in padavine. Sprememba temperature je bila najbolj izrazita pri Savinji in Muri, kjer so se vrednosti znižale za 6,6 °C oziroma 6,2 °C. Zatem so se temperature rek

Frequent and intense temperature fluctuation was evident during the summer months, due to rapid changes to the air temperatures and summer thunderstorms. The temperatures of most selected rivers (save for Vipava in Dornberk) reached the



Slika 1: Temperature vode (T) slovenskih rek leta 2008 na izbranih vodomernih postajah in srednje mesečne temperature (sTs) v dolgoletnem obdobju

Figure 1: Water temperatures (T) of Slovenian rivers in 2008 at selected water gauging stations and the mean monthly temperatures (sTs) during the multi-annual period

vse do konca leta postopoma zniževale. Najbolj izrazita je bila ohladitev v novembru. Reke so se v začetku decembra sicer še enkrat segrele, v drugi polovici meseca pa spet ohlajale. Dravinja v Vidmu in Vipava v Dornberku sta zadnji decembrski dan dosegli najnižje letne vrednosti (preglednica 2).

Časovno spreminjanje temperatur jezer

Temperaturi Bohinjskega in Blejskega jezera se v začetku leta vse do konca marca nista bistveno spreminjali. V aprilu in maju sta temperaturi obeh jezer strmo naraščali. Temperatura Bohinjskega jezera je pri tem izrazito nihala. V prvi polovici junija sta se obe jezeri ohladili, nato pa sta temperaturi spet strmo narasli, pri čemer se je Bohinjsko jezero v desetih dneh segrelo za 7 °C. V poletnih mesecih je predvsem pri Bohinjskem jezeru opaziti pogosta in izrazita temperaturna nihanja. Jezero se je sredi avgusta v enem dnevu ohladilo za 4 °C. V prvi polovici septembra se temperaturi obeh jezer nista bistveno spreminjali, v drugi polovici je sledila hitra ohladitev obeh jezer. Temperatura Bohinjskega jezera se je v drugi polovici septembra znižala z 19 °C na 11,2 °C. Blejsko jezero pa se je ohladilo za 4,4 °C. Sredi oktobra se je Bohinjsko jezero še enkrat segrelo, sicer pa sta se obe jezeri vse do konca leta postopno ohlajali. Blejsko jezero je bilo vse leto toplejše od Bohinjskega, in sicer v celoletnem povprečju za 2,3 °C.

maximum annual values in the first days of July (Table 1). The temperatures of most observed rivers decreased rapidly mid-September. This was caused by the cooling of the atmosphere and precipitation. The temperature change was most significant on the Savinja and Mura rivers where the values dropped by 6.6°C and 6.2°C, respectively. After that the river temperatures gradually declined until the end of the year. The cooling of weather was most noticeable in November. The rivers did actually warm up one more time in the beginning of December, cooling down again in the second part of the month. The Dravinja River in Videm and Vipava River in Dornberk reached the lowest annual values on the last day of December (Table 2).

Timeline of lake temperature changes

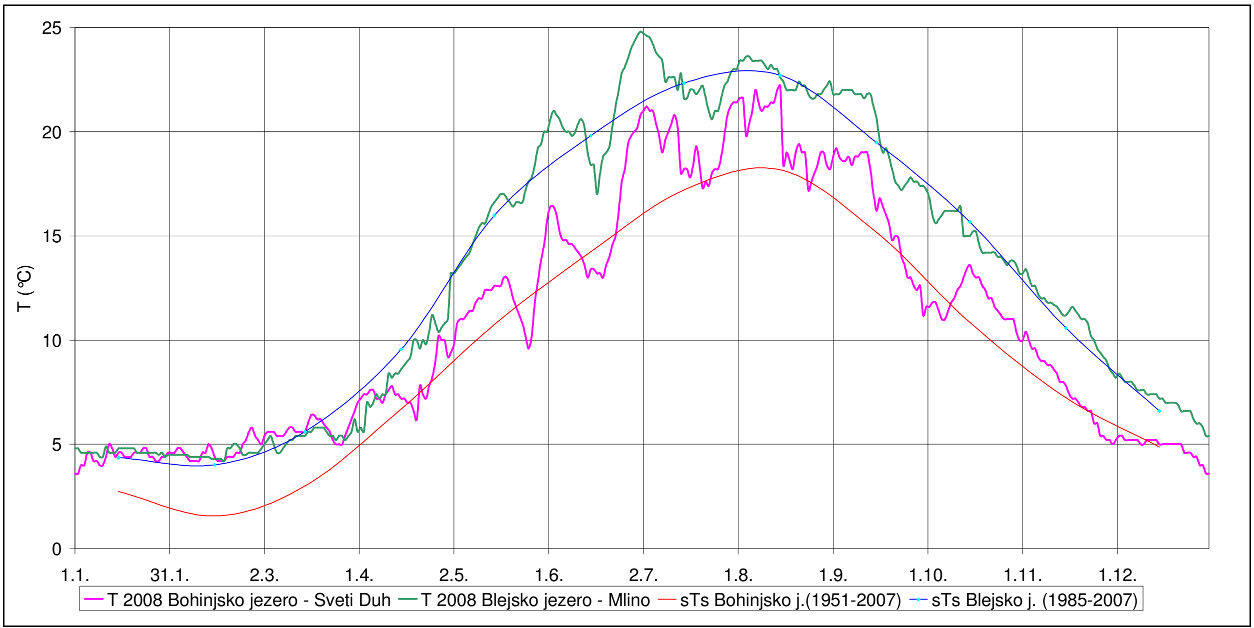
The temperatures of Lake Bohinj and Lake Bled did not change significantly from the start of the year until late March. The temperatures of both lakes increased rapidly in April and May. The temperature of Lake Bohinj fluctuated significantly during this period. In the first half of June both lakes cooled down, followed again by a sudden rapid rise in temperatures, in particular Lake Bohinj's temperature increased by 7°C within 10 days. During the summer months the frequent and severe temperature fluctuations of Lake Bohinj are noticeable. The lake cooled by 4°C mid-August within a day. The temperatures of both lakes did not change significantly within the first half of September, which was followed by a rapid decrease in temperatures of both lakes in the second half of the month. The temperature of Lake Bohinj decreased from 19°C to 11.2°C in the second half of September. Meanwhile, Lake Bled cooled by 4.4°C during this period. Lake Bohinj warmed up again mid-October, otherwise both lakes gradually cooled until the end of the year. Throughout the year, Lake Bled was warmer than Lake Bohinj, i.e. by 2.3°C on average.

Preglednica 1: Najvišje temperature izbranih rek in jezer v letu 2008 in v obdobju
Table 1: Highest temperatures of the selected rivers and lakes in 2008 and in the reference period

Vodotok *Stream*	Vodomerna postaja *Gauging Station*	Leto 2008 *Year 2008* Tvk (^{0}C)	Datum *Date*	Obdobje *Period* Tvk	Datum *Date*	Obdobje *Period*
Mura	Gornja Radgona	22,5	4.7.	23,3	23.7.2003	1989-2007
Dravinja	Videm	23,2	4.7.	28,6	2.8.1994	1982-2007
Ljubljanica	Moste	18,7	7.7.	23,8	16.8.1988	1954-2007
Soča	Solkan	24	6.7.	20,0	9.8.1994	1953-2007
Sava	Litija	19	5.7.	24,6	8.8.2003	1953-2007
Savinja	Laško	24,5	3.7.	24,5	20.7.2007	1954-2007
Vipava	Dornberk	18	14.8.	24.0	13.8.2003	1980-2007
Blejsko jezero	Mlino	24,8	1.7.	25.4	9.8.1998	1985-2007
Bohinjsko jezero	Sveti duh	22,2	15.8.	24.1	31.7.1983	1951-2007

Preglednica 2: Najnižje temperature izbranih rek in jezer v letu 2008 in v obdobju
Table 2: Lowest temperatures of the selected rivers and lakes in 2008 and in the reference period

Vodotok *Stream*	Vodomerna postaja *Gauging Station*	Leto 2008 *Year 2008*		Obdobje *Period*		
		Tnk (^{0}C)	Datum Date	Tnk	Datum Date	Obdobje *Period*
Mura	Gornja Radgona	1,2	1.1.	0	4.1.1997	1989-2007
Dravinja	Videm	0,6	31.12.	0	17.2.1983	1982-2007
Ljubljanica	Moste	4,2	2.1.	1.0	11.2.1956	1954-2007
Soča	Solkan	2,7	21.2.	0	15.2.1956	1953-2007
Sava	Litija	2,8	16.2	0	3.2.1954	1953-2007
Savinja	Laško	0,9	17.2.	0	5.1.1954	1954-2007
Vipava	Dornberk	3,4	31.12.	0.1	6.1.1985	1980-2007
Blejsko jezero	Mlino	4	18.2.	1.2	29.1.1987	1985-2007
Bohinjsko jezero	Sveti duh	3,6	1.1.	0	14.2.1952	1951-2007



Slika 2: Temperature vode (T) Blejskega in Bohinjskega jezera leta 2008 in srednje mesečne temperature (sTs) v dolgoletnem obdobju
Figure 2: Water temperatures (T) of Lake Bled and Lake Bohinj in 2008 and the mean monthly temperatures (sTs) during the multi-annual period

Primerjava značilnih temperatur z večletnim obdobjem

Srednje mesečne temperature rek so bile v vsem letu 2008 višje kot v primerjalnem obdobju na Muri v Gornji Radgoni, Savi v Litiji, Savinji v Laškem, Soči v Solkanu in na Bohinjskem jezeru. Pri rekah je največje odstopanje opaziti pri Soči v Solkanu, ko so srednje mesečne temperature višje od dolgoletnega povprečja v maju za 2,0 °C, juniju za 3,1 °C in juliju za 3,8 °C. Na Savinji v Laškem so bile srednje mesečne temperature vse leto višje, in to za 1 do 2,5 °C. Največje odstopanje pri Bohinjskem jezeru je opaziti v februarju, marcu in juliju, ko so bile srednje mesečne temperature višje za 3,1 °C, 2,7 °C, in 2,2 °C. Pri Dravinji v Vidmu, Ljubljanici v Mostah in Vipavi v Mirnu pa so bile srednje mesečne temperature v poletnih mesecih nižje od temperatur v primerjalnem

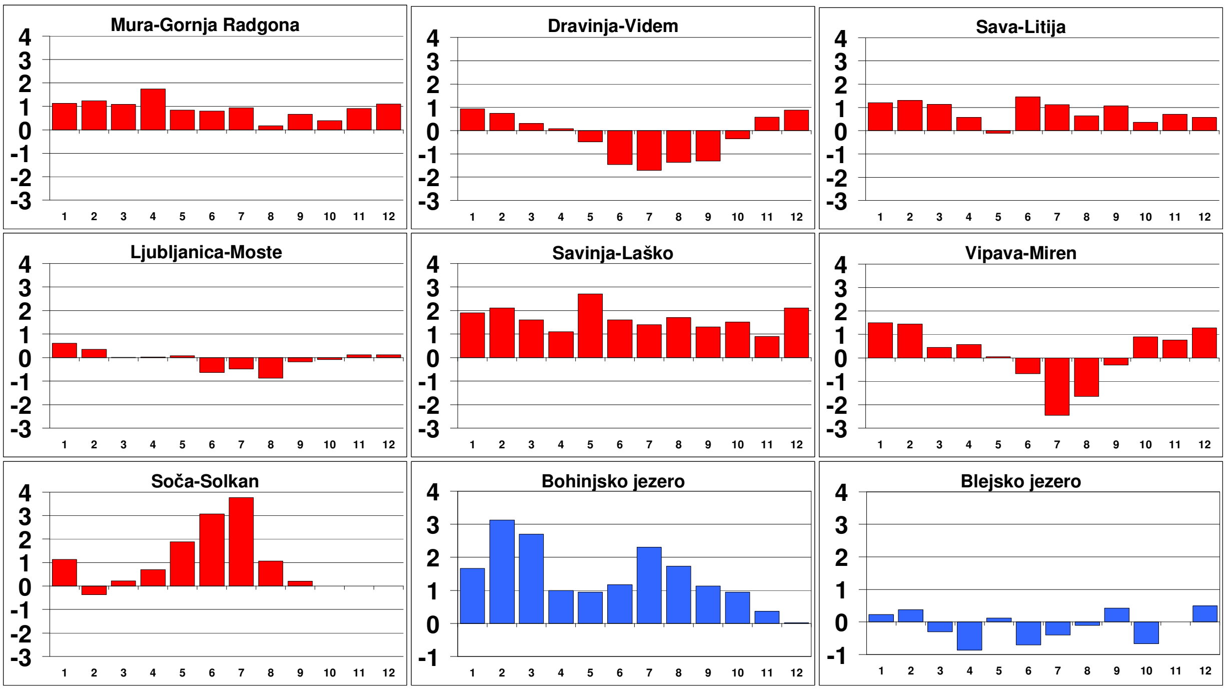
Comparison of characteristic temperatures to the multi-annual period

Throughout the year 2008, the mean monthly river temperatures were higher than in the reference period in Gornja Radgona on the Mura River, Litija on the Sava River, Laško on the Savinja River, Solkan on the Soča River and in Lake Bohinj. The greatest deviation is most evident on the Soča River in Solkan where the mean monthly temperatures were higher than the multi-annual average in May by 2.0°C, in June by 3.1°C and in July by 3.8°C. The mean monthly temperatures were higher all year round in Laško on the Savinja River, i.e. by 1-2.5°C. The greatest deviation can be noticed in Lake Bohinj in February, March and July when the mean monthly temperatures were higher by 3.1°C, 2.7°C, and 2.2°C, respectively. The mean monthly temperatures during the obdobju. Na Vipavi v Mirnu je razlika v juliju 2,5 °C (slika 3).

Srednje letne temperature so pri večini izbranih rek primerljive z dolgoletnim povprečjem, le pri Muri, Savi, Savinji in Bohinjskem jezeru so vrednosti višje. Odstopanje je največje pri Savinji za 1,9 °C (slika 4). Na reki Soči imamo podatke o temperaturi vode le za prvih devet mesecev leta.

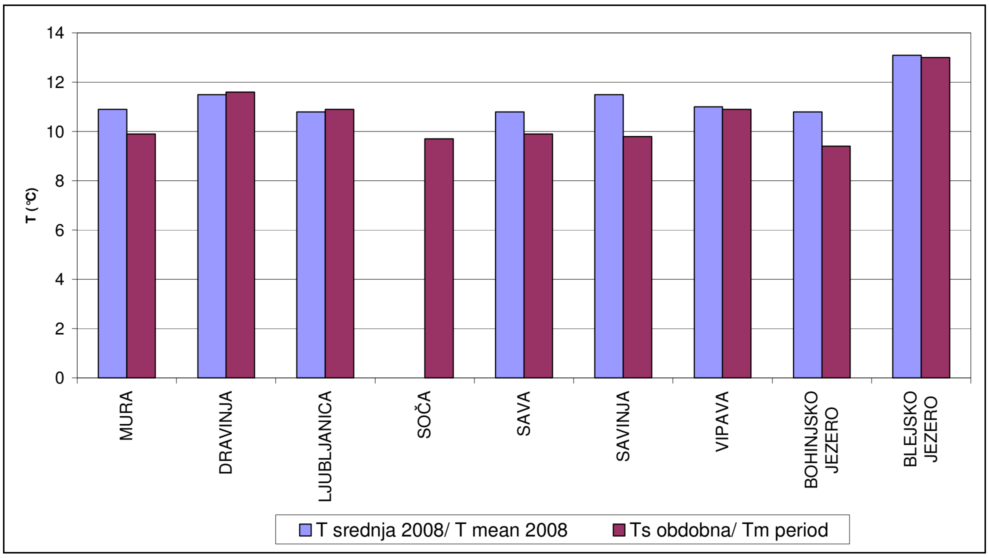
summer months in Videm on the Dravinja River, Moste on the Ljubljanica River and Miren on the Vipava River were lower compared to the reference period temperatures. A 2.5°C difference was recorded in Miren on the Vipava River (Figure 3).

The mean annual temperatures of most selected rivers are comparable to the multi-annual average. Only the Mura, Sava, Savinja rivers and Lake Bohinj recorded higher values. The deviation is the greatest on the Savinja River – 1.9°C (Figure 4). We hold data on the water temperature only for the first months of the year for the Soča River.



Slika 3: Odstopanja srednjih mesečnih temperatur rek in jezer v letu 2008 od srednjih mesečnih temperatur obdobja

Figure 3: Deviations of mean monthly temperatures of rivers and lakes in 2008 from the mean monthly temperatures of the reference period



Slika 4: Primerjava srednjih letnih temperatur rek in jezer v letu 2008 s srednjimi letnimi temperaturami obdobja

Figure 4: Comparison of mean annual temperatures of rivers and lakes in 2008 to the mean monthly temperatures of the reference period

VSEBNOST IN PREMEŠČANJE SUSPENDIRANEGA MATERIALA V REKAH

Mag. Florjana Ulaga

Eden od potencialnih dejavnikov, ki vplivajo na obseg in intenziteto uničujočih učinkov voda, je premeščanje (rečni transport) hribinskega materiala. Posledica premeščanja materiala je spreminjanje pokrajine, povzročanje škode ob poplavah na kmetijskih zemljiščih in prenos onesnaženosti po reki. Ob izrednih hidroloških razmerah se poleg povečanega pretoka rek in rinjenih plavin močno poveča tudi vsebnost suspendiranega materiala v vodi. Na Agenciji RS za okolje izvajamo monitoring suspendiranega materiala v okviru hidrološkega monitoringa. Iz meritev vsebnosti suspendiranega materiala in izmerjenega pretoka izračunamo količino premeščenega materiala po vodotoku. Večina materiala se premesti ob visokih vodah, zaradi česar je potrebno pogosto vzorčenje prav v času visokih voda.

V monitoring suspendiranega materiala je bilo v letu 2008 vključenih 11 merilnih mest: na Muri v Gornji Radgoni, Savi v Hrastniku, Savinji v Velikem Širju, Vipavi v Mirnu, Soči v Kobaridu, Idrijci v Hotešku, Bači v Bači pri Modreju, Reki v Cerkvenikovem mlinu, Rižani v Kubedu in na Dragonji v Podkaštelu. Na postaji Suha na Sori je odvzem vzorcev potekal z avtomatskim vzorčevalnikom, na ostalih postajah pa so bili vzorci odvzeti ročno. Na vseh merilnih mestih je monitoring potekal ob izrednih hidroloških razmerah. Enkrat ali večkrat dnevno se odvzame vzorec vode s prostornino enega litra. Vzorci so analizirani v laboratoriju po klasični filtracijski metodi. Rezultati analiz so izmerjene vsebnosti suspendiranega materiala (c), izražene v g/m^3 vode. Mreža vodomernih postaj, na katerih je v letu 2008 potekal odvzem vzorcev, je prikazana na karti v IV. delu publikacije.

Rezultati meritev vsebnosti suspendiranega materiala v letu 2008

V letu 2008 smo največje vsebnosti suspendiranega materiala izmerili v vzorcih, odvzetih junija v Muri, julija v Sori, Savinji, Vipavi in Rižani in decembra v Savi, Idrijci in Reki. V Soči in Bači so bile največje vsebnosti izmerjene 30. oktobra, v Dragonji pa januarja (preglednica 1).

V nobenem vzorcu nismo zabeležili vsebnosti

CONCENTRATION AND TRANSPORT OF SUSPENDED MATERIAL IN RIVERS

Florjana Ulaga, MSc

One of the potential factors influencing the size and intensity of the destructive effects of waters is the river transport of hilly material. The result of material transport is the changing of the landscape, damage during floods to the agricultural land and transfer of pollution down the river. During extraordinary hydrological conditions, the concentration of suspended material in the water also increases significantly in addition to the increased river discharge and bed load. The EARS conducts suspended material monitoring within hydrological monitoring. The quantity of transported material down the watercourse is calculated based on the measurements of suspended material concentration and the measured discharge. The majority of material is transported during high waters, thus frequent sampling is necessary precisely during this period.

11 water gauging stations were involved in the monitoring of suspended material in 2008: Gornja Radgona on the Mura River, Hrastnik on the Sava River, Veliko Širje on the Savinja River, Miren on the Vipava River, Kobarid on the Soča River, Hotešek on the Idrijca River, Bača pri Modreju on the Bača River, Cerkvenikov mlin on the Reka River, Kubed on the Rižana River and Podkaštel on the Dragonja River. The sampling at the Suha gauging station on the Sora River was conducted with an automatic sampler, while samples were taken manually at other stations. Monitoring was performed at all monitoring stations only during extraordinary hydrological conditions. A sample of one litre of water is taken once or several times a day at the gauging stations. The samples are analysed in a laboratory using a classic filtration method. The results of analyses are measured concentrations of suspended material (c) expressed in g/m^3 of water. The network of water gauging stations at which sampling was performed in 2008 is shown on the map in Part IV of the publication.

The results of monitoring the suspended material concentration in 2008

In 2008, the maximum concentration of suspended material was measured in samples taken in June on the Mura River, in July on the Sora, Savinja, Rižana rivers and in December on the Sava, suspendiranega materiala, ki bi bila večja od obdobne, vseeno pa je bila vsebnost 30. oktobra 2008 v Soči v Kobaridu izredno velika, saj je razen leta 2000, ko so se v vzorcu odražale posledice zemeljskega plazu, vsebnost 5501 g/m^3 največja izmerjena vsebnost celotnega obdobja opazovanj reke Soče (slika 1). Istega dne je bil odvzet vzorec tudi v Bači, vsebnost je bila močno povečana in je znašala 2846 g/m^3.

Idrijca and Reka rivers. The Soča and Bača rivers recorded their highest concentrations on 30 October, while the Dragonja River recorded maximum concentrations in January (Table 1).

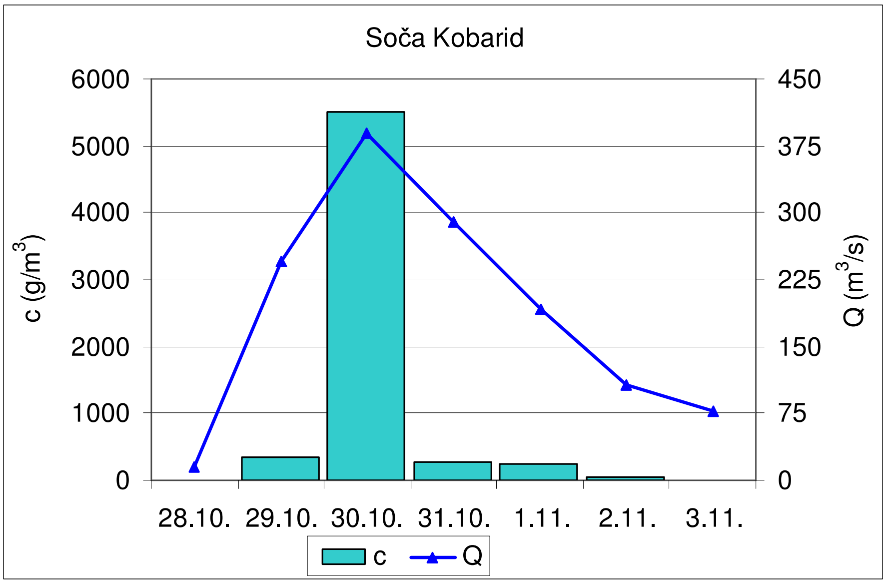
We did not record a higher concentration of suspended material than the periodical values in any samples, nevertheless the concentration on 30 October 2008 was extremely high in Kobarid on the Soča River, as except for the year 2000 when the samples reflected the results of the landslide, the measured concentration of 5,501 g/m^3 is the highest measured concentration of the entire period of observations on the Soča River (Figure 1). Samples were also taken on the same day on the Bača River, also demonstrating a considerable increase in concentration 2,864 g/m^3.

Preglednica 1: Največje vsebnosti suspendiranega materiala v vzorcih leta 2008 in največje izmerjene vsebnosti v obdobju 1977–2007

Table 1: Maximum concentrations of suspended material in the samples in 2008 and the maximum measured concentrations during the reference period (1977-2007)

Vodotok *Stream*	Vodomerna postaja *Gauging station*	2008		1977 - 2007	
		Vsebnost c (g/m^3) *Concentration c (g/m^3)*	Datum vzorčenja *Date of sampling*	Največja obdobna vsebnost c (g/m^3) *The highest concentration in the period c (g/m^3)*	Datum največje obdobne vsebnosti *Date of the highest concentration in the period*
Mura	Gornja Radgona	1179	27.06.	2364	16.05.1996
Sava	Hrastnik	1135	18.12.	6405	19.09.2007
Sora	Suha	1159	18.07.	8120	28.02.1977
Savinja	Veliko Širje	1733	14.07.	9574	14.04.1994
Soča	Kobarid	5501	30.10.	8112	17.11.2000
Bača	Bača pri Modreju	2846	30.10.	5125	21.08.1988
Idrijca	Hotešk	1139	05.12.	3743	09.10.1993
Vipava	Miren	235	15.07.	1105	27.10.2004
Reka	Cerkvenikov mlin*	160	12.12.	280	12.11.2001
Rižana	Kubed**	174	31.07.	189	14.08.2006
Dragonja	Podkaštel**	242	12.12.	1362	13.02.2007

* Vzorčenje poteka od leta 2001. ** Vzorčenje poteka od leta 2006.
*Sampling performed since 2001. **Sampling performed since 2006.

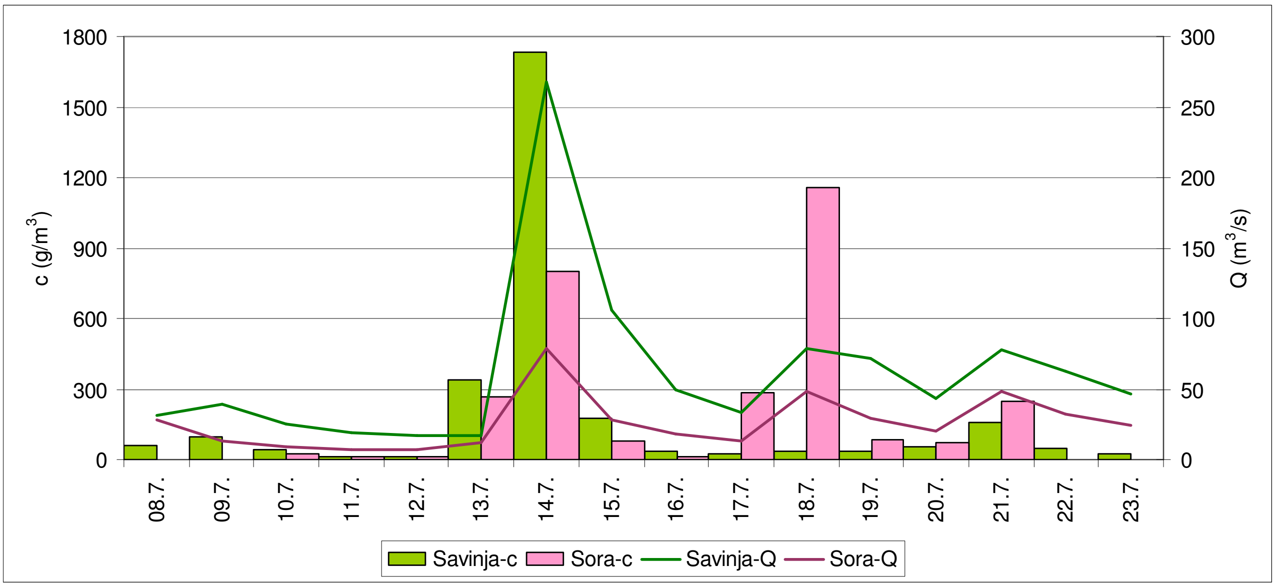


Slika 1: Povečana vsebnosti suspendiranega materiala v Soči in povečan pretok v oktobru 2008

Figure 1: Increased suspended material concentration in the Soča River and increased discharge in October 2008

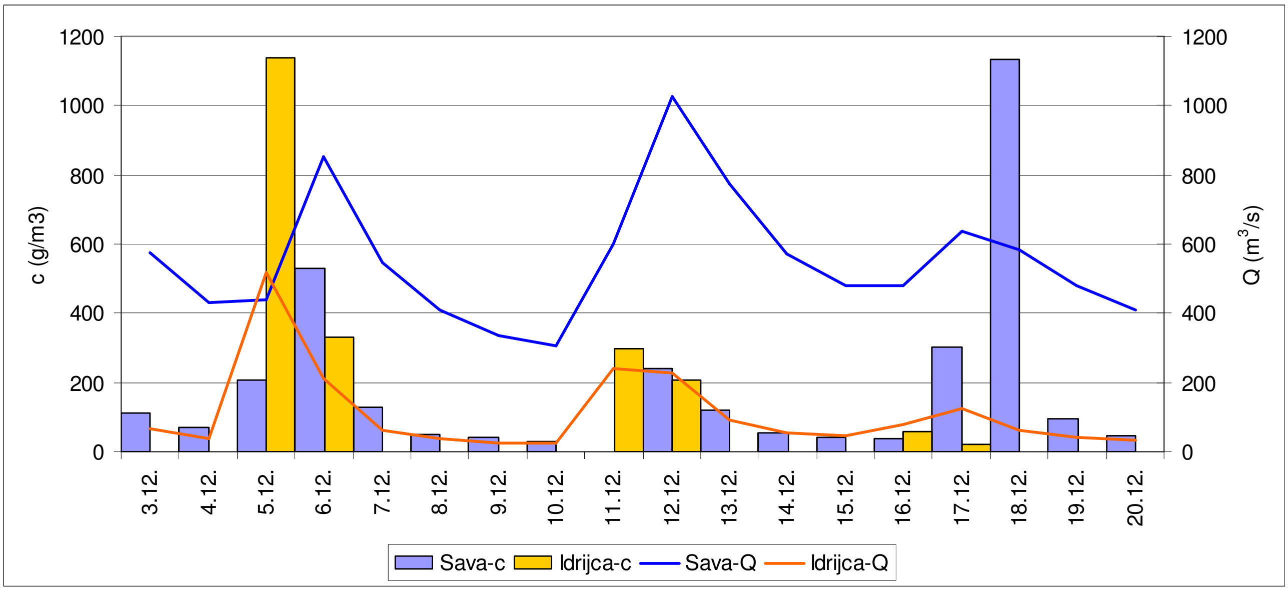
Na postaji Veliko Širje na Savinji smo največjo vsebnost suspendiranega materiala izmerili julija, ko je bila vsebnost 1733 g/m^3, kar je za 30-krat preseženo obdobno povprečje, ki znaša 58 g/m^3 (slika 2). V Sori je bila vsebnost septembra 1156 g/m^3, kar za 58-krat presega obdobno povprečje. Tudi v Vipavi in Rižani smo izmerili povečano vsebnost suspendiranih snovi v poletnih mesecih, kar ne sovpada s pretočnimi režimi rek jugozahodne Slovenije. Vsebnost suspendiranega materiala v rekah je bila povečana ob poletnih nevihtah, ko so bili veliki tudi pretoki rek.

The highest suspended material concentration was measured in July at the Veliko Širje station on the Savinja River, amounting to 1,733 g/m^3, which is 30 times the amount of the periodical average of 58 g/m^3 (Figure 2). The concentration of the suspended material in the Sora River amounted to 1,156 g/m^3 in September, which is 58 times the amount of the periodical average. We also measured an increased suspended material concentration in the Vipava and Rižana rivers during the summer months, which is not in accordance with the river regimes of the south-western part of Slovenia. The suspended material concentration in rivers was increased during summer thunderstorms, when the river discharges also grew.



Slika 2: Povečana vsebnost suspendiranega materiala julija 2008 v Savinji in Sori

Figure 2: Increased suspended material concentration in July 2008 in the Savinja and Sora rivers



Slika 3: Povečana vsebnost suspendiranega materiala v decembru 2008 v Savi in Idrijci.
Figure 3: Increased suspended material concentration in December 2008 in the Sava and Idrijca rivers

V Savi v Hrastniku in v Idrijci smo največje vsebnosti suspendiranega materiala izmerili decembra. V Idrijci je bila vsebnost izredno povečana (1139 g/m^3) sočasno z največjim letnim pretokom na vodomerni postaji v Hotešku (slika 3). Povečane vsebnosti smo izmerili tudi v Reki in Dragonji, kjer je bil 12. decembra povečan tudi pretok. V Gornji Radgoni smo izmerili največjo vsebnost suspendiranega materiala junija, kar je skladno s pretočnim režimom Mure.

Premeščanje suspendiranega materiala

Iz vsebnosti suspendiranega materiala in izmerjenega pretoka izračunamo količino premeščenega suspendiranega materiala na dan. V preglednici 2 so zbrani podatki o srednjih vrednostih premeščenega suspendiranega materiala na vodomernih postajah in največjem premeščanju suspendiranega materiala v letu 2008. Vrednosti v rekah z iztokom v Jadransko morje pa tudi Idrijca in Sava v Hrastniku izkazujejo izredno premeščanje suspendiranega materiala v času decembrskih visokih voda. V Savinji, Sori in Muri je bilo največ suspendiranih snovi premeščenih ob poletnih visokih vodah, v Bači in Soči pa oktobra.

Po analizi odvzetih vzorcev smo ocenili, da naj bi Soča v 81 urah med 29. oktobrom ob 8. uri in 1. novembrom ob 17. uri skozi rečni profil v Kobaridu prenesla 2.514.410 ton materiala, kar bi pomenilo v podobnih visokovodnih razmerah v povprečju 31.000 ton na uro. Največ suspendiranega materiala je Soča prenesla 30. oktobra ob 8. uri, kar 2141 kg/sekundo. Takšna količina je izredno velika in se odraža tako v prenosu onesnaženosti, spreminjanju rečnega profila kot tudi pri

The highest suspended material concentrations were measured in December in Hrastnik in the Sava River and in the Idrijca River. The concentration in the Idrijca River was greatly increased (1,139 g/m^3) to coincide with the highest annual discharge at the water gauging station in Hotešek (Figure 3). Increased concentration was also recorded in the Reka and Dragonja Rivers where the discharge had also increased on 12 December. We measured the highest concentration of suspended material in Gornja Radgona in June, which corresponds to Mura's discharge regime.

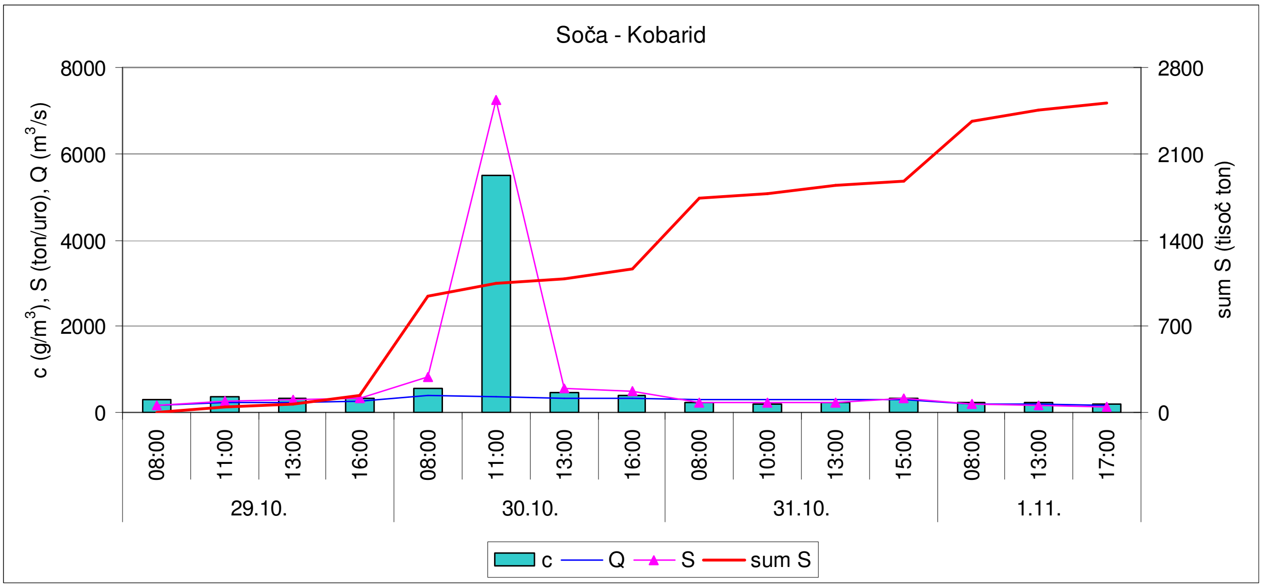
Transport of suspended material

The quantity of transported material per day is calculated based on the suspended material concentration and the measured discharge. The data on mean values of transported suspended material at water gauging stations and maximum transport of suspended material in 2008 are shown in Table 2. Values in rivers with outflows into the Adriatic Sea as well as the Idrijca and Sava rivers in Hrastnik demonstrate exceptional transportation of suspended material during high waters in December. The Savinja, Sora and Mura rivers recorded maximum levels of transported suspended material during the summer high water levels, while the Soča and Bača rivers recorded such levels in October.

Upon analysing the taken samples we determined that the Soča River transported 2,514,410 tons of material through the river profile in Kobarid between 29 October (8 am) and 1 November (5 pm), collectively 81 hours, which in similar high water levels means 31,000 tons per hour. The spreminjanju celotne pokrajine ob reki.

maximum amount of suspended material was transported on 30 October at 8 a.m. (2,141 kg/s).

That is an extremely large amount reflected in the transfer of pollution, the changing of the river profile as well as in the changing of the entire landscape alongside the river.



Slika 4: Izjemno povečano premeščanje suspendiranega materiala v Soči, november 2008
Figure 4: Exceptional increase in transportation of suspended material in Soča, November 2008

Preglednica 2: Največje letno premeščanje suspendiranega materiala med odvzetimi vzorci v letu 2008 ter srednja obdobna vrednost premeščenega suspendiranega materiala
Table 2: Maximum annual transportation of suspended material among the samples taken in 2008 and mean periodical value of the transported suspended material

Vodotok *Stream*	Vodomerna postaja *Gauging station*	Največji letni 2008 S (kg/s) *The highest annual transport S (kg/s)*	Datum vzorčenja 2008 *Date of sampling 2008*	Srednji obdobni transport (kg/s) *Mean transport in the period (kg/s)*
Mura	Gornja Radgona	271	17.08.	12
Sava	Hrastnik	661	18.12.	16
Sora	Suha	57	18.07.	3,3
Savinja	Veliko Širje	264	14.07.	6
Soča	Kobarid	2141	30.10.	19,6
Bača	Bača pri Modreju	104	30.10.	2,6
Idrijca	Hotešk	230	05.12.	12,8
Vipava	Miren	17	11.12.	1,1
Reka	Cerkvenikov mlin*	32	12.12.	0,7
Rižana	Kubed**	4	12.12.	0,5
Dragonja	Podkaštel**	4,8	12.12.	6

* Vzorčenje poteka od leta 2001.
*Sampling performed since 2001.

** Vzorčenje poteka od leta 2006.
**Sampling performed since 2006.

B. PODZEMNE VODE

STANJE ZALOG PODZEMNIH VODA V ALUVIALNIH VODONOSNIKIH V LETU 2008

Urška Pavlič

Leta 2008 sta v aluvialnih vodonosnikih prevladovali običajno in nizko vodno stanje. Od običajnih gladin podzemne vode so zaradi negativnega letnega odklona padavin odstopala območja vodonosnikov severovzhodne Slovenije. Podpovprečne gladine so prevladovale tudi v vodonosniku Vipavske doline, vzrok za to je bilo obnavljanje vodnih zalog iz preteklih sušnih let. Nizke in zelo nizke vodne zaloge v vodonosnikih Sorškega in Kranjskega polja so bile, kot že mnoga leta, posledica umetnega režima nihanja podzemnih voda, ki je nastalo ob zajezitvi reke Save leta 1986. Nadpovprečne gladine podzemnih voda so bile večino leta 2008 merjene v delu Mirenskega, Vrtojbenskega in Ljubljanskega polja, pripisujemo jih presežku padavin. Najbolj sušna meseca sta bila september in oktober, decembra pa so bile izmerjene najvišje gladine podzemnih voda.

Na stanje zalog podzemnih voda vpliva količina padavin, ki se posredno ali neposredno infiltrira v vodonosnik.V letu 2008 je bilo napajanje aluvialnih

B. GROUNDWATER

GROUNDWATER STORAGE IN ALLUVIAL AQUIFERS IN 2008

Urška Pavlič

In alluvial aquifers in 2008, low or normal water levels were prevalent. Aquifer regions of north-eastern Slovenia deviated from normal groundwater levels due to the deficit in annual precipitation. Below average levels also prevailed in the Vipava Valley aquifer due to the recovery of water reserves from previous years of drought. Low and very low water reserves in aquifers of the Sora and Kranj Field were, like many years before, a result of the artificial groundwater fluctuation regime due to the impoundment of the Sava River in 1986. The above-average groundwater levels were measured for the majority of 2008 in parts of the Miren, Vrtojba and Ljubljana Field and were attributed to the precipitation surplus. The driest months were September and October, while December recorded higher levels of groundwater.

The quantity of precipitation which is directly or indirectly infiltrated in the aquifer influences the volume of groundwater reserves. In 2008, the recharging of alluvial aquifers through the infiltration of precipitation in the western part of the

Vipavska dolina (foto: Arhiv ARSO)
Vipava Valley (photo: EARS archives)

vodonosnikov z infiltracijo padavin na zahodu države večje kot običajno. Največ padavin je območje Murske kotline prejelo julija, ostala območja aluvialnih vodonosnikov pa decembra. V Vipavski in Soški dolini je bilo padavin za približno eno desetino več kot znaša dolgoletno povprečje, kar je ugodno vplivalo na obnavljanje zalog podzemnih voda po triletnem padavinskem primanjkljaju tega območja. Običajnih letnih padavin v letu 2008 ni doseglo območje Murske in Dravske kotline. Za najbolj sušen mesec je na območju večine vodonosnikov veljal september, izjema so bili vodonosniki Murske ter Krške in Brežiške kotline z najmanjšo izmerjeno količino padavin v mesecu januarju.

Aluvialni vodonosniki se napajajo tudi z infiltracijo iz rek, pri čemer mora obstajati hidravlična povezava med vodotokom in podzemno vodo. V splošnem vodnatost rek v letu 2008 ni izrazito odstopala od dolgoletnega povprečja. Napajanje vodonosnikov je bilo zaradi nadpovprečnih vodostajev površinskih voda najbolj intenzivno v decembru, najmanj pa v jesenskih mesecih z minimumom v septembru.

Prostorska variabilnost zalog podzemne vode v letu 2008

V povprečju so leta 2008 prevladovale običajne zaloge podzemnih voda. Zelo nizka in nizka vodna stanja so bila značilna le za vodonosnike Vipavske doline in Sorškega polja ter za dele Prekmurskega, Apaškega, Dravskega, Ptujskega, Krškega in Kranjskega polja. V delih vodonosnikov Mirenskega, Vrtojbenskega in Ljubljanskega polja so v letu 2008 prevladovale nadpovprečno visoke vodne zaloge. Značilne letne gladine podaja preglednica 1, prostorsko variabilnost zalog podzemnih voda v letu 2008 pa sliki 1 in 4.

Značilne letne gladine podzemnih voda, Hnk, Hs in Hvk, so grobi pokazatelj vodnih zalog oziroma statistično povprečnega režima na letni ravni. Ti statistični parametri omogočajo grobo oceno variabilnosti v prostoru, ne morejo pa zajeti časovne variabilnosti med letom. Zaradi nizkih vodostajev rek, ki so hidravlično povezani s podzemno vodo, in zaradi primanjkljaja padavin na območju severovzhodne Slovenije je v delih vodonosnikov ob Muri in Dravi leta 2008 prevladovalo nižje stanje zalog podzemnih voda, kot je običajno. Kljub temu odstopanja od povprečnih gladin podzemnih voda tega območja niso bila zelo velika.

Režim nihanja podzemne vode je v Krški vasi na južnem obrobju vodonosnika Krškega polja

country was higher than usual. The majority of precipitation fell in the Mura Basin in July, while in other areas of alluvial aquifers in December. There was approx. one tenth more precipitation compared to the multi-annual average in the Vipava and Soča valleys, which had a positive impact on the restoration of groundwater reserves after the three-year precipitation shortage in the area. The usual annual precipitation in 2008 did not hit the area of the Mura and Drava basins. September was the driest month for most of the aquifer areas, save for the aquifers of the Mura, Krško and Brežice basins with the lowest measured quantity of precipitation in January.

Alluvial aquifers are fed through infiltration from rivers, provided that a hydraulic link between the watercourse and the groundwater exists. In general, the water abundance in 2008 did not deviate significantly from the multi-annual average. The feeding of aquifers was most intense in December due to the above-average levels of surface waters, while being at its lowest during autumn, reaching the minimum in September.

Spatial variability of groundwater reserves in 2008

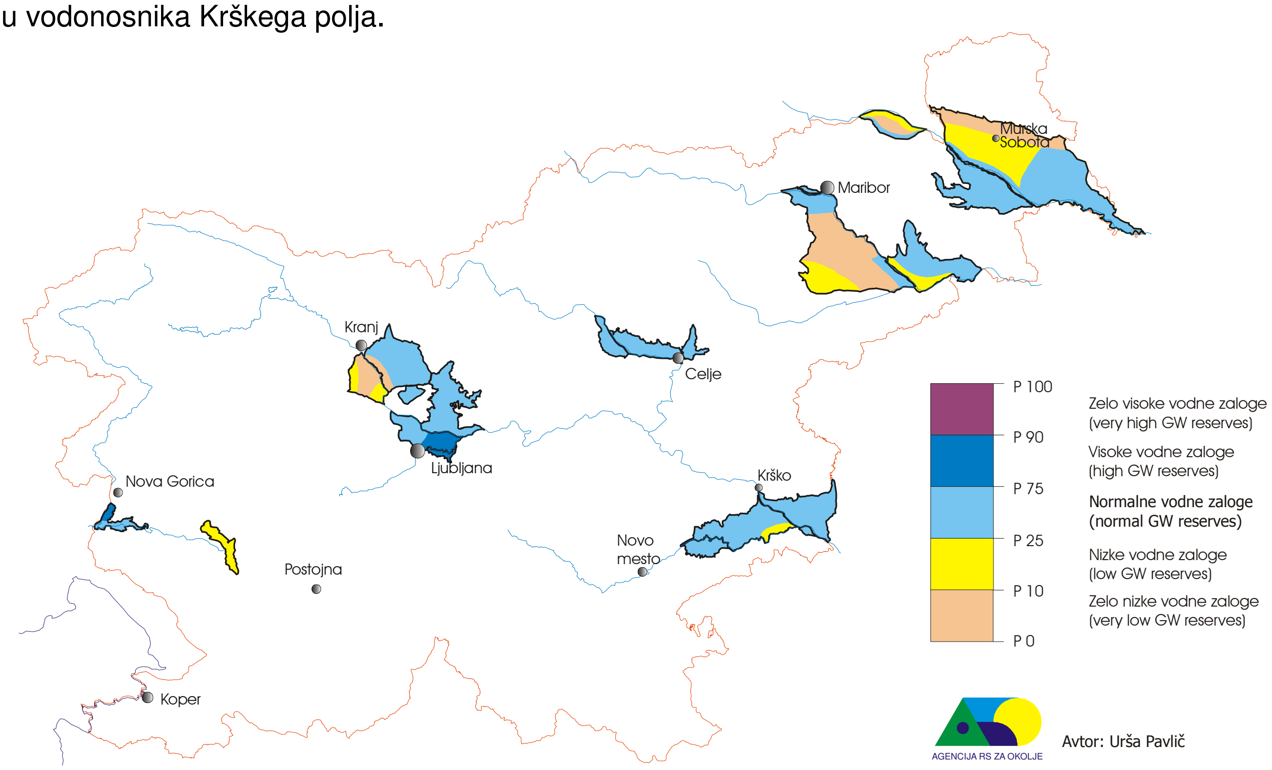
On average normal values of groundwater reserves prevailed in 2008. Very low and low water levels were characteristic only for aquifers of the Vipava Valley and Sora Field and for parts of the Prekmurje, Apače, Drava, Ptuj, Krško and Kranj Fields. In parts of the aquifers Miren, Vrtojba and Ljubljana Field above-average high water reserves were prevalent in 2008. Characteristic annual water levels are shown in Table 1, while the spatial variability of groundwater reserves in 2008 is demonstrated in Figures 1 and 4.

The characteristic annual levels Hnk, Hs and Hvk are a general indicator of groundwater storage or the statistical average regime at the annual level. These statistical parameters enable a rough estimate of spatial variability, though cannot cover the time variability during the year. Due to low water levels of rivers hydraulically linked to the groundwater and precipitation deficit in the area of north-eastern Slovenia, a lower than usual level of groundwater reserves prevailed in parts of the aquifers along the Mura and Drava rivers in 2008. Nevertheless, the deviations from the average groundwater levels of this area were not significant.

The groundwater fluctuation regime in Krška vas on the south edge of the Krško Field aquifer is subjected to the fluctuation regime of the Krka River hydraulically linked to the aquifer (Figure 3).

pogojen z režimom nihanja reke Krke, ki je v hidravlični povezavi z vodonosnikom (slika 3). Ker je bila v letu 2008 v povprečju vodnatost Krke nekoliko pod dolgoletnim povprečjem, je posledično takšno stanje prevladovalo tudi v tem delu vodonosnika Krškega polja.

Seeing that the average water abundance of the Krka River was slightly below the multi-annual average in 2008, such conditions also prevailed in this part of the Krško Field aquifer.



Slika 1: Srednje letne gladine leta 2008 v večjih aluvialnih vodonosnikih
Figure 1: Mean annual water levels in 2008 in larger alluvial aquifers

Kljub ugodnim klimatskim razmeram na območju aluvialnih vodonosnikov na zahodu države je leta 2008 v Vipavski dolini prevladovalo podpovprečno vodno stanje. Razlog pripisujemo obnavljanju zalog podzemnih voda iz preteklih let, ko je v tem vodonosniku kar tri leta zapored zaradi primanjkljaja padavin in visoke stopnje evapotranspiracije prevladovalo zelo nizko stanje zalog podzemnih voda (slika 2). Podoben primer obnavljanja zalog podzemnih voda smo več let po izraziti hidrološki suši med letoma 2002 in 2003 spremljali tudi v aluvialnih vodonosnikih Murske kotline.

Despite favourable climate conditions in the area of alluvial aquifers in the western part of the country, below-average water levels prevailed in the Vipava Valley in 2008. This was attributed to the recovery of groundwater reserves from previous years, when a very low level of groundwater reserves existed in this aquifer due to three consecutive years of a precipitation deficit and a high degree of evapotranspiration (Figure 2). A similar case of groundwater recovery was also observed for several years after the intense hydrological drought between the years 2002 and 2003 in alluvial aquifers of the Mura Basin.

Že vrsto let v hidroloških letopisih poročamo o vplivu zajezitve Save pri Mavčičah na režim nihanja podzemne vode v vodonosnikih pretežnega dela Sorškega polja in dela Kranjskega polja. Pojav zniževanja gladin podzemnih voda zaradi zamuljevanja brežin akumulacijskega jezera in s tem postopnega zmanjševanja hidravlične povezanosti med površinsko in podzemno vodo smo v teh vodonosnikih spremljali tudi leta 2008.

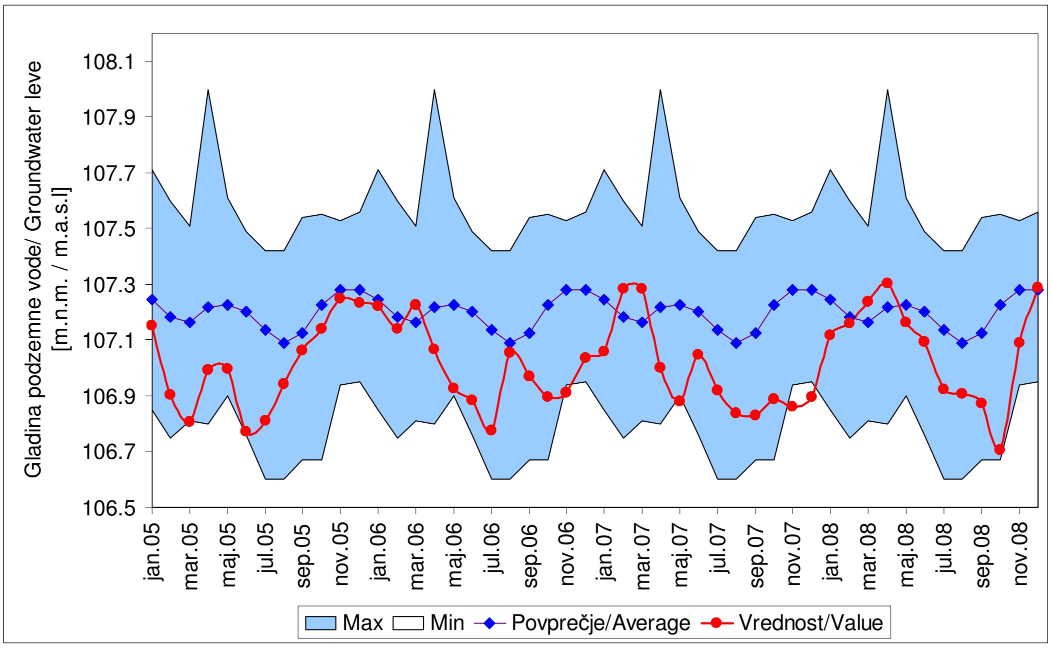
We have reported for a number of years now in hydrological yearbooks on the influence of the impoundment of the Sava River at Mavčice on the groundwater fluctuation regime in aquifers in most parts of the Sora Field and in parts of the Kranj Field. The groundwater level decrease due to the silting up of the accumulation lake and with it the gradual decrease in the hydraulic link between the surface water and groundwater was observed in these aquifers in 2008 too.

Nadpovprečno stanje zalog podzemnih voda je leta 2008 prevladovalo v severnem delu

The above-average amount of groundwater reserves prevailed in 2008 in the northern part of

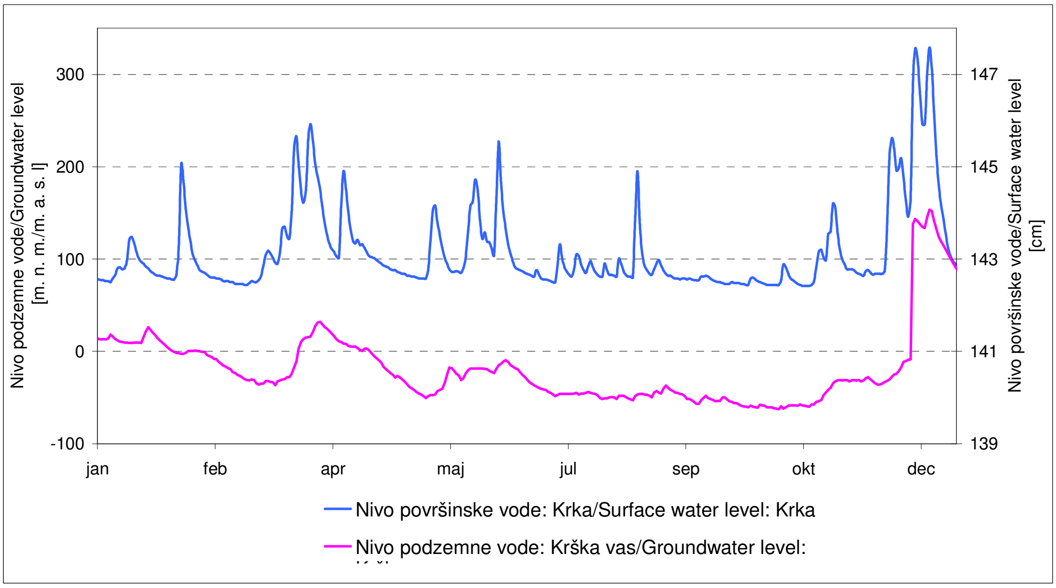
Mirenskega in Vrtojbenskega polja ter na vzhodu Ljubljanskega polja, kar pripisujemo ugodnim klimatskim razmeram teh vodonosnikov. Na severnem območju Mirenskega in Vrtojbenskega polja na režim nihanja gladin podzemne vode poleg padavin vplivata tudi dotok iz kraškega zaledja in hidrološko stanje reke Soče, vzhodni del Ljubljanskega polja pa se napaja z infiltracijo padavin in reke Save ter z dotoki podzemne vode iz drugih delov vodonosnika Ljubljanskega polja.

the Miren and Vrtojba Field and also in the eastern part of the Ljubljana Field, which can be attributed to favourable climate conditions in these aquifers. In addition to the precipitation, the inflow from the karstic hinterland and the hydrological conditions of the Soča River also influences the fluctuation regime of the groundwater levels in the northern area of the Miren and Vrtojba Field. The eastern part of the Ljubljana Field feeds on the infiltration of precipitation and the Sava River and with inflows of groundwater from other parts of the Ljubljana Field aquifer.



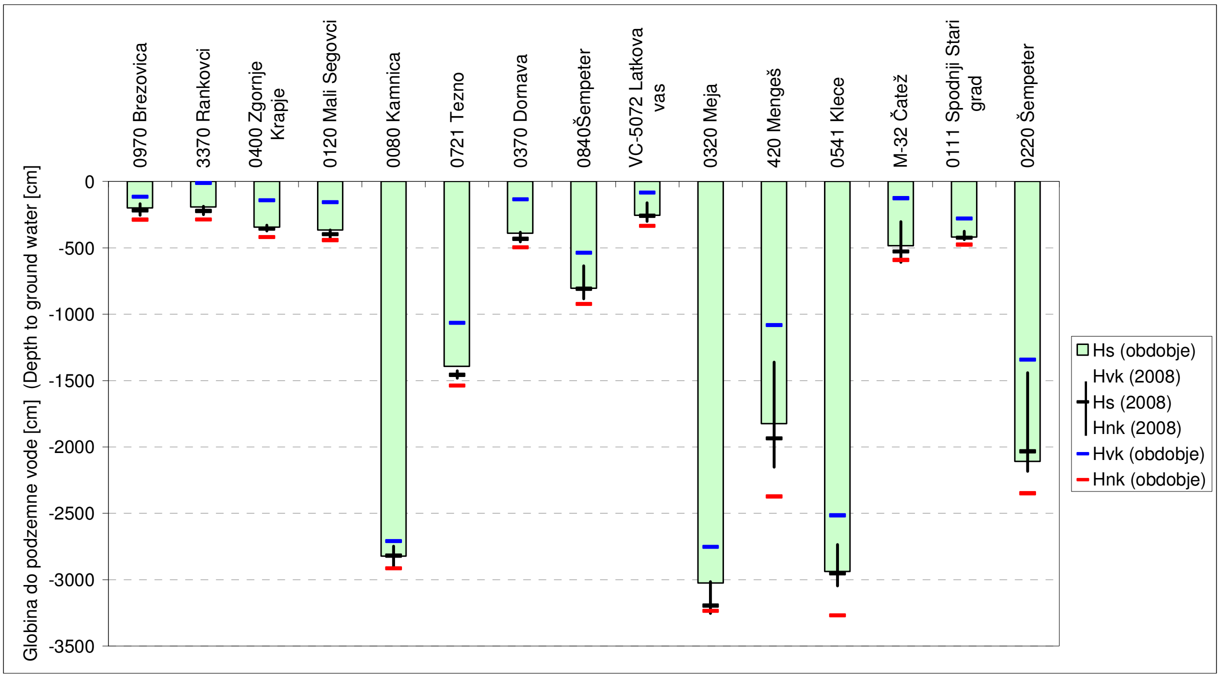
Slika 2: Nihanje povprečnih mesečnih gladin podzemne vode med letoma 2005 in 2008 glede na dolgoletne povprečne, minimalne in maksimalne mesečne vrednosti na merilnem mestu v Vipavskem Križu (vodonosnik Vipavske doline)

Figure 2: Fluctuation of average monthly groundwater levels between 2005 and 2008 with regard to the multi-annual average, minimum and maximum monthly values at the gauging station in Vipavski Križ (the aquifer of the Vipava Valley)



Slika 3: Primerjava med nihanjem vodostajev reke Krke v Podbočju in gladine podzemne vode v Krški vasi v letu 2008

Figure 3: Comparison of fluctuation of water levels of the Krka River in Podbočje and the groundwater levels in Krška vas in 2008



Slika 4: Primerjava značilnih globin do podzemne vode v letu 2008 z značilnimi gladinami za primerjalno obdobje (preglednica 1) (Hs – srednja letna/obdobna gladina, Hnk – najnižja letna/obdobna gladina, Hvk – najvišja letna/obdobna gladina)
Figure 4: Comparison of characteristic depths to groundwater in 2008 with characteristic water levels for the comparable period (Table 1) (Hs – mean annual/periodical level, Hnk – lowest annual/periodical level, Hvk – highest annual/periodical level)

Preglednica 1: Primerjava značilnih globin do podzemne vode v letu 2008 z značilnimi globinami dolgoletnega primerjalnega obdobja (V. Savić)
Table 1: Comparison of characteristic depths to groundwater in 2008 with characteristic depths of the multi-annual reference period (V. Savić)

Postaja *Station*	Vodonosnik *Aquifer*	2008			Obdobje / *Period*		
		Hnk (cm)	Hs (cm)	Hvk (cm)	Hnk (cm)	Hs (cm)	Hvk (cm)
0970 Brezovica	PREKMURSKO POLJE	254	218	168	287	203	129
3370 Rankovci	PREKMURSKO POLJE	250	222	187	286	181	56
0400 Zgornje Krapje	MURSKO POLJE	374	356	329	405	344	241
0120 Mali Segovci	APAŠKO POLJE	424	398	365	441	363	151
0080 Kamnica	VRBANSKI PLATO	2901	2820	2747	2915	2832	2725
0721 Tezno	DRAVSKO POLJE	1481	1457	1427	1537	1436	1267
0370 Dornava	PTUJSKO POLJE	455	432	381	497	411	260
0840Šempeter	SP. SAVINJSKA DOL.	884	808	636	923	802	537
VC-5072 Latkova vas	DOLINA BOLSKE	301	259	160	322	255	86
0320 Meja	SORŠKO POLJE	3253	3196	3016	3252	3058	2754
420 Mengeš	DOLINA KAMNIŠKE BISTRICE	2152	1935	1360	3441	2793	1946
0541 Klece	LJUBLJANSKO POLJE	3046	2952	2736	3194	2976	2635
M-32 Čatež	ČATEŠKO POLJE	608	527	302	638	539	108
0111 Sp. Stari grad	BREŽIŠKO POLJE	439	424	375	470	418	279
0220 Šempeter	VIPAVSKO-SOŠKA DOLINA	2184	2034	1442	2323	2154	1378

Časovna variabilnost zalog podzemne vode v letu 2008

V prvih dveh mesecih so v aluvialnih vodonosnikih prevladovale nizke in običajne zaloge podzemnih voda. Od marca do avgusta so se vodne gladine v nekaterih vodonosnikih zviševale do nadpovprečnih vrednosti, v nekaterih pa so se že sicer nizke zaloge podzemnih voda še naprej zniževale. Sledilo je tromesečno obdobje s primanjkljajem padavin in nizkimi vodostaji rek in posledično tudi nizkimi in zelo nizkimi zalogami podzemnih voda. Najbolj prizadeto območje je bil severovzhod države. December je veljal za moker mesec. Zaloge podzemnih voda so se tedaj v pretežnih delih Ljubljanske kotline, doline Bolske ter Mirenskega in Vrtojbenskega polja in v delu Brežiške kotline dvignile do zelo visokih vrednosti. Nihanje mesečnih gladin podzemnih voda prikazujejo preglednica 2 in sliki 5 in 6.

Januarja so predvsem zaradi primanjkljaja padavin prevladovale nizke in običajne zaloge podzemnih voda. Zelo nizke gladine so bile izmerjene v osrednjih delih Apaškega, Dravskega in Sorškega polja ter v delih vodonosnikov Krške, Brežiške in Ljubljanske kotline. Nizko vodno stanje se v večini teh vodonosnikov ni obnovilo vse do zadnjega meseca leta. Zelo nizke zaloge podzemnih voda so bile januarja zabeležene tudi v vodonosniku Vrbanskega platoja, ki pa so bile posledica umetnega znižanja podzemne vode zaradi osuševanja gradbene jame v Mariboru in del v strugi reke Drave. Ugodne klimatske razmere so januarja prevladovale le na območju vodonosnikov Vipavske in Soške doline, zaradi česar so se zelo nizke gladine iz leta 2007 ponekod zvišale do običajnih, ponekod pa do nadpovprečnih vrednosti. Podobno vodno stanje kot v januarju se je nadaljevalo tudi v **februarju**, ko je bilo padavin na vseh območjih vodonosnikov zopet manj, kot je značilno za ta mesec. Do nizkih zalog podzemnih voda so se vodne gladine tedaj znižale tudi v vodonosnikih Krškega polja in doline Kamniške Bistrice ter v delih Prekmurskega in Ptujskega polja, spodnje Savinjske ter Vipavske in Soške doline. **Marec** je bil padavinsko obilen. Zaloge podzemnih voda so se tedaj na večini merilnih mest spodnje Savinjske doline, Šentjernejskega in Čateškega polja ter Vipavske in Soške doline obnovile do nadpovprečnih vrednosti. Nadpovprečno napajanje z infiltracijo padavin na območju vodonosnikov Vipavske in Soške doline in Ljubljanske kotline je **aprila** povzročilo dvig gladin podzemnih voda v vodonosnikih tega območja, ponekod so bile tam zabeležene tudi zelo visoke zaloge podzemnih voda. V ostalih območjih države napajanje z infiltracijo padavin aprila ni doseglo dolgoletnega

Temporal variability of groundwater reserves in 2008

In the first two months low and usual groundwater reserves prevailed in the alluvial aquifers. From March to August, the water levels in some aquifers increased to above-average values; in some places the already low groundwater reserves continued to decrease. A three-month period with a precipitation deficit and low water levels of rivers followed, which also resulted in low and very low groundwater reserves. The region most affected was the north-eastern part of the country. December was a very wet month. Groundwater reserves increased to very high levels at that time in most parts of the Ljubljana Basin, Bolska Valley, Miren and Vrtojba Field and in parts of the Brežice Basin. The fluctuation of monthly groundwater levels is demonstrated in Table 2 and Figures 5 and 6.

Low and usual groundwater reserves were prevalent in **January** mainly due to the precipitation deficit. Very low levels were measured in the central parts of Apače, Drava and Sora fields and in parts of the aquifers in the Krško, Brežice and Ljubljana basins. Low water levels did not recover in most of these aquifers until the last month of the year. Very low groundwater reserves were also recorded in the Vrbanski plateau in January, resulting from the artificial decrease in the groundwater due to draining the excavation site in Maribor and work in the riverbed of the Drava River. Favourable climate conditions were prevalent in January only in the region of the Vipava and Soča Valley aquifers, as a result of which the very low levels from 2007 rose in some places to the normal level, while in others to above-average values. Similar water conditions in January continued over to **Febraury** when precipitation again dropped in all areas of aquifers to a level below the values characteristic for this month. The water levels decreased to very low groundwater reserves at that time also in the aquifers of the Krško Field and Kamniška Bistrica Valley and in parts of the Prekmurje and Ptuj fields, lower Savinja, Vipava and Soča valleys. Precipitation was abundant in **March**. Groundwater reserves recovered to above-average values at most of the gauging stations of the lower Savinja Valley, Šentjernej and Čatež fields, and Vipava and Soča valleys. Above-average feeding through precipitation infiltration in the area of aquifers in the Vipava, Soča valleys and Ljubljana Basin was caused in **April** by the rise of groundwater levels in aquifers of this region; in some of these places very high reserves of groundwater were also recorded. In other areas of the country feeding through precipitation povprečja, zato so se zaloge podzemnih vod postopoma zniževale. **Maj** je bil padavinsko suh, sončnih dni je bilo veliko, temperature pa za ta mesec nadpovprečne. Ti dejavniki so ugodno vplivali na povečano stopnjo evapotranspiracije, neugodno pa na povečanje zalog podzemnih voda. V maju so se zato gladine podzemnih voda na večini merilnih mest v aluvialnih vodonosnikih znižale. **Junija** je bilo vodno stanje različno. Območje doline Kamniške Bistrice in Ljubljanskega polja ter del vodonosnika spodnje Savinjske doline ter Mirenskega in Vrtojbenskega polja je bilo bogato s količinami podzemnih voda, gladine podzemnih voda vodonosnikov Prekmurskega in Ptujskega polja ter Vipavske doline pa so se na večini merilnih mest znižale do zelo nizkih vrednosti. Ugodne padavinske in hidrološke razmere površinskih voda so ugodno vplivale na polnjenje zalog podzemnih voda v **juliju**. V tem času se je stanje glede na mesec prej izboljšalo v delih vodonosnikov severovzhodne Slovenije in Ljubljanske kotline, medtem ko se je vodno stanje vodonosnikov Krške in Brežiške kotline ponekod poslabšalo. Krivca sta bila predvsem povečano izhlapevanje in poraba padavinske vode za rast rastlin, kar je preprečilo infiltracijo vode proti gladini v aluvialnih vodonosnikih. Zelo podobno julijskemu je bilo stanje zalog podzemnih voda tudi v **avgustu**. Jesen je leta 2008 veljala za sušno s skromno količino padavin in nizkimi vodostaji rek, posledično pa tudi z nizkimi zalogami podzemnih voda. Zelo nizke vrednosti zalog podzemnih voda so bile **septembra** in **oktobra** zabeležene na pretežnem območju Prekmurskega, Apaškega, Dravskega, Čateškega, Brežiškega in Sorškega polja ter Vipavske doline. **Novembra** so se ponekod zaloge podzemnih voda obnavljale, ponekod pa zniževale. Zelo nizko vodno stanje je še vedno prevladovalo v vodonosnikih severovzhodne Slovenije ter Čateškega, Sorškega in Kranjskega polja, medtem ko se je podzemna voda izraziteje dvignila v vodonosnikih spodnje Savinjske doline ter Vipavske in Soške doline. **December** je bil padavinsko obilen. Na vseh območjih aluvialnih vodonosnikov je padlo več padavin kot običajno. V povprečju so bili tudi pretoki rek dvakrat bolj vodnati, kot je značilno za ta mesec. Klimatske razmere so bile v tem času ugodne za zaloge podzemnih voda. Na večini merilnih mest vodonosnikov Mirenskega in Vrtojbenskega polja, Ljubljanske kotline in doline Bolske so bile zabeležene zelo visoke gladine podzemnih voda. Kljub nadpovprečnemu napajanju pa si od nizkih in zelo nizkih zalog podzemnih voda iz preteklih sušnih mesecev decembra nista opomogla osrednja dela Dravskega in Apaškega polja.

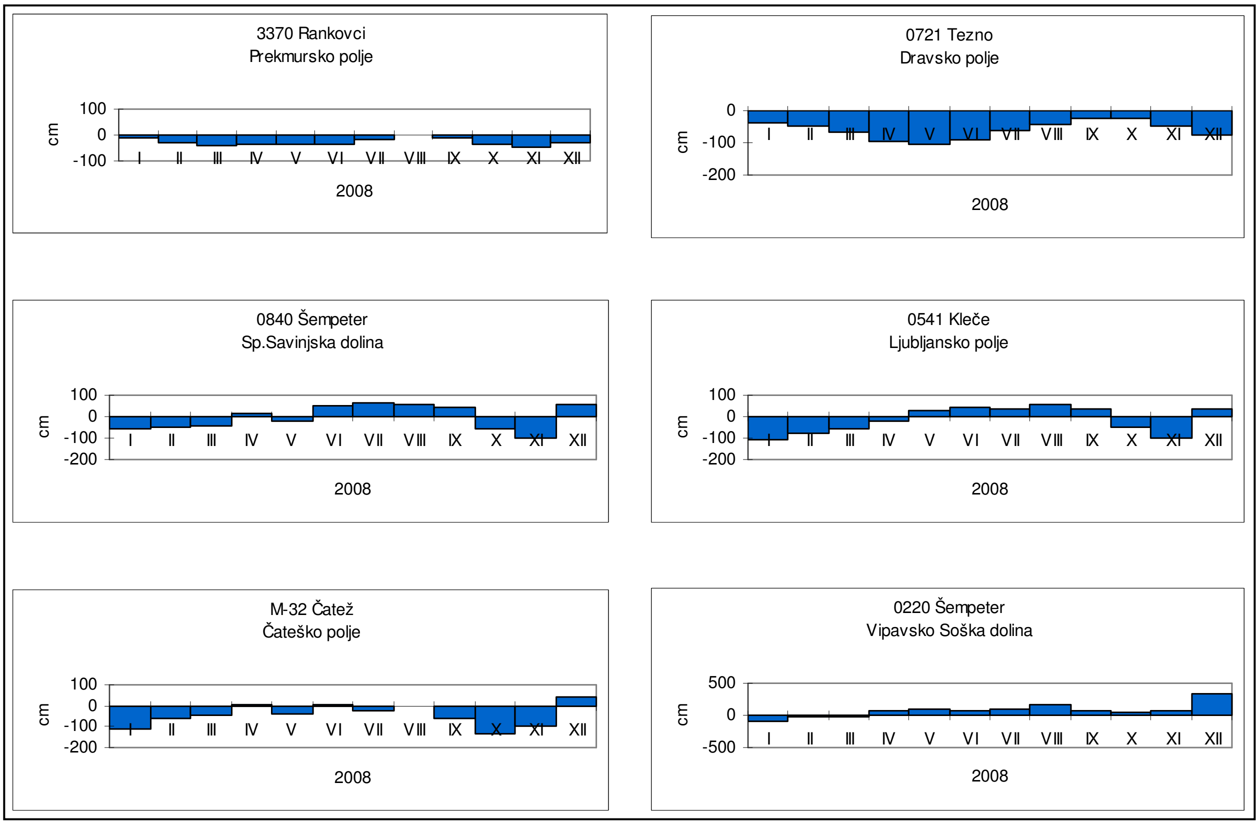
infiltration in April did not reach the multi-annual average which resulted in the gradual decrease of the groundwater reserves. **May** was dry with many sunny days recording above-average temperatures. These factors positively influenced the increased degree of evapotranspiration while having a negative effect on the increase of groundwater reserves. Thus, May recorded lower groundwater levels at most of the gauging stations in alluvial aquifers. **June** had various water conditions. The area of Kamniška Bistrica and Ljubljana Field and part of the aquifer of lower Savinja Valley and Miren-Vrtojba Field were abundant with groundwater, while the groundwater levels of aquifers of the Prekmurje and Ptuj fields and Vipava Valley decreased to very low values at most gauging stations. Favourable precipitation and hydrological conditions of surface water positively influenced the filling of groundwater reserves in **July**. In this period the conditions compared to the month prior improved in parts of the aquifers of north-eastern Slovenia and the Ljubljana Basin while worsening for some aquifers in certain areas of the Krško-Brežice Basin. The factors responsible were the increased evaporation and the consumption of rainfall for plant growth preventing the infiltration of water toward the surface in alluvial aquifers. The conditions of groundwater reserves in **August** were similar to those in July. Autumn in 2008 was dry with a limited amount of precipitation and low river stages and as a result also low groundwater reserves. Very low values of groundwater reserves were recorded in **September** and **October** in most parts of the Prekmurje, Apače, Drava, Čatež, Brežice and Sora fields and the Vipava Valley. In **November** the groundwater reserves recovered in some areas, while dropping in others. Very low water levels still dominated aquifers in north-eastern Slovenia and in the Čatež, Sora and Kranj fields, while the groundwater levels rose in aquifers of the lower Sava Valley and Vipava-Soča Valley. Precipitation was abundant in **December**. More precipitation than usual fell in all alluvial aquifer areas. On average the river discharges were also twice more water-abundant than the characteristic values for this month. The climate conditions during this period were favourable for groundwater reserves. Very high levels of groundwater were recorded at most of the gauging stations of aquifers of the Miren-Vrtojba Field, Ljubljana basin and Bolska Valley. Despite above-average feeding, the central parts of the Drava and Apače Field in December failed to recover from the low and very low groundwater reserves from the previous years of drought.

Preglednica 2: Srednje mesečne globine do podzemne vode v letu 2007 (V. Savić, U. Pavlič)
Table 2: Mean monthly groundwater levels in 2008 (V. Savić, U. Pavlič)

Postaja Station	Vodonosnik Aquifer	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0970 Brezovica	PREKMURSKO POLJE	186	196	197	199	224	238	233	239	244	235	223	195
3370 Rankovci	PREKMURSKO POLJE	192	201	209	213	223	236	228	217	229	240	248	226
0400 Zgornje Krapje	MURSKO POLJE	341	355	365	365	361	349	351	347	352	365	370	358
0120 Mali Segovci	APAŠKO POLJE	395	402	389	410	417	417	398	384	386	399	405	377
0080 Kamnica	VRBANSKI PLATO	2894	2891	2869	2844	2839	2810	2773	2759	2780	2796	2775	2771
0721 Tezno	DRAVSKO POLJE	1431	1446	1463	1472	1467	1463	1451	1450	1446	1450	1464	1477
0370 Dornava	PTUJSKO POLJE	405	426	434	425	437	432	429	436	439	450	448	419
0840Šempeter	SP. SAVINJSKA DOL.	839	864	860	788	839	767	743	775	785	851	866	720
VC-5072 Latkova vas	DOLINA BOLSKE	279	291	286	244	273	228	229	249	254	291	288	196
0320 Meja	SORŠKO POLJE	3243	3236	3246	3204	3174	3189	3185	3162	3165	3219	3241	3094
420 Mengeš	D. KAMNIŠKE BISTRICE	2116	2131	2131	2014	1954	1861	1838	1805	1884	1972	1980	1523
0541 Klece	LJUBLJANSKO POLJE	3005	3017	3033	2968	2898	2895	2900	2908	2949	3005	3000	2847
M-32 Čatež	ČATEŠKO POLJE	564	564	542	453	522	496	536	547	580	599	521	399
0111 Sp. Stari grad	BREŽIŠKO POLJE	421	429	421	404	426	429	428	429	433	437	423	404
0220 Šempeter	VIPAVSKO-SOŠKA D.	2130	2070	2106	2029	2017	2042	2061	2042	2103	2078	2006	1723

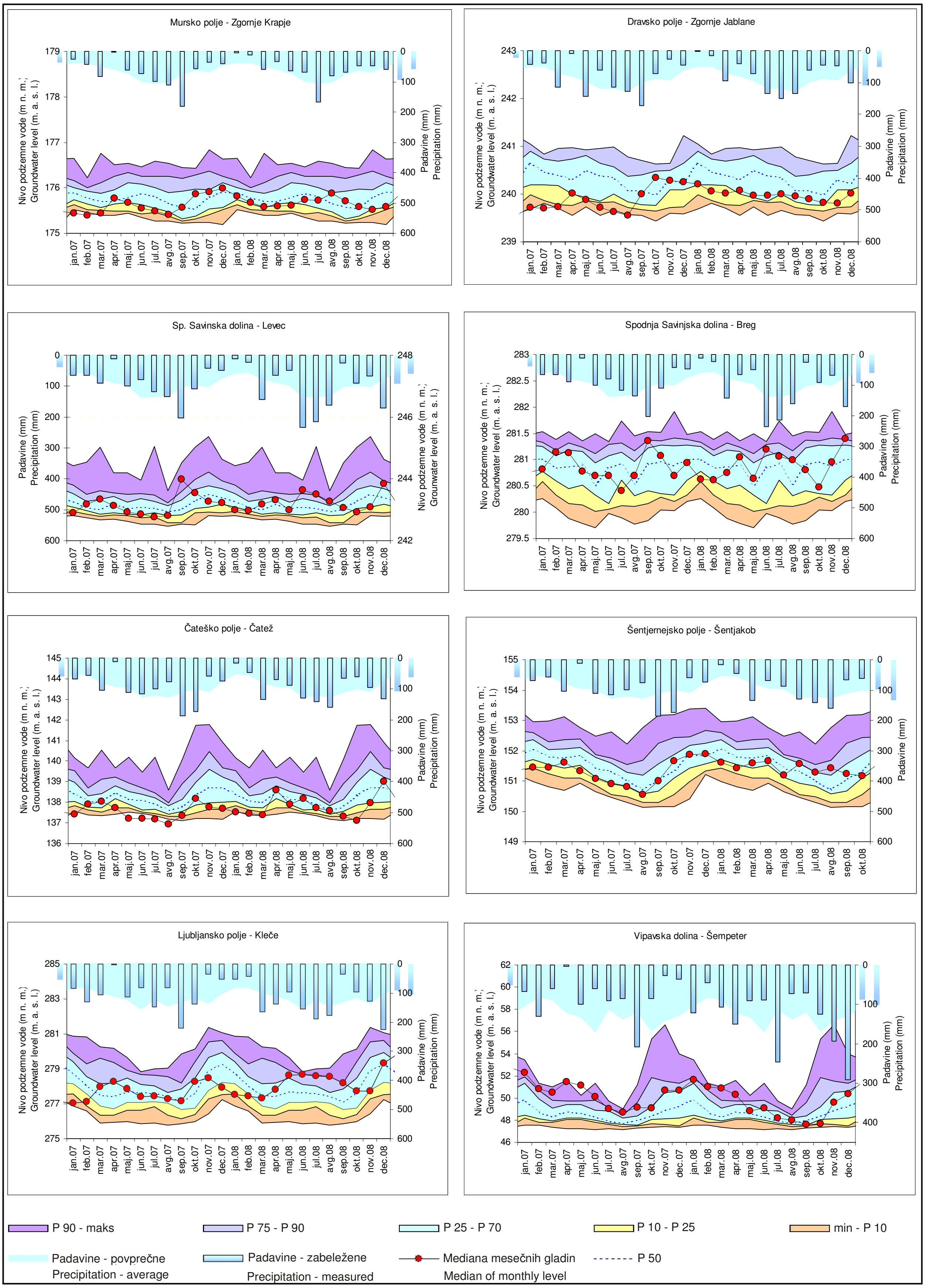
Povprečne letne vrednosti zalog podzemnih voda so bile v območju nizkih in običajnih gladin. Odstopala so območja vodonosnikov Ljubljanskega ter Mirenskega in Vrtojbenskega polja z nadpovprečnimi vodnimi zalogami, kjer je bilo napajanje z infiltracijo padavin nadpovprečno. Nizke vrednosti zalog podzemnih voda so na severovzhodu države prevladovale zaradi letnega padavinskega primanjkljaja in podpovprečnih vodostajev rek, na območju Kranjskega in Sorškega polja pa zaradi umetnega vpliva na režim podzemne vode, ki je nastal ob zajezitvi Save pri Mavčičah. Najbolj sušni meseci so bili september, oktober in november, december pa je bil z vidika polnjenja zalog podzemnih voda najbolj ugoden. Kljub ugodnim klimatskim in hidrološkim razmeram površinskih voda se podzemne vode vodonosnika Vipavske doline niso obnovile do normalnih vrednosti. Ta primer dokazuje, da dolgotrajne hidrološke suše lahko neugodno vplivajo na količinsko stanje podzemnih voda še vrsto let po pojavu ekstremno nizkih vodnih razmer v vodonosniku.

The average annual values of groundwater reserves were within the range of low and usual water levels. Deviations occurred in aquifer areas of the Ljubljana and Miren-Vrtojba fields with above-average water reserves where the feeding through infiltration of precipitation was above-average. Low values of groundwater reserves prevailed in the north-east of the country due to the annual precipitation deficit and below-average river stages, while in the area of the Kranj and Sora fields this was due to the artificial influence on the groundwater regime which occurred upon the impoundment of the Sava River at Mavčiče. September, October and November were the driest months, while December was the best month in terms of filling the groundwater reserves. Despite favourable climate and hydrological conditions of surface waters, groundwaters of the aquifer in the Vipava Valley were not restored to their normal values. This shows that long-term hydrological droughts can negatively affect the quantity of groundwaters for a number of years after the occurrence of extremely low water conditions in the aquifer.



Slika 5: Odstopanja srednjih mesečnih gladin podzemne vode v letu 2008 glede na srednje mesečne gladine za dolgoletno primerjalno obdobje (V. Savić)
Figure 5: Deviations from the mean monthly groundwater levels in 2008 with regard to the mean monthly water levels for the multi-annual reference period (V. Savić)

Območje vodonosnika Dolina Bolske (foto: arhiv ARSO)
Aquifer Dolina Bolske (photo: EARS archives)



Slika 6: Mediane mesečnih gladin podzemnih voda (m.n.v.) v letih 2007 in 2008 – rdeči krogci, v primerjavi z značilnimi percentilnimi vrednostmi gladin primerjalnega obdobja 1990–2001

Figure 6: Medians of monthly groundwater levels (in m above sea level) in 2007 and 2008 – red circles in comparison to the characteristic percentile values of water levels during the 1990-2001 reference period

C. IZVIRI

MONITORING IZVIROV

Niko Trišić

Program hidrološkega monitoringa izvirov se je začel konec leta 1999 s postavitvijo prvih dveh podatkovnih registratorjev na izvirih Divje jezero in Podroteja, z namenom podrobneje spoznati hidrološke značilnosti posameznih kraških izvirov. V naslednjih letih smo opazovalno mrežo razširili še na najpomembnejše izvire na območju Notranjske, Dolenjske in Kamniških Alp.

V letu 2008 je program obsegal skupno 18 opazovalnih lokacij. Zbrani, obdelani in vneseni v podatkovno bazo so podatki za 14 lokacij. Na profilu Mošenik pri Podljubelju opazovanja niso potekala zaradi spremembe profila in zasutja vodomera, na izviru Rakitnice pa zaradi izpada delovanja aparata. Podatki za izvir Završnice se morajo še kompenzirati, za vrtino B-2 Brestovica, pa jih podajamo informativno. V vseh merskih profilih spremljamo parametre vodostaja (H cm) in temperaturo (T ℃), na nekaterih pa še specifično električno prevodnost (SEP µS/cm)

Izviri na območju Podroteje

Na območju izvirov Podroteja smo z namenom oceniti prispevne količine kraškega dela zaledja Idrijce v njenem zgornjem toku vzpostavili meritve na izviru Podroteje, na Jezernici, izviru Divje jezero, na Idrijci nad izviri Podroteje ter na kanalu Idrijce. Na podlagi rezultatov meritev v letu 2008 lahko ocenimo deleže posameznih prispevnih območij. V letu 2008 ocenjujemo delež izvira Divje jezero z iztokom Jezernica na Qs = 1,3–1,5 m^3/s, delež izvirov Podroteja pa na 2–2,5. m^3/s. Srednji letni pretok v kanalu Idrijce je med 0,75 in 1,0 m^3/s in se upošteva pri bilančnem podatku za pretok Idrijce v profilu AMP. Ta v letu 2008 znaša 9,4 m^3/s, kar je nadpovprečna letna vrednost, ki za obdobje 1954–2007 znaša 8,85 m^3/s. Tako zajema prispevni delež kraških izvirov v skupnem pretoku Idrijce v profilu AMP med 3,3 in 5 m^3/s. Procentualno to pomeni tretjinski do polovični delež, upoštevaje povprečna vodna stanja. Pri nizkih je delež kraškega iztoka v celotnem pretoku Idrijce v profilu AMP večji. Ob posameznih stanjih lahko celoten pretok v profilu AMP Idrijca Podroteja napaja le iztok izvirov Podroteje. V letu 2008 so bile izvedene meritve pretoka v razponu

C. SPRINGS

SPRINGS MONITORING

Niko Trišić

The spring hydrological monitoring program was started at the end of 1999 by setting up the first two data-recording devices at the Diveje jezero and Podroteja springs with the goal of getting to know the hydrological characteristics of individual karstic springs. In the following years we extended the observation network also to the most important springs in the area of Notranjska, Dolenjska and Kamnik Alps.

In 2008, the program covered a total of 18 observation locations. Data for 14 locations are gathered, processed and entered into the database. Observation at the Mošenik profile in Podljubelj was not carried out due to the changing of the measuring profile and filling, and also because of malfunction of the device at the Rakitnica spring. Data for the Završnice spring must still be compensated while the data for the B-2 Brestovica borehole are provided just for information purposes. We monitor water level parameters (H cm) and the temperature (T ℃) in all measuring profiles, while in some also the specific electrical conductivity (SEP µS/cm).

Springs in the Podroteja area

With the goal of estimating the contribution quantities of the karstic hinterland of the Idrijca River in its upper reach, we performed measurements in the Podroteja region at the Podroteja spring, on Jezernica, Divje jezero spring, Idrijca above the Podroteja springs and on the Idrijca channel. Based on measurement performed in 2008 we can estimate the shares of individual catchment areas. In 2008 we estimate the share of the Divje jezero spring with outflow Jezernica at Qs = 1.3–1.5 m^3/s, while the share of Podroteja springs at 2-2.5 m^3/s. The mean annual discharge in the Idrijca River channel ranges from 0.75 to 1.0 m^3/s and is taken into account in the balance data for the Idrijca discharge in the AGS profile. In 2008, it stood at 9.4 m^3/s, representing an above-average annual value compared to the multi-annual average (1954-2007; at 8.85 m^3/s). So the contributing share of karstic springs in the total discharge of the Idrijca River within the AGS profile ranges between 3.3 and 5 m^3/s. In terms of

1,22–4,46 m^3/s, na Jezernici pa je najvišji merjeni pretok dosegel 58,5 m^3/s.

V objektu črpališča na enem od izvirov Podroteja spremljamo in beležimo 3 parametre: vodostaj (H), specifično električno prevodnost (SEP) in temperaturo vode (T), s 15-minutno frekvenco. Podatkovni nizi podajajo značilne časovne razporeditve, ki so s trendnimi linijami posameznih parametrov jasno predstavljene. Parametra temperatura in specifična prevodnost sta premosoodvisna, vodostaji pa podajajo obratno soodvisnost glede na ostala dva parametra (slika 1). Najvišje vrednosti SEP in T nastopajo ob nastopu nizkih vodostajev poleti oziroma jeseni. V letu 2008 je bil trend upadanja nizkih baznih vodostajev izrazito dolgotrajen, od maja do oktobra, in se je 16. oktobra približal obdobnemu beleženemu minimumu iz leta 2001. Visokovodni valovi so nastopali v novembru in v decembru, ko so se zaloge podzemne vode po nizkem stanju v oktobru obnovile.

Niza vrednosti srednjih in minimalnih letnih vodostajev v obdobju 1999–2008 kažeta trend upadanja. Srednji letni vodostaji v zadnjih nekaj letih sicer ne upadajo več, nizki vodostaji pa ta trend ohranjajo. Možna razlaga je, da je to posledica črpanj za oskrbo z vodo.

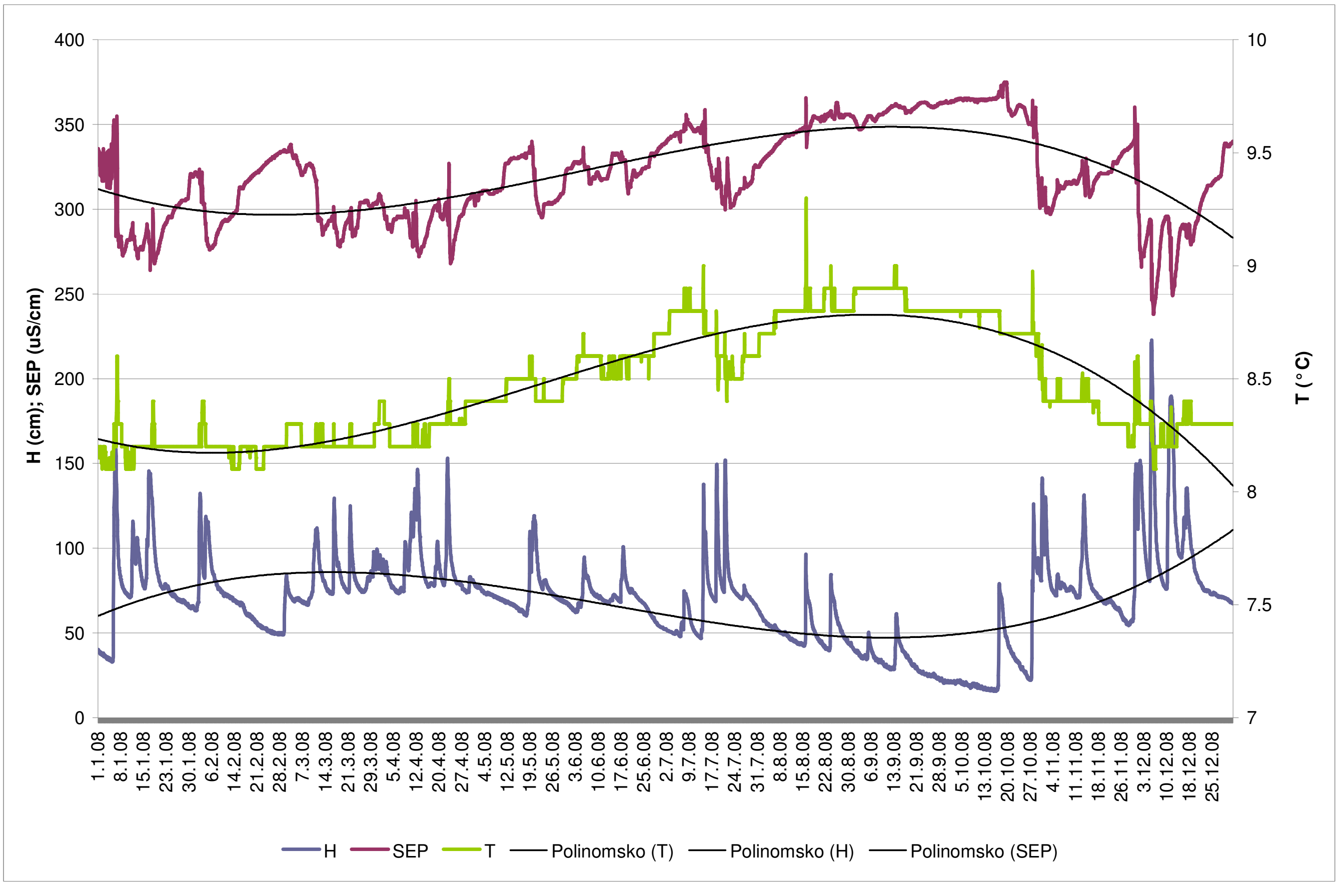
Izviri Podroteje skupaj z izviri Vipave, Hublja in Mrzleka reprezentativno podajajo značilnosti visokega krasa Trnovskega gozda. Osnovne značilnosti tega območja so razvita brezna in pretakanje podzemne vode v velikih globinah tudi na večje razdalje. Temperature podzemne vode nihajo v razponu med 8 in 9 °C, vrednosti SEP pa med 250 in 370 µS/cm. Razpored mesečnih nizkih baznih vodostajev ponazarja tudi mesečne zaloge podzemne vode v vodonosniku. Temu razporedu sledijo tudi srednji mesečni vodostaji, saj njihov značilni razpored sloni na ravneh baznih vodostajev (slika 3).

percentage this means a one-third or one-half share considering the average water conditions. At low values the karstic outflow share within the total discharge of the Idrijca River is higher within the AGS profile. In certain conditions, the entire discharge within the AGS profile Idrijca Podroteja can feed only on the outflow of the Podroteja springs. In 2008, the discharge measurements recorded ranged from 1.22-4.46 m^3/s, while the highest measured discharge reached 58.5 m^3/s on the Jezernica River.

At the water extraction facility on one of the Podroteja springs we monitor and record 3 parameters: the water level parameter, specific electrical conductivity (SEP) and water temperature (T), with a 15-minute frequency. The data series provide characteristic timetables clearly represented with trend lines of individual parameters. The temperature and specific electrical conductivity parameters are linearly proportionate, while the water levels are inversely proportionate with regard to the aforementioned parameters (Figure 1). The highest SEP and T values appear upon the occurrence of low water levels in the summer or autumn. In 2008, the declining trend of low base water levels was extremely long-term, from May to October, and on 16 October approached the recorded periodical minimum from 2001. The high-water waves occurred in November and December when the groundwater reserves recovered from the low level in October.

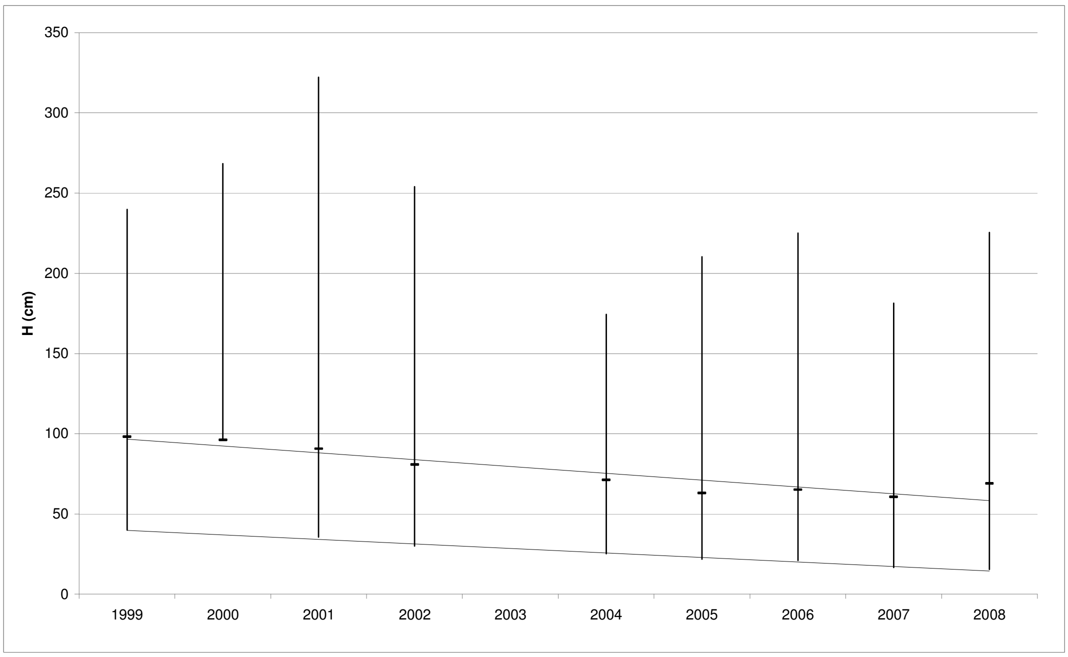
The series of mean and minimum annual water levels in the 1999-2008 period indicate a declining trend. The mean annual water level values in the last few years have stopped dropping while the low water levels have maintained this trend. This could possibly be a result of extractions for water supply.

Podroteja springs together with the Vipava, Hublelj and Mrzlek springs provide representative characteristics of the high karst of Trnovski gozd. The basic characteristics of this region are developed chasms and the flowing of groundwater in great depths also to distant areas. Groundwater temperatures fluctuate from 8 to 9°C, while SEP values range from 250 to 370 µS/cm. The monthly low base water level timeline also shows the monthly groundwater reserves in the aquifer. This timeline is also followed by mean monthly water levels, as their characteristic timeline abides by the base water level levels (Figure 3).



Slika 1: Časovni potek vodostajev (H), specifične električne prevodnosti (SEP) in temperature (T) na izviru Podroteja

Figure 1: Timeline of water levels (H), specific electrical conductivity (SEP) and temperatures (T) on the Podroteja spring



Slika 2: Značilni letni vodostaji (Hs, Hvk, Hnk) v obdobju 1999–2008 na izviru Podroteja in linearna trenda Hs in Hnk (high-low diagram)

Figure 2: Characteristic annual water levels (Hs, Hvk, Hnk) in the 1999–2008 period on the Podroteja spring and linear trends Hs and Hnk (high-low diagram)

Preglednica 1: Mesečne (2008) in obdobne mesečne (1999–2008) vrednosti vodostajev (H), specifične električne prevodnosti (SEP) in temperature (T) izvira Podroteja
Table 1: Monthly (2008) and periodical monthly (1999-2008) value of water levels (H), specific electrical conductivity (SEP) and temperatures (T) of the Podroteja spring

H	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Hs	Hmax	Hmin
2008	78	69	81	89	74	70	70	52	32	36	77	100	69	226	15
1999-2008	85	85	96	91	81	70	62	55	59	73	87	87	68	322	15
SEP	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Hs	SEPmax	SEPmin
2008	297	310	306	293	315	325	329	347	358	359	319	294	321	375	222
1999-2008	314	310	301	296	314	328	328	328	333	330	320	309	318	375	222
T	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Hs	Tmax	Tmin
2008	8.2	8.2	8.2	8.3	8.4	8.6	8.7	8.8	8.9	8.7	8.4	8.3	8.5	9.3	8.1
1999-2008	8.3	8.2	8.3	8.4	8.6	8.8	8.9	8.9	8.9	8.6	8.5	8.3	8.6	9.3	8.1

Slika 3: Potek srednjih mesečnih in nizkih mesečnih vodostajev(H) v obdobju 2004–2008
Figure 3: Timeline of mean monthly and low monthly water levels (H) in the 2004-2008 period

Izvir Kamniške Bistrice

Na izviru Kamniške Bistrice spremljamo vodostaj, SEP in temperaturo izvira od leta 2001. Izvir predstavlja hidrogeološke značilnosti alpskega krasa z veliko vertikalno komponento pretakanja in kratkim zadrževalnim časom v vodonosniku. Režim izvira se odraža z nizkimi vodostaji v zimskem času in povečanim iztokom v poletnem času, ko se iztekajo vodne zaloge v snežni odeji v visokogorju. Kljub nizkemu letnemu razponu nihanj v okviru dobre 1 °C temperatura izvira značilno odraža vrsto napajanja. V zimskem času je voda izvira toplejša, saj izteka t. i. bazni tok, ki se ne bogati s hladnejšimi zimskimi padavinami. Poletni iztok predstavlja večinoma snežnica, ki je hladnejša. Podoben časovni razpored podaja parameter SEP, saj je zimski bazni tok bolj

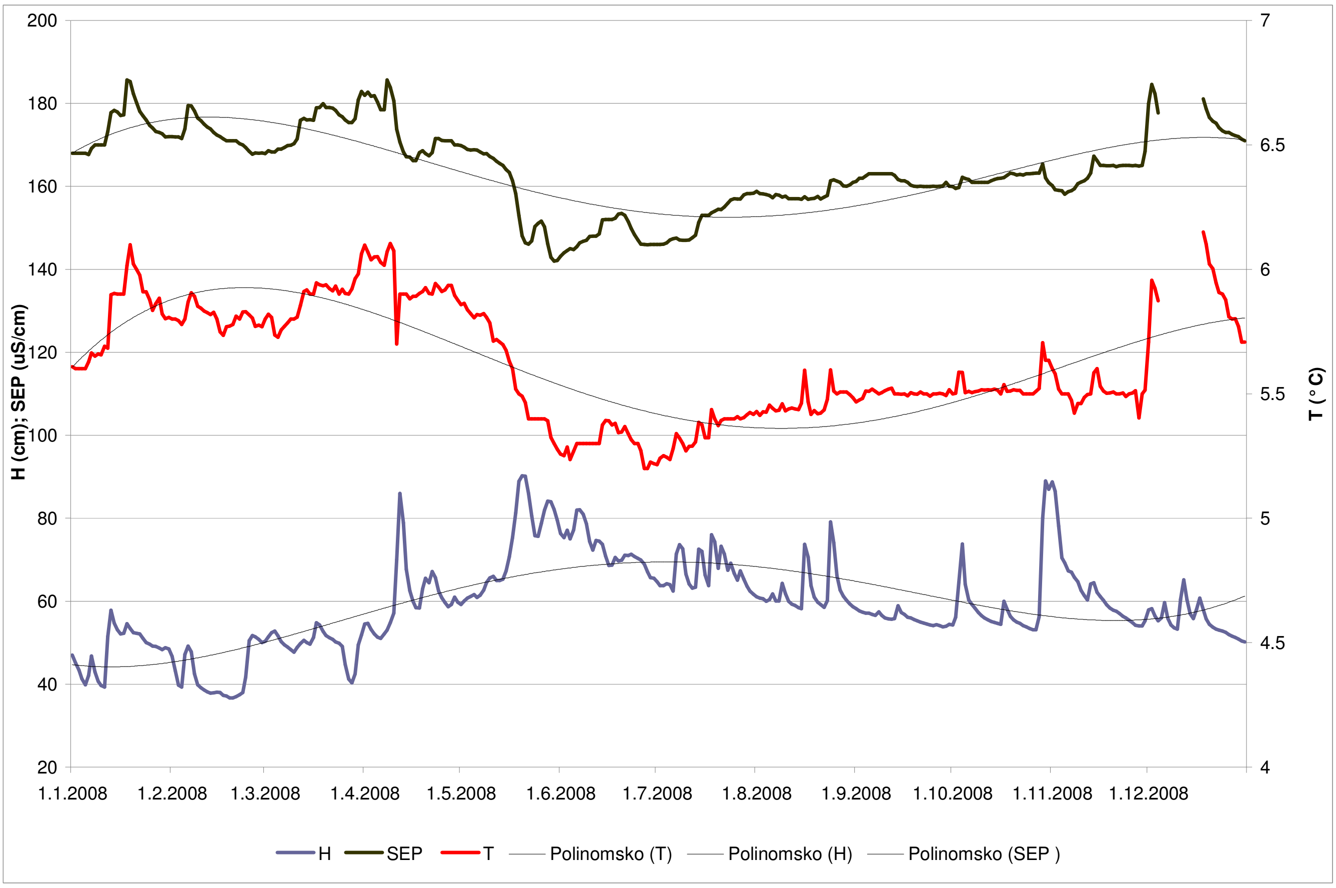
Kamniška Bistrica spring

We have been monitoring the water level, SEP and water temperature on the Kamniška Bistica spring since 2001. The spring represents the hydrogeological characteristics of the Alpine karst with a large vertical flow element and short retention time in the aquifer. The spring regime is reflected through low water levels during the winter and increased outflow in the summer, when the water reserves flow out from the snow cover melting in the high mountain range. Despite the low annual fluctuation amplitude within a little over 1°C, the spring temperature provides the characteristic type of feeding. In the winter the spring water is warmer as the outflow is the so-called base flow, which is not recharged with the colder winter precipitation. The summer outflow mineraliziran kot poletna komponenta napajanja. Primerjava mesečnih vrednosti parametrov SEP in temperaturo podaja dobro medsebojno odvisnost. Nekoliko odstopata le vrednosti za maj in junij, ko se deleži posameznih komponent napajanja lahko hitro menjajo.

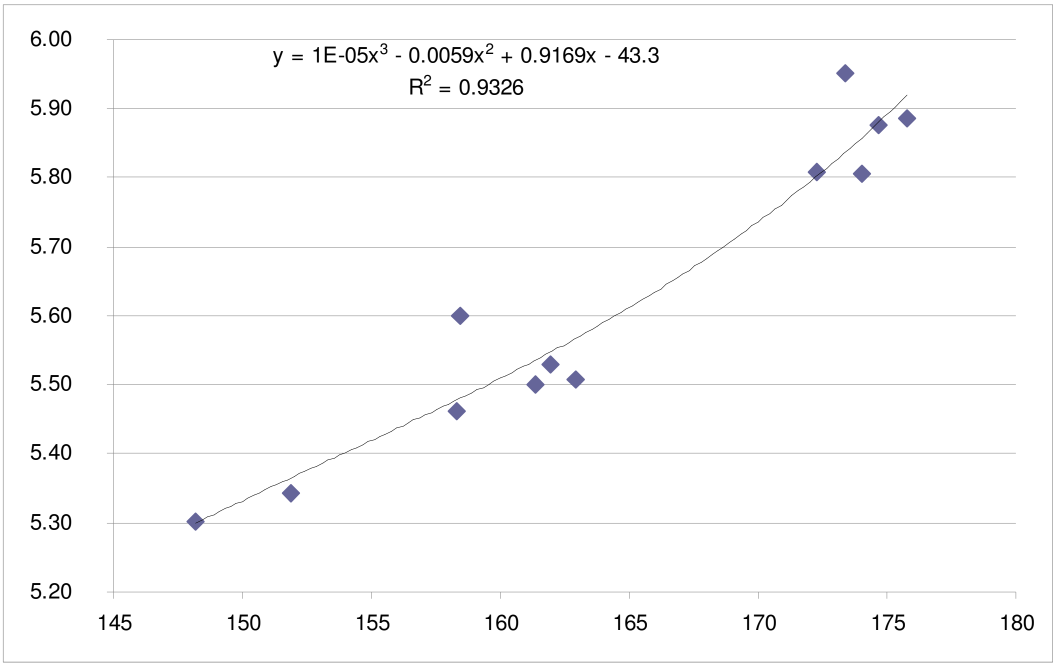
Poleg za alpski kras značilnega režima iztoka so zanj značilne glede na druga kraška območja v Sloveniji tudi nizke temperature in nizka mineralizacija vode. Vrednosti posameznih parametrov v letu 2008 ne odstopajo od obdobnih beleženih vrednosti.

consists mostly of snow-water, which is colder. A similar timeline is provided by the SEP parameter, as the winter base flow is more mineralised than the summer feeding component. The comparison of monthly values of the SEP and temperature parameters provides good interdependence. Slight deviations were only recorded in values for May and June, when the shares of individual feeding components can rapidly change.

Besides the outflow regime characteristic for the Alpine karst, low temperatures and low mineralisation of water are also characteristic for the spring with regard to the other karstic regions in Slovenia. The values of individual parameters in 2008 do not deviate from the periodical recorded values.



Slika 4: Časovni potek vodostaja (H), specifične električne prevodnosti (SEP) in temperature (T) na izviru Kamniške Bistrice
Figure 4: Timeline of water levels (H), specific electrical conductivity (SEP) and temperatures (T) on the Kamniška Bistrica spring



Slika 5: Odvisnost mesečnih vrednosti SEP in T na izviru Kamniške Bistrice
Figure 5: Correlation (dependence) between monthly SEP and T values on the Kamniška Bistrica spring.

Preglednica 2: Mesečne in letne (2008) ter obdobne vrednosti vodostajev (H) specifične električne prevodnosti (SEP) in temperature izvira Kamniške Bistrice (T)
Table 2: Monthly, annual (2008) and periodical values of water levels (H), specific electrical conductivity (SEP) and temperatures of the Kamniška Bistrica spring (T)

H	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letne Hs	letni H max	letni H min
2008	48	42	50	61	73	73	67	62	56	60	63	55	59	92.3	34.8
2002-2008	42	41	49	58	68	67	63	60	61	61	57	52	57	97,7	24,6
SEP	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	SEPs	SEPmax	SEPmin
2008	174	172	175	173	158	148	152	158	161	162	163	176	164	182	141
2002-2008	169	173	176	172	158	151	153	160	162	163	164	170	164	195	117
T	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	T s	T max	T min
2008	5.8	5.8	5.9	6.0	5.6	5.3	5.3	5.5	5.5	5.5	5.5	5.9	5.6	6.3	5.1
2002-2008	5.6	5.8	5.9	5.9	5.5	5.3	5.4	5.4	5.5	5.5	5.5	5.6	5.6	6.9	4.8

Letošč

Menina planina predstavlja kompleks pretežno triasnih dolomitov, ki predstavljajo vodonosnik kraško razpoklinskega tipa. Po strukturi se območje uvršča v območje Južnih Alp z značilno narivno zgradbo ozemlja. Večina vode iz vodonosnika se izteka v izvire Krope in Letošča ter v niz izvirov ob Dreti, na jugu pri Vranskem pa je edini močnejši izvir Podgrajščica. Letošč izvira ob prelomu, ki preseka in razmakne tufe in tufite, tako da ob nastali vrzeli izdanjajo triasni dolomiti, ki omogočijo iztekanje iz zaledja vodonosnika. Zaledja posameznih izvirov v karbonatnem masivu Menine planine ni mogoče razmejevati. Ocene velikosti zaledja izvira Letošč se gibljejo od 2 do

Letošč

The Menina planina (plain) represents a complex of mostly Triassic dolomites making up the karst-fractured aquifer. In terms of structure the region is classified among the Southern Alps with a characteristic overthrust land structure. Most of the water from the aquifer outflows into the Kropa and Letošč springs and in the series of springs alongside the Dreta River, while Podgrajščica represents the only powerful spring in the south at Vransko. Letošč rises alongside the rupture which cuts through and pushes aside the tuffs and tuffits, so Triassic dolomites arise alongside this gap enabling the outflow from the aquifer hinterland. The hinterlands of individual springs in the

2,7 km^2 (Geološki zavod Slovenije). Voda iz izvira Letošč oskrbuje s pitno vodo sistem za območje Celja in okolico.

Od leta 2005 na izviru deluje hidrološka merilna postaja Letošč, kjer se beležijo vodostaj, specifična električna prevodnost in temperatura ter občasno izvajajo hidrometrične meritve pretoka.

V režimu izvira Letošč izstopajo vrednosti vodostajev oziroma pretokov v aprilu, ko nastopajo izrazite najvišje mesečne vrednosti v letu. Istočasno upade temperatura izvira, mesečne vrednosti SEP pa nihajo le v ozkem območju. Zaradi nižjega geografskega položaja zaledja nastopi topljenje snežne odeje dosti prej kot v alpskem visokogorju, ko se ta dogodek beleži šele od maja.

V letu 2008 so najvišji pretoki nastopili v decembru, ko so si sledili 4 visokovodni valovi po intenzivnih padavinah. Zaradi nadpovprečnega stanja so bili tudi srednji mesečni pretoki najvišji v letu. Niso pa dosegli najvišjega stanja iz septembra 2007, ko je najvišji vodostaj dosegel 150 cm.

carbonate mass of the Menina planina cannot be delimited. The size estimates of the Letošč spring hinterland range from 2-2.7 km^2 (Geological Survey of Slovenia). Water from the Letošč spring supplies drinking water for the area of Celje with its surroundings.

The Letošč hydrological gauging station has been operating on the spring since 2005, where the water levels, specific electrical conductivity and temperature are recorded in addition to occasionally performing hydrometric measurements of the discharge.

The values of the water levels or discharges in April, when the highest monthly values of the year are recorded, stand out from the regime of the Letošč spring. At the same time the temperature of the spring drops while the monthly SEP values fluctuate only in a narrow area. Due to the lower geographic location of the hinterland melting of the snow cover occurs much earlier than in the Alpine high mountain range, where melting does not occur until May.

Preglednica 3 : Mesečne, letne in obdobne vrednosti vodostajev (H) na izviru Letošč
Table 3: Monthly, annual and periodical values of water levels (H) on the Letošč spring

H	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	H s	H max	H min
2008	33	30	35	49	32	36	32	32	28	28	38	51	35	100.9	23.6
Hs	31	33	39	52	34	32	27	30	34	32	33	38	34	150.1	22.3

Slika 6: Srednje mesečne vrednosti H, SEP in T v obdobju 2005–2008 za izvir Letošč
Figure 6: Mean monthly values (H, SEP and T) in the 2005-2008 period for the Letošč spring

Slika 7: Potek srednjih mesečnih vodostajev (H cm) v posameznih letih delovanja postaje na izviru Letošč

Figure 7: Timeline of mean monthly water levels (H cm) in individual years of station operation on the Letošč spring

Poltarica

Izvir Poltarica je eden od izvirov Krke, ki izdanja na območju vasi Gradiček pri Krki na stiku triasnih dolomitov v podlagi in jurskih dobro prepustnih apnencev. Zaledji obeh glavnih izvirov Poltarice in Krke se prepletata in ju je nemogoče razlikovati. Skupna velikost zaledja obeh izvirov se ceni na 290 km^2, iz razmerja vodnobilančnih členov pa se ocenjuje velikost zaledja Poltarice na 57 km^2. Zaledje izvirov Krke obsega območje ponikalnice Rašice, območje Dobrepolja in Radenskega polja pri Grosupljem. Gradijo ga dobro prepustne jurske in kredne kamenine, na območjih Dobrepolja in Radenskega polja pa so poleg apnencev tudi triasni dolomiti.

Izvir Poltarice je bil opazovan že v obdobju 1955–1972. Srednji pretok izvira v tem obdobju je znašal 1,44 m^3/s. Za spremljanje režima izvira, kjer se izvaja tudi monitoring kvalitete, pa smo izvir ponovno uvrstili v merilno mrežo konec leta 2006.

Na podlagi spremljanja urnih vrednosti vodostajev in pretvorbe v pretok so v obdobju 2007–2008 značilni podatki za izvir Poltarica nižji kot v obdobju 1955–1972. Režim nihanja vodostajev kaže na maksimuma v marcu in decembru, s tem, da je decembrska visoka vrednost posledica visokih valov konec leta 2008. Najnižji pretoki se spustijo celo pod 0,1 m^3/s. Predvsem meritvam pretokov ob nizkih vodostajih bomo posvetili posebno pozornost v naslednjih letih, saj so ti podatki najpomembnejši za ocenjevanje količinskega stanja vodnih teles podzemnih voda.

In 2008, the maximum discharges occurred in December when 4 high-water waves followed one another after intense precipitation. Due to the above-average water conditions, the mean monthly discharges were also at their highest annual values. However they failed to reach the highest level from September 2007 when the highest water level reached 150 cm.

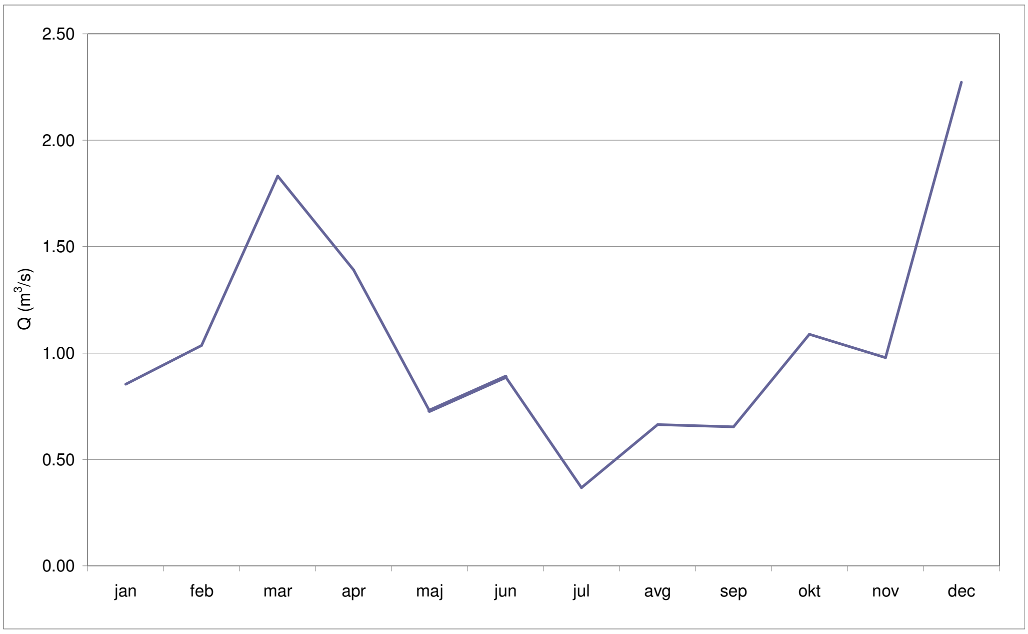
Poltarica

The Poltarica spring was one of Krka's springs, which rises from the ground in the Gradiček pri Krki village at the contact of Triassic dolomites in the base and Jurassic highly permeable limestones. The hinterlands of both primary springs of Poltarica and Krka are intertwined and thus impossible to distinguish from one another. The total area of the hinterland of both springs is estimated at 290 km^2, while the size of the Poltarica hinterland is estimated at 57 km^2 derived from the ratio of water balance elements. The background of the Krka springs covers the area of the Rašica sinking stream, Dobrepolje and Radensko polje pri Grosupljem. It is composed of highly permeable Jurassic and cretaceous rocks, and in the area of Dobrepolje and Radenci Field also Triassic dolomites besides limestones.

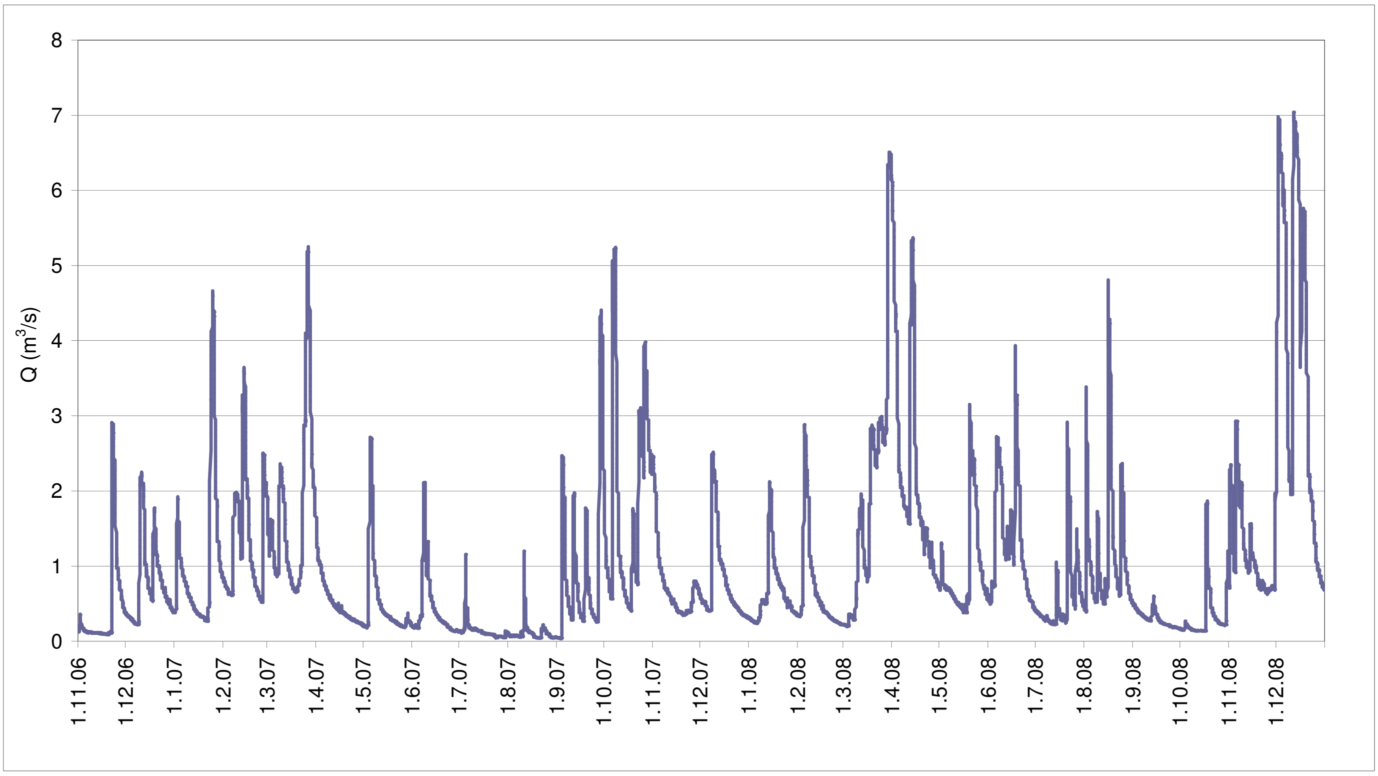
The Poltarica spring was observed within the 1955-1972 period. The mean discharge of the spring during this period stood at 1.44 m^3/s. In order to monitor the spring's regime where the monitoring of quality is also performed, we again classified this spring into the gauging network at the end of 2006.

Preglednica 4: Srednji mesečni in letni pretok (Q m3/s) na izviru Poltarica
Table 4: Mean monthly and annual discharge (Q m3/s) on the Poltarica spring

Qs	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni
2007	1.07	1.39	1.73	0.52	0.50	0.41	0.14	0.12	1.01	1.85	0.75	0.79	0.85
2008	0.63	0.69	1.93	2.26	0.96	1.36	0.59	1.21	0.30	0.33	1.20	3.75	1.27
Qs	0.85	1.04	1.83	1.39	0.73	0.89	0.37	0.66	0.65	1.09	0.98	2.27	1.06



Slika 8: Potek urnih pretokov (Q) v letih 2007/2008 na izviru Poltarica
Figure 8: Timeline of hourly discharges (Q) in the years 2007/2008 on the Poltarica spring



Slika 9: Potek srednjih mesečnih pretokov (Q) na izviru Poltarica za obdobje 2007–2008
Figure 9: Timeline of mean monthly discharges (Q) for the period 2007-2008 on the Poltarica spring

Težka voda

Iz sklenjenega dobro prepustnega kraškega vodonosnika na območju Gorjancev se vode iztekajo pretežno le v izvire Težke vode, Krupe in Metliškega Obrha. Podzemeljska razmejitev med njimi še ni mogoča, rezultati že izvedenih raziskav pa kažejo na obširna razvodna območja v njihovem zaledju, ki napajajo vse tri izvire. Bifurkacijska območja so tako na območju Ponikev na Gorjancih, kjer največ vode odteče v izvir Težke vode, kot tudi v območju Malinske drage med Krupo in Metliškim Obrhom.

Tudi izvir Težke vode je že bil vključen v hidrološko mersko mrežo v letih 1955–1985. S ponovnim aktiviranjem merskega profila želimo preveriti in točneje oceniti režim in količine iztoka izvira. Z detaljnejšim beleženjem vodostajev se opazijo tudi posegi, ki jih pri enkratdnevnih opazovanjih ni mogoče zabeležiti. Na podlagi meritev pretokov, izvedenih v zadnjih letih, smo revidirali funkcijsko odvisnost Q-H v merskem profilu.

Srednji letni pretoki so v novejšem obdobju nižji. Beleženi posegi na območju izvirov znižujejo minimalne pretoke v merskem profilu, minimalne vodostaje (12 cm), ki ob teh posegih nastopijo, pa ne moremo pretvoriti v pretok, ker meritev ob teh dogodkih nimamo.

Najnižji vodostaj, ob katerem se je izvajala hidrometrična meritev, je znašal 35,5 cm s pretokom 0,100 m^3/s. Za obstoječo pretočno krivuljo pa upoštevamo vodostaje nad 32 cm. V letu 2008 obdobni ekstremi na izviru Težke vode ne nastopajo, najvišji v obdobju 2004–2008 je le srednji letni pretok. Za točnejšo oceno najnižji pretokov bo potrebna izvedba serije meritev ob najnižjih vodostajih zunaj vpliva umetnih posegov.

Based on monitoring the hourly values of water levels and conversion into discharge the characteristic data for the Polterica spring during the period 2007-2008 is lower compared to the 1955-1972 period. The water level fluctuation regime indicates the maximum in March and December, provided that December's high value is a result of high-water waves at the end of 2008.The lowest discharges can drop even under 0.1 m^3/s. We will pay special attention to discharge measurements at low water levels in the next few years as this data is the most significant for estimating the quantity status of groundwater bodies.

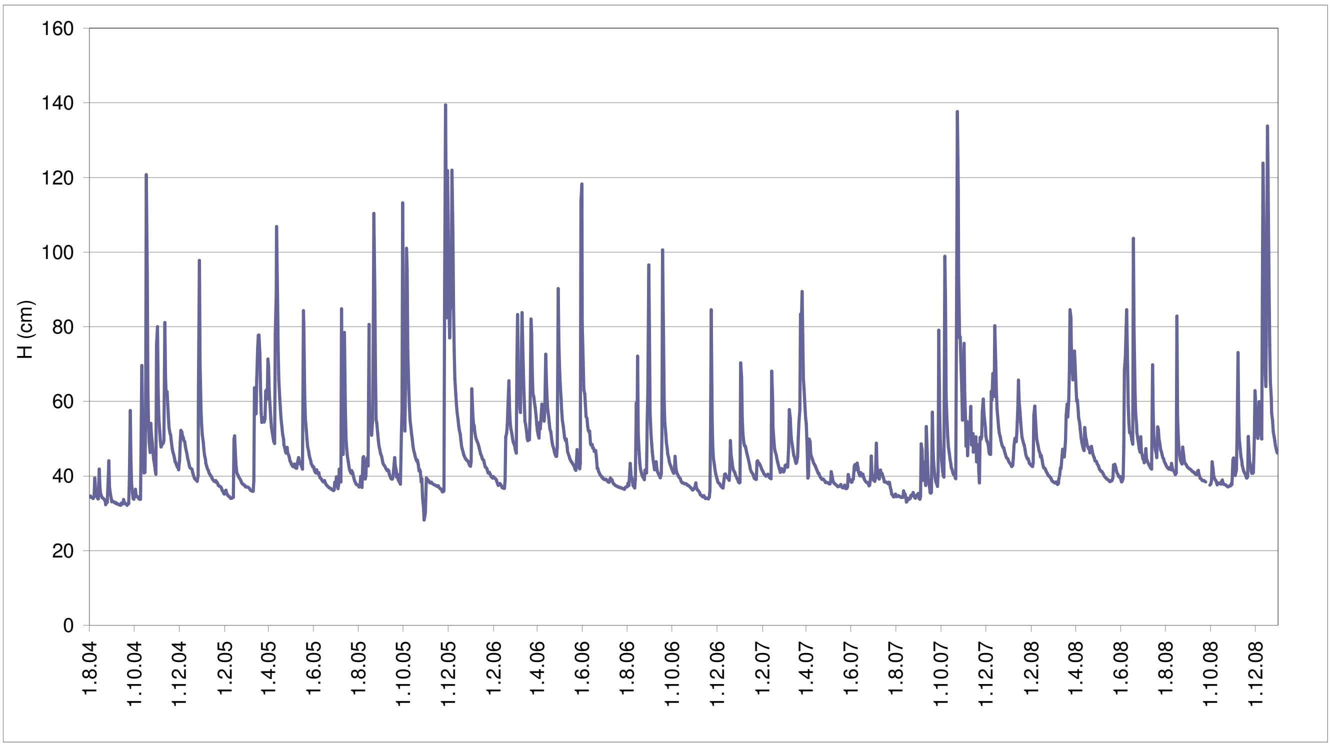
Težka voda

From the closed highly permeable karstic aquifer in the area of Gorjanci, waters run off mainly only into the Težka voda, Krupa and Metliški Obrh springs. The underground demarcation between them is impossible, while the results of the performed studies indicate extensive catchment areas in their background feeding all three springs. The bifurcation areas are thus located in the region of Ponikve na Gorjancih, where the major portion of water runs off to the Težka voda spring, as also in the region of Malinska draga between Krupa and Metliški Obrh.

The Težka voda spring was already integrated in the hydrological gauging network during 1955-1985. By reactivating the measurement profile we wish to verify and accurately estimate the regime and outflow quantity of the spring. With detailed recording of water levels also developments affecting the water are noticed, which otherwise cannot be recorded during daily observation. Based on discharge measurements, carried out in the last few years, we have revised the functional correlation Q-H in the measuring profile.

Preglednica 5: Značilni mesečni in letni pretoki (Q m^3/s)v obdobjih 1955–1985 in 2004–2008 za izvir Težka voda
Table 5: Characteristic monthly and annual discharge (Q m^3/s) during the period 1955–1985 and 2004–2008 for the Težka voda spring

Q	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Qs	Q max	Q min
1955-1985	0.62	0.61	0.8	0.89	0.65	0.55	0.4	0.34	0.41	0.55	0.75	0.79	0.61	10.7	0
2004								0.11	0.09	0.63	0.75	0.58	0.42	7.53	
2005	0.28	0.21	0.76	0.98	0.55	0.23	0.47	0.73	0.44	0.66	0.62	1.13	0.52	7.03	
2006	0.49	0.45	1.10	0.86	0.75	0.63	0.20	0.51	0.59	0.24	0.26	0.27	0.52	8.49	0.04
2007	0.47	0.42	0.78	0.35	0.20	0.28	0.23	0.09	0.38	1.08	0.71	0.77	0.47	6.96	
2008	0.58	0.44	0.75	0.63	0.29	0.89	0.52	0.45	0.29	0.22	0.45	1.43	0.57	7.18	0.09
Q s	0.38	0.31	0.81	0.81	0.49	0.38	0.40	0.27	0.25	0.58	0.62	0.73	0.52	8.49	



Slika 10: Časovni potek dnevnih vodostajev (H cm) v merskem profilu Težka voda v letih 2004–2008
Figure 10: Timeline of daily water levels (H cm) in the Težka voda measuring profile during 2004-2008

Metliški Obrh

Izvir Metliški Obrh je bil v program monitoringa izvirov uvrščen leta 2003 z vgradnjo podatkovnega zapisovalnika v območje izvira. Beležili smo potek vodostajev, SEP in temperaturo izvira. Izvir je pomemben, ker predstavlja enega od redkih izvirov na tem območju in je zato tudi zajet za vodooskrbo Metlike, čeprav je zaradi svoje lege v središču mesta ogrožen. Predvsem v poletnih mesecih izvir zaradi črpanj skoraj presahne in vodni tok se pojavi šele v območju vodomera. Oktobra 2008 je bil aparat zaradi obnovitvenih del na območju črpališča demontiran in po petletnem opazovanju s krajšimi prekinitvami smo meritve na tej lokaciji zaključili. Vodomer smo za odčitavanje vodostaja ob vzorčenjih izvira pustili v merskem profilu.

Ob nizkih vodostajih območje, v katerem je bila vstavljena sonda za SEP in temperaturo, presuši, zato ne podajamo vrednosti za nizke ekstreme SEP, saj so beležene vrednosti nerealne. Ocena nizkega pretoka je približna, saj so zaradi frekvence črpanj in zaraščenosti profila meritve v poletnem času nezanesljive. Pridobljeni podatkovni nizi nudijo na podlagi časovnih razporedov posameznih parametrov vpogled v osnovne hidrološke značilnosti izvira, ki je, glede na pretežno kraški karakter zaledja, specifičen z relativno visokimi vrednostmi SEP in tudi temperatur.

The mean annual discharges are lower in recent times. The recorded activities affecting the springs area lower the minimum discharge in the measuring profile, while minimum water levels (12 cm) occurring during these activities, cannot be converted into discharge as we do not have measurements at our disposal during these events.
The lowest water level upon which hydrometric measurements were performed was recorded at 35.5 cm with the discharge of 0.100 m^3/s. We take into account water levels above 32 cm for the existing rating curve. In 2008 the periodical extremes on the Težka voda spring did not appear, the highest in the period of 2004-2008 was only the mean annual discharge. A series of measurements at the lowest water levels outside the influence of artificial activities must be performed for a more accurate estimate of discharges.

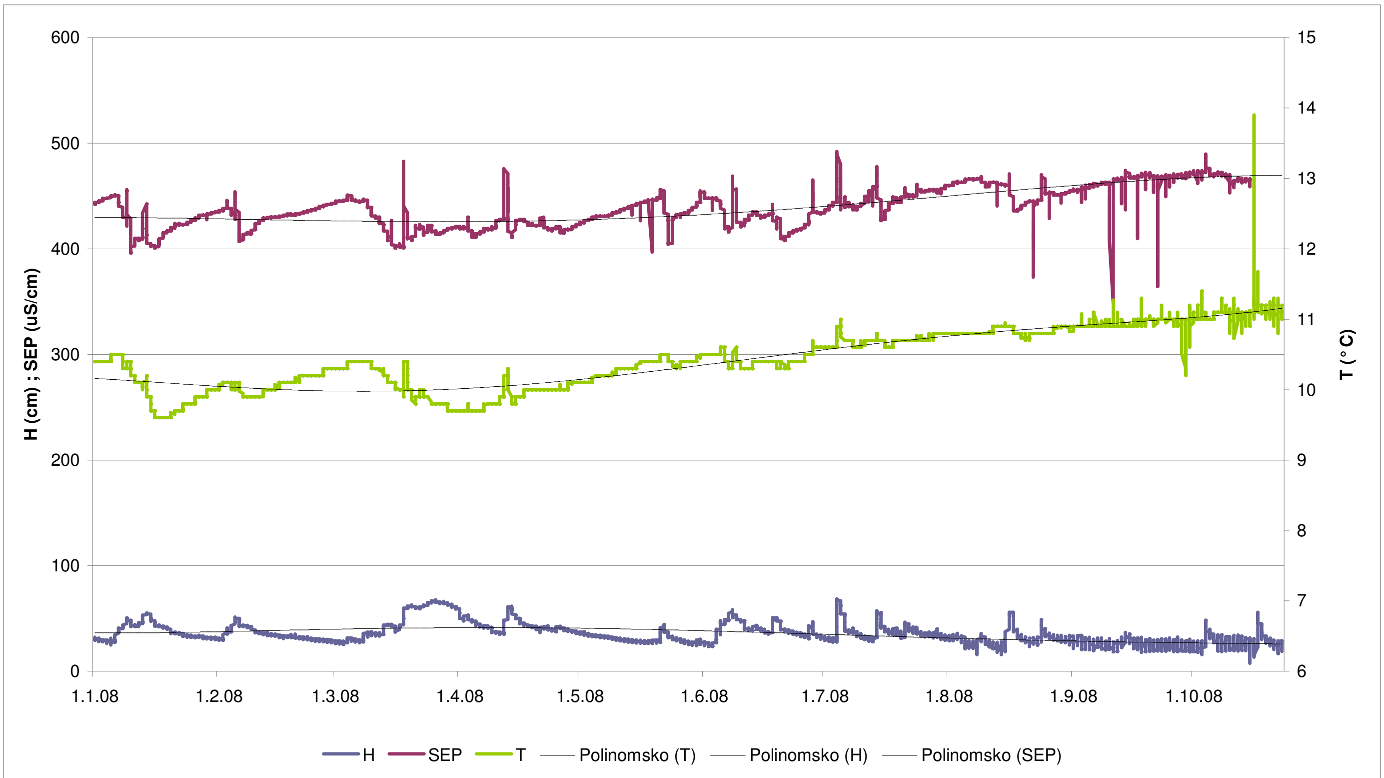
Metliški Obrh

The Metliški Obrh spring was classified in the spring monitoring program in 2003 with the installation of the data-recording device in the spring's area. We recorded the timeline of water levels, SEP and the temperature of the spring. The spring is important because it represents one of the rare springs in this area and thus also captured for the water supply of Metlika even though it is threatened due to its location in the city

Izvir metliški obrh (foto: arhiv Arso)
The Metliški Obrh spring (photo: EARS archives)

centre. Mainly during the summer months the spring almost dries up because of the extractions not appearing until reaching the area of the water gauge. In October 2008 the device was dismantled due to repair work in the area of the extraction site and after 5 years of observations with some short breaks measurements at this location were concluded. The water gauge for reading the water level upon sampling at the spring was left in the measuring profile.

At low water levels the area, in which the probe for measuring SEP and the temperature was inserted, dries up, so we do not provide values for low SEP extremes as the recorded values are unrealistic. The low discharge estimate is approximate as measurements during the summer are unreliable due to the extraction frequency and overgrown area of the profile. The obtained data series provide insight based on a timeline of individual parameters into basic hydrological characteristics of the spring, which is, with regard to the mainly karstic character of the hinterland, specific with relative high SEP and also temperature values.



Slika 11: Časovni potek vodostajev (H), specifične električne prevodnosti (SEP) in temperature (T) na izviru Metliški Obrh v letu 2008
Figure 11: Timeline of water levels (H), specific electrical conductivity (SEP) and temperatures (T) on the Metliški Obrh spring in 2008

Ker smo kontinuirane meritve na izviru zaključili, podajamo tabele značilnih vrednosti vseh treh merjenih parametrov za celotno merilno obdobje na izviru.

Seeing that we ended the continuous measurements at the spring, we provide tables of characteristic values of all three measured parameters for the entire measuring period at the spring.

Preglednica 6: Značilne mesečne in letne vrednosti pretokov (Q m^3/s) v obdobju opazovanj na izviru Metliški Obrh
Table 6: Characteristic monthly and annual values of discharges (Q m^3/s) during the observation period at the Metliški Obrh spring

Q	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Letni Qs	Q max	Qmin
2004	0.31	0.36	1.21	0.97	0.25	0.25	0.36	0.23	0.17	0.49	0.46	0.35	0.44	2.03	0.002
2005	0.18	0.19	0.55	0.56	0.41	0.10	0.12	0.36	0.12	0.34	0.30	0.71	0.33	1.69	0.003
2006	0.43	0.27	0.69	0.60	0.42	0.46	0.08	0.29	0.29	0.08	0.16	0.14	0.33	1.59	0.007
2007	0.38	0.35	0.50	0.17	0.10	0.11	0.07	0.03	0.28	0.50	0.39	0.49	0.28	1.78	0.002
2008	0.33	0.26	0.68	0.49	0.17	0.37	0.32	0.18	0.09	0.14			0.31	1.53	0.002
Qs	0.33	0.29	0.71	0.53	0.27	0.26	0.19	0.21	0.19	0.32	0.33	0.42	0.34	2.03	0.002

Preglednica 7: Značilne mesečne in letne vrednosti specifične električne prevodnosti (SEP µS/cm) na izviru Metliški Obrh
Table 7: Characteristic monthly and annual values of specific electrical conductivity (SEP µS/cm) at the Metliški Obrh spring

SEP	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	letni	SEP max
2004	426	417	406	393	433	439	429	445	454	445	438	450	433	496
2005	446	446	418	421	421	440	429	428	441	453	462	442	437	498
2006	448	443	412	427	435	421	463	431	432	459	455	415	437	499
2007	434	430	426	450	452	438	440	315	400	410	420	435	421	486
2008	427	431	426	421	436	430	448	454	464	493			445	493
SEP s	436	433	418	426	436	433	442	413	438	452	444	436	434	

Preglednica 8: Značilne mesečne in letne vrednosti temperature vode (T °C) na izviru Metliški Obrh
Table 8: Characteristic monthly and annual value of water temperature (T °C) at the Metliški Obrh spring

T	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Letni Ts	T max	T min
2004	10.4	10.0	9.9	9.9	10.4	10.6	10.5	10.8	11.0	10.8	10.8	10.6	10.5	13.0	10.3
2005	10.4	10.5	10.0	10.1	10.3	10.6	10.7	10.7	10.9	10.9	11.1	10.6	10.6	11.3	9.4
2006	10.4	10.4	9.7	10.0	10.3	10.5	10.8	10.7	10.8	11.0	11.0	10.8	10.5	11.2	9.5
2007	10.5	10.4	10.3	10.4	10.6	10.7	11.0	12.3	11.0	10.8	10.6	10.3	10.8	15.5	10.0
2008	10.0	10.1	10.1	9.9	10.3	10.4	10.7	10.8	10.9	11.1			10.4	16.1	9.7
T s	10.4	10.3	10.0	10.1	10.4	10.6	10.7	11.1	10.9	10.9	10.9	10.6	10.6	16.1	9.4

Krupa

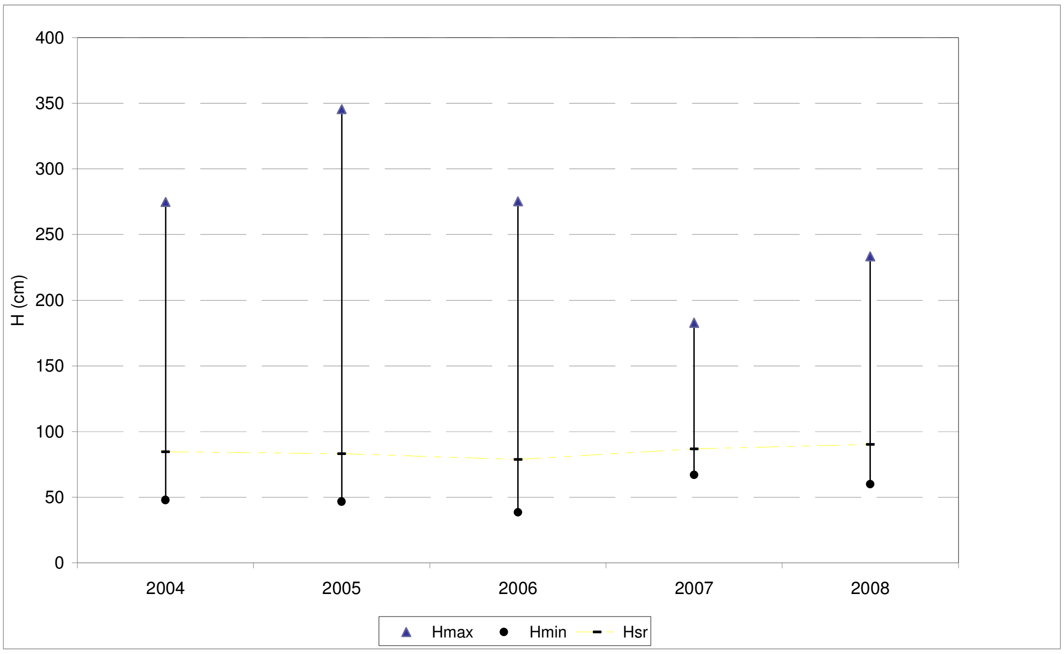
Izvir Krupe s srednjim letnim pretokom več kot 3 m^3/s predstavlja najmočnejši vodni vir v Beli krajini. Krupa je najnižji izvir iz globokega vodonosnika in drenira skupaj z Lahinjo in Dobličico bazne odtoke obsežnega kraškega vodonosnika. Za merski profil Krupe v Dolencih podajamo značilne vodostaje, beležene v obdobju 2004–2008. Za 2008 je izdelana pretočna krivulja veljavna v območju od 52 do 260 cm, zato smo kot primerjavo obdobnih letnih vrednosti podali vodostaje.

Krupa

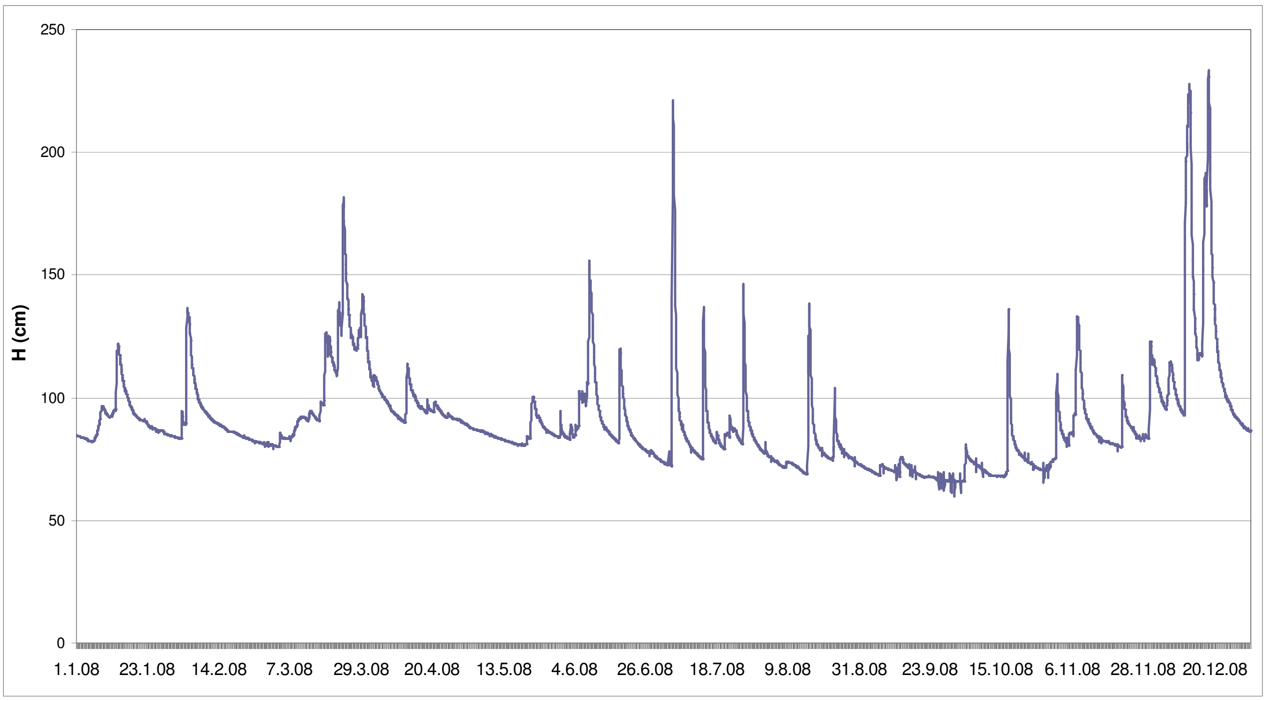
The Krupa spring with a mean annual discharge exceeding 3 m^3/s represents the most powerful water source in Bela Krajina. Krupa is the lowest spring from a deep aquifer and together with Lahinja and Dobličica drains the base outflows of the extensive karstic aquifer. We provide characteristic water levels for the measuring profile of Krupa in Dolence, recorded in the period of 2004-2008. A rating curve was prepared for 2008 applying for the area between 52-260 cm, and for this reason we submitted the water levels as a comparison of the periodical annual values.

Preglednica 9: Značilni vodostaji (H cm) izvira Krupe v merskem profilu Dolence v obdobju 2004–2008
Table 9: Characteristic water levels (H cm) of the Krupa spring in the measuring profile Dolence during 2004-2008

H (cm)	jan	feb	mar	apr	maj	jun	Jul	avg	sep	okt	nov	dec	Hs	Hmax	Hmin
2004								70.0	64.2	104.3	93.4	90.4	84.5	274.7	47.8
2005	73.2	68.2	94.5	98.7	87.6	63.8	73.0	92.7	82.5	95.8	100.3	102.5	83.2	345.5	46.7
2006	89.5	80.9	109.0	98.4	94.1	84.6	54.6	67.9	86.8	55.3	58.0	71.2	78.8	275.2	38.4
2007	85.9	83.3	103.2	85.5	79.6	82.7	75.6	72.6	84.5	97.8	95.0	96.6	86.9	182.8	66.9
2008	91.1	90.5	105.7	97.0	85.7	90.7	89.5	77.9	69.4	73.4	89.1	120.5	90.1	233.4	59.9
Hs	79.9	75.4	99.4	96.5	87.1	73.3	73.1	79.1	72.3	92.4	89.5	94.0	84.3	345.5	38.4



Slika 12: High-low diagram značilni letnih vodostajev (H cm) na izviru Krupe
Figure 12: High-low diagram of characteristic annual water levels (H cm) at the Krupa spring



Slika 13: Razporeditev urnih vodostajev (H cm) v letu 2008 na izviru Krupe
Figure 13: Allocation of hourly water levels (H cm) in 2008 at the Krupa spring

V merskem profilu, ki je približno 2 km pod izvirom, se med letom beležijo tudi opazni posegi v naravni režim vodotoka. Na pregradi, ki zajezuje iztok izvira, se manipulira z zapornicami, kar se kaže v občasnih krajših znižanjih vodostajev. Poleg tega je opazen dvig minimalnih vodostajev v letih 2007 in 2008 po dvigu kote zajezitve na pregradi v letu 2006. Ta dvig dosega 20 cm, to pa je pri nizkih vodostajih že sprememba, ki jo bo treba v naslednjih letih spremljati in analizirati.

Količinsko najizdatnejša v letu 2008 sta marec in december, visok vodni val pa je nastopil tudi v juliju, z drugo najvišjo letno konico. Najnižji vodostaji nastopijo konec septembra in v začetku oktobra po sušnem septembru, ki je tudi v povprečju pretokov izrazito najnižji v letu.

Bilpa

Izvir Bilpe predstavlja iztok voda z območja Kočevskega polja, oziroma je podzemeljsko povezan s ponikalnico Rinžo, katere tok ponikuje na območju Zajčjega polja pri Livoldu. Minimalni pretoki izvira Bilpa v območju 0,15 m^3/s zajemajo približno desetino nizkih iztokov z območja vodonosnega sistema Kočevje-Goteniška gora z velikostjo skoraj 600 km^2. Poleg izvira Bilpa so najizdatnejši iztoki iz tega sistema še izviri Čabranke, Kotnice, Rakitnice in Ribnice. Tudi izvirno območje Bilpe je zajezeno z umetno pregrado, kar poleg vpliva visokovodnih valov Kolpe na vodostaje v območju izvira še dodatno otežuje točno ocenjevanje režima. Nizki vodostaji so izravnani in so v območju vodostajev 82–83 cm, sunki pod 80 cm so posledica občasnih manipulacij z zapornico na jezu. Visoki valovi so v letu 2008 segali do vodostajev 200 cm, v decembru beleženi visoki vodostaji, ki so dosegali 300 cm, pa so bili pod vplivom zajezitve visokih voda Kolpe. Zato je tudi določitev pretokov ob teh stanjih nezanesljiva oziroma celo nemogoča.

Parametra SEP in temperatura, ki se beležita v izviru, podajata tudi soodvisnost časovnega poteka vrednosti, s tem da to ni pravilo pri vsakem dogodku. Vrednosti SEP se gibljejo v razponu med 350 in 450 µS/cm, s kratkimi sunki, ki prekoračujejo te vrednosti, povprečje pa je v območju 400 µS/cm. Te vrednosti kažejo na daljše zadrževalne čase v vodonosniku, kot je to značilno za območja visokega krasa. Povprečna letna temperatura izvira je v območju 9,5 °C, značilen pa je izravnan potek temperatur v območju 10,5 °C od junija do visokovodnih valov v decembru.

Hidrometrične meritve pretoka so bile v obdobju 2005–2008 izvedene v razponu od najnižjega

In the measuring profile, which is located approx. 2 km downstream, noticeable developments affecting the natural watercourse regime are also recorded during the year. On the barrier which impounds the spring's outflow the gates are controlled, which is demonstrated through periodical short decreases of the water levels. In addition the rise in minimum water levels was evident between 2007 and 2008 after raising the barrage height in 2006. This increase reached 20 cm, which at low water levels signifies a change which must be monitored and analysed in the next few years.

March and December were the most abundant months in 2008 in terms of quantity, while the high-water wave occurred also in July with the second highest annual peak. The lowest water levels occur at the end of September and at the start of October after a dry September, which is by far the lowest in the year, also considering the discharge average.

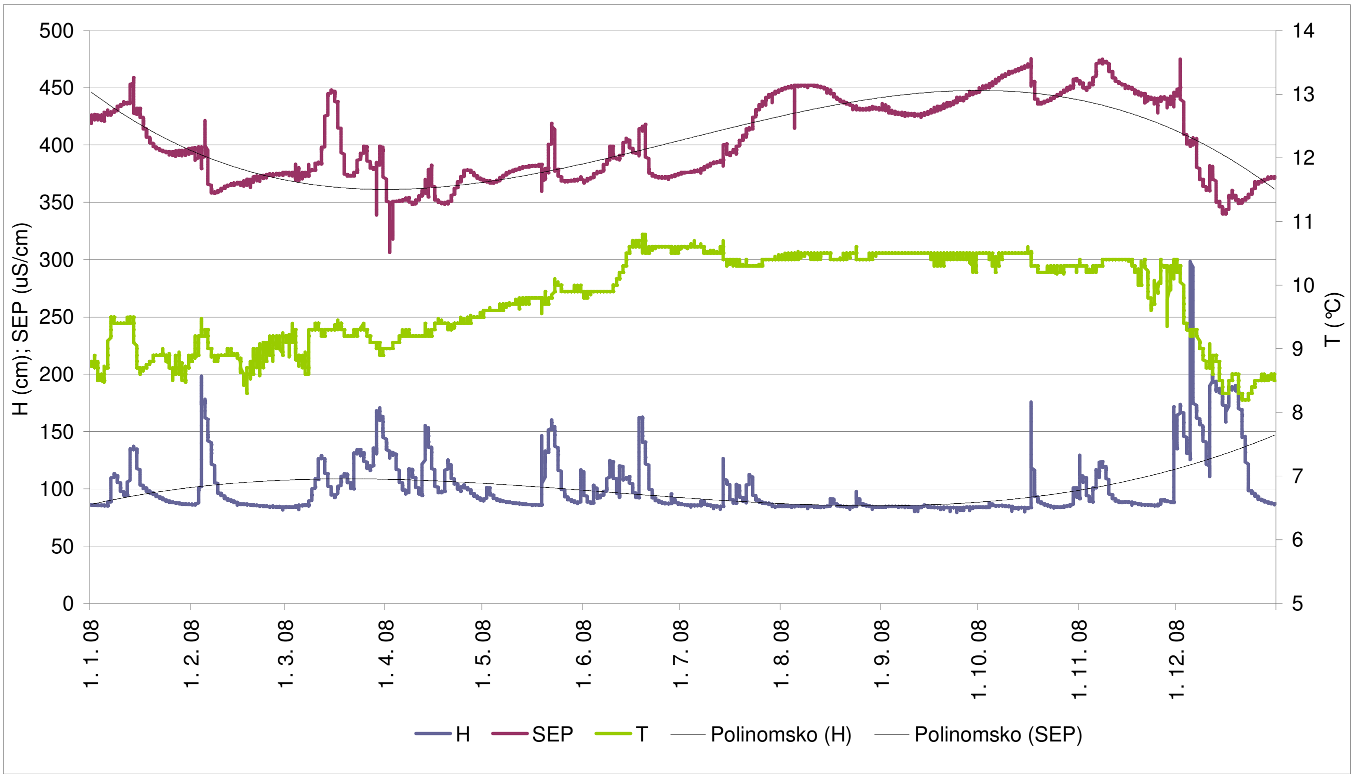
Bilpa

The Bilpa spring represents the water outflow from the region of the Kočevje Field and is connected underground with the Rinža sinking river the stream of which sinks in the area of Zajčje polje at Livold. The minimum discharges of the Bilpa spring in the range of 0.15 m^3/s cover approx. one tenth of the low outflows from the region of the water bearing system Kočevje-Goteniška gora, which is almost 600 km^2 in size. Beside the Bilpa spring the most abundant outflows of this system include the springs of the Čabranka, Kotnica, Rakitnica and Ribnica rivers. The spring area of Bilpa is also impounded with an artificial barrier which besides the influencing the water levels in the area of the spring through Kolpa's high-water waves also makes accurate estimation of the regime more difficult. Low water levels are levelled and stand at 82-83 cm in the area of the water levels. Thrusts under 80 cm are a result of occasional gate handling on the dam. High waves in 2008 reached water levels up to 200 cm, while the high water levels recorded in December reaching 300 cm were affected by the impoundment of the Kolpa River's high waters. That is why also the determination of discharges in these conditions is unreliable and even impossible.

The SEP and temperature parameters recorded at the spring also provide the correlation of the timeline of values, although this is not a rule at every occurrence. The SEP values range from 350 and 450 µS/cm, with short thrusts which exceed pretoka 0,14 m^3/s do najvišjega s pretokom 15,3 m^3/s. Ocenitev realnega najvišjega pretoka zaenkrat še ni mogoča.

these values, the average being around 400 µS/cm. These values indicate longer retention periods in the aquifer than are characteristic for the region of the high karst. The average annual temperature of the spring is around 9.5℃, though levelled temperatures in the area of 10.5℃ are characteristic from June to the occurrence of high-water waves in December.

Hydrometrical measurements of the discharge were performed during the 2005-2008 period in the range from the minimum discharge of 0.14 m^3/s to the maximum discharge of 15.3 m^3/s. Estimating the actual maximum discharge is not yet possible at this time.



Slika 14: Časovni potek vodostajev, SEP in temperature v letu 2008 na izviru Bilpa

Figure 14: Timeline of water levels, SEP and temperature in 2008 at the Bilpa spring

Preglednica 10: Značilni mesečni, letni in obdobni (2005–2008) vodostaji (H), specifična električna prevodnost (SEP) in temperatura (T) na izviru Bilpa

Table 10: Characteristic monthly, annual and periodical (2005-2008) water levels (H), specific electrical conductivity (SEP) and temperature (T) at the Bilpa spring

H	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Hs	Hmax	Hmin
2008	97	98	110	110	99	102	90	85	84	87	95	147	100	299	77
2005-2008	100	101	111	100	97	96	87	85	91	97	99	115	99	415	74
SEP	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	SEPs	SEPmax	SEP min
2008	415	373	390	359	376	384	402	443	433	453	451	374	404	476	304
2005-2008	415	391	384	370	384	392	406	433	433	436	434	394	406	479	272
T	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Ts	Tmax	Tmin
2008	8.9	8.9	9.2	9.3	9.8	10.3	10.4	10.5	10.5	10.4	10.3	8.8	9.8	11.0	8.2
2005-2008	9.0	8.9	9.0	9.3	9.6	10.0	10.2	10.4	10.5	10.4	10.0	9.1	9.6	11.0	7.7

Veliki Obrh

Izvir Veliki Obrh pri Vrhniki na Loškem polju predstavlja skupaj z Malim Obrhom in izviri pri gradu Snežnik prvo izvirno območje Ljubljanice na območju Slovenije. Združeni tok Obrha na koncu Loške doline pri Danah ponikuje in podzemno odteka proti Cerkniškemu polju. Prispevno območje Loške doline se razteza na povodje Trbuhovice na Hrvaškem, Babnega polja, Retja in Racne gore ter na jugu na obsežen masiv Snežnika. Občasno visoki dotoki na polje, ki nimajo površinskega odtoka in lahko ponikujejo le v omejeni količini, Loško polje tudi poplavijo.

V letu 2008 je bil srednji letni vodostaj v merskem profilu najvišji v obdobju 2004–2008 in je dosegel srednji letni pretok 2,02 m^3/s. Letna ekstrema ne dosegata obdobnih konic, pa tudi razporeditev srednjih mesečnih vodostajev v letu 2008 sledi obdobnim značilnostim. Najizdatnejši meseci so marec, april in december, najmanj izdatna pa september in oktober. Najnižji letni vodostaj, ki nastopa v merskem profilu, je bil zabeležen 27. februarja 2008, vendar je očitno posledica kratkotrajnega umetnega vpliva. Ti sunki so opazni pri beleženju vodostajev s frekvenco na 1 uro, dnevna povprečja te sunke zakrijejo (slika 15). Največji pretok je bil zabeležen 12. decembra v enem od zaporednih visokih valov s konico 18 m^3/s.

Veliki Obrh

The Veliki Obrh spring at Vrhnika on the Lož Field represents the first spring area of the Ljubljanica River in Slovenia together with Mali Obrh and springs at Snežnik Castle. The united Obrh stream, at the end of the Lož Valley near Dane, sinks and runs off underground towards the Cerknica Field. The catchment area of the Loška dolina (valley) extends to the drainage basin of Trbuhovica in Croatia, Babno polje (field), Retje and Racna gora and in the south to the extensive Snežnik mass. Occasional high inflows to the field, which have no surface-water outflow and can sink only in limited quantity, also flood Loško polje.

In 2008 the mean annual water level in the measurement profile was the highest during 2004-2008 and reached the mean annual discharge of 2.02 m^3/s. The annual extremes do not reach the periodical peaks and also the distribution of mean monthly water levels in 2008 follow the periodical characteristics. March, April and December were the most water-abundant, while September and October were the driest. The lowest annual water level occurring in the measuring profile was recorded on 27 February 2008, although this is obviously the result of a short-term artificial influence. These thrusts were noticeable during recording water levels with a 1-hour frequency. Daily averages conceal such thrusts (figure 15). The highest discharge was recorded on 12 December in one of the consecutive high-water waves with a peak of 18 m^3/s.

Preglednica 11: Značilni mesečni, letni in obdobni (2004–2008) vodostaji (H cm) na izviru Veliki Obrh
Table 11: Characteristic monthly, annual and periodical (2004-2008) water levels (H cm) at the Veliki Obrh spring

H (cm)	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	nov	dec	Hsr	Hmax	Hmin
2008	311	309	318	339	308	317	306	315	301	299	317	349	316	407	294
H s	313	306	320	326	315	310	309	305	305	320	320	323	314		
Hmax	383	363	378	378	406	389	359	386	382	411	413	417		417	
Hmin	290	291	295	298	295	296	296	279	294	286	296	292			279

Brestovica

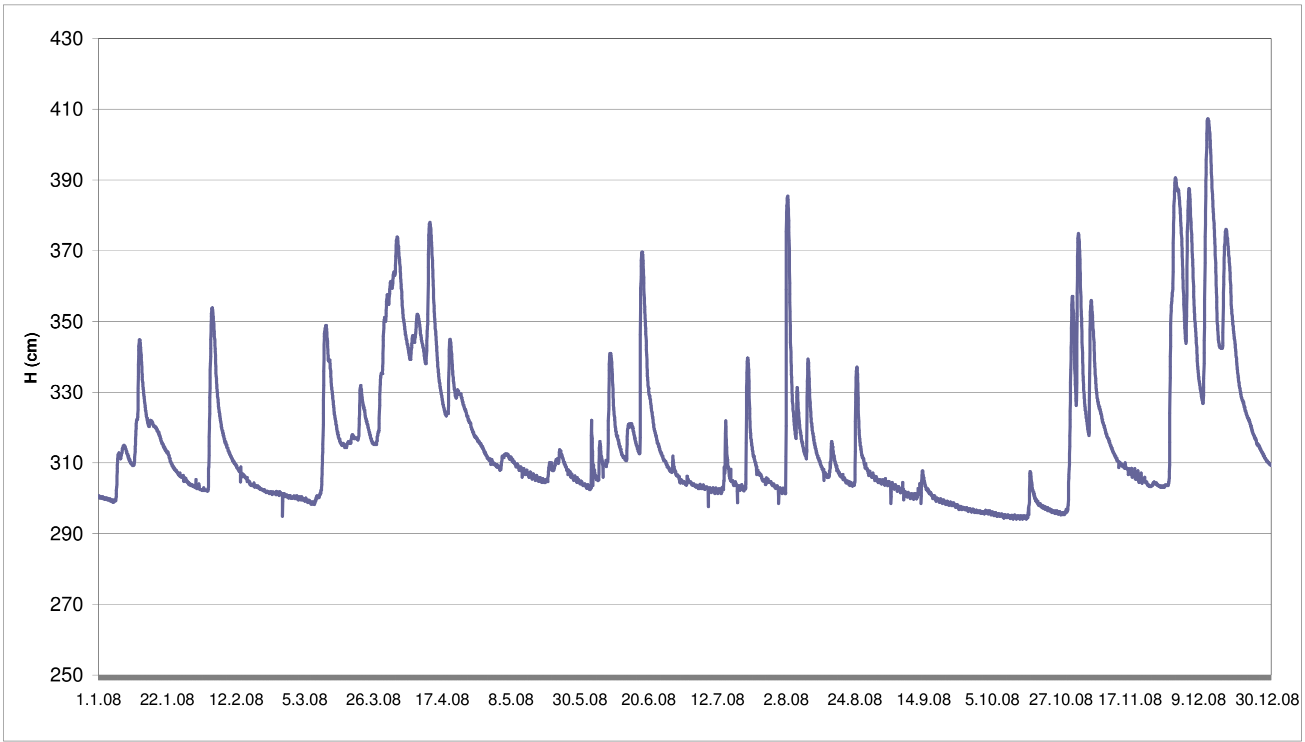
Na območju Klaričev pri Brestovici na Krasu beležimo v vrtini B-2, ki je le nekaj kilometrov oddaljena od iztoka podzemne vode v morje, nihanja gladin podzemne vode v kraškem vodonosniku (slika 16). Nizki vodostaji odražajo frekvenco nihanj plimovanja morja, visoki valovi pa so posledica hidroloških razmer v povodjih Reke, Vipave in tudi Soče ter padavin na območju matičnega Krasa. Decembra 2008 je zabeležena skoraj 10-metrska amplituda, ki je tudi najvišja v dosedanjem obdobju opazovanj od konca leta

Brestovica

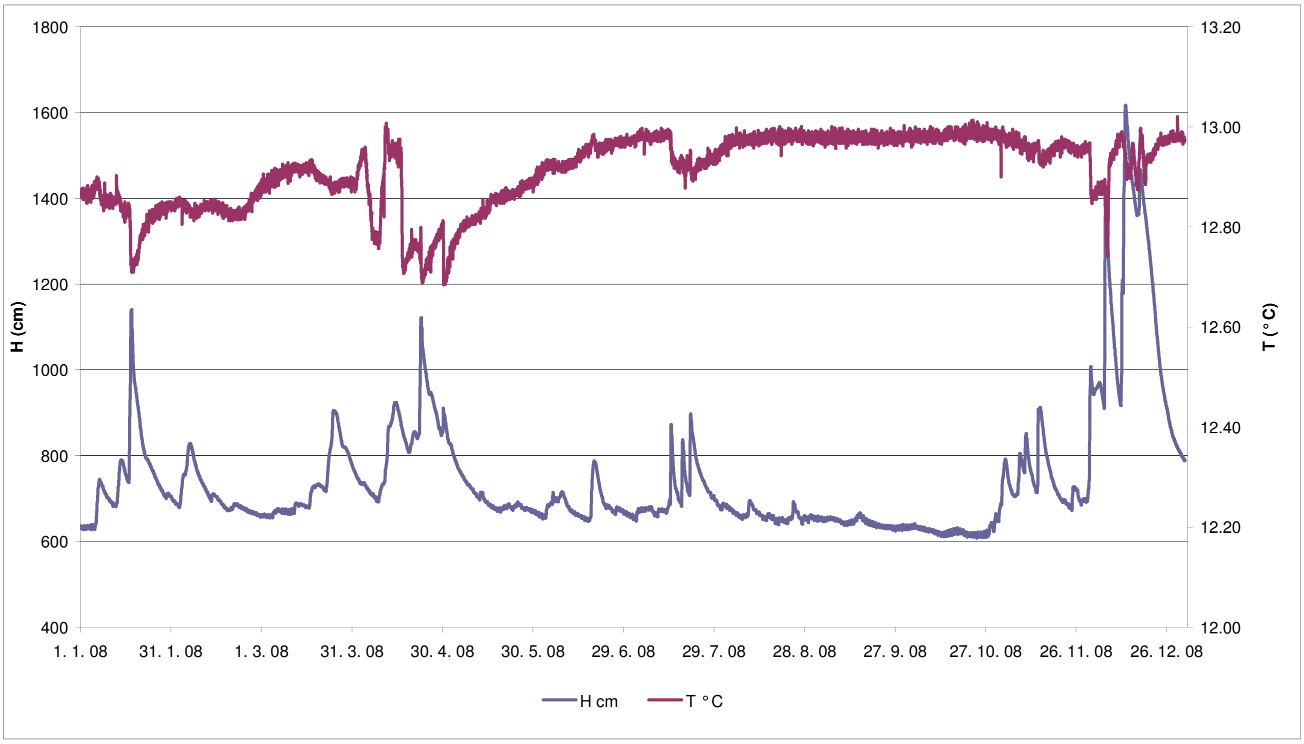
We recorded fluctuation of the ground water levels in the karstic aquifer in the area of Klariči at Brestovica in the Karst region in the B-2 well, only a few kilometres from the outflow of the groundwater into the sea (figure 16). The low water levels reflect the fluctuation frequency of the sea tides, while the high-water waves are a result of hydrological conditions in the drainage basins of the Reka, Vipava and Soča rivers, and precipitation in the area of the classical Karst. In December 2008, almost a ten-metre amplitude

2005. Ta visokovodni val je posledica izdatnih padavin v severozahodni Sloveniji in na območju Ilirske Bistrice ter visokih pretokov Reke s povratno dobo 5–10 let, Soče in Vipave.

was recorded, which is also the highest in recent periods of observation after the end of 2005. This high-water wave was a result of abundant precipitation in north-western Slovenia and in the area of Ilirska Bistrica and high discharges of the Reka River with a 5-10 year return period, Soča and Vipava rivers.



Slika 15: Potek urnih vodostajev (H cm) na izviru Veliki Obrh v letu 2008
Figure 15: Timeline of hourly water levels (H cm) at the Veliki Obrh spring in 2008



Slika 16: Potek urnih vodostajev (H cm) in temperatur (T) v vrtini B-2 Brestovica
Figure 16: Timeline of hourly water levels (H cm) and temperature (T) in the B-2 Brestovica well

D. MORJE

PLIMOVANJE MORJA

Igor Strojan

Plimovanje je pojav periodičnega spreminjanja gladine v morjih in oceanih. Na naši obali imamo mešan tip plimovanja, največkrat se dnevno zamenjata po dve plimi in oseki. Najpomembnejši vpliv na plimovanje imata poleg kroženja Zemlje gravitacijski sili Lune in Sonca. To imenujemo astronomsko plimovanje in ga je mogoče izračunati in napovedati vnaprej. Izmerjena plima pa se od astronomske lahko bistveno razlikuje. To razliko največkrat povzroča vreme. Burja in visok zračni pritisk znižujeta plimovanje, južni in jugovzhodni veter ter nizek zračni pritisk pa vplivata na zvišanje morske gladine.

Pri spremljanju gladine morja obravnavamo urne (to so trenutne vrednosti ob polnih urah) in ekstremne vrednosti (navadno po dve visoki in dve nizki vodi v dnevu). Iz urnih podatkov izračunamo srednjo dnevno vrednost (SDV v tabeli D.3), iz teh srednjo mesečno (SMV v tabeli D.3) in iz teh srednjo letno vrednost (SLV v tabeli D.3).

Pri opazovanju visokih voda določimo, katera od visokih voda v dnevu je bila višja (VVV), iz teh podatkov nato izračunamo povprečje (SVVV v tabeli D.2). Izračunamo tudi srednjo visoko vodo, ki je povprečje obeh visokih voda v dnevu oziroma vseh v mesecu in letu (SVV v tabeli D.2), ter določimo najvišjo gladino morja v mesecu in letu (NVVV v tabeli D.2 in D.4).

Podobno velja za nizke vode, kjer določimo nižjega od obeh ekstremov (NNV) ter iz njega računamo povprečje (SNNV v tabeli D.2). Srednja nizka voda (SNV v tabeli D.2) je povprečje vseh nizkih voda v dnevu, mesecu in letu. Najnižja gladina morja v mesecu in letu je označena z NNNV in jo najdemo v tabelah D.2 in D.4

Preglednica s podatki je objavljena v tretjem delu letopisa.

Višine morja v letu 2008

Značilnosti leta 2008 so nadpovprečna srednja letna višina morja, izredno visoka najvišja in nizka najnižja višina morja. Srednja višina morja 221 cm v letu 2008 je bila kar 5 cm višja od dolgoletnega povprečja. Najvišja letna višina morja, 372 cm, 1.

D. SEA

SEA TIDES

Igor Strojan

The tide is the expression used to describe periodical fluctuations of the sea and ocean levels. Our coast has a mixed type of tide, most often with two high and two low tides occurring daily. In addition to the Earth's movement, the tide is influenced by the gravitational forces of the Moon and the Sun.This is called the astronomical tide, which can be calculated and forecast in advance. The measured tide may vary considerably from the astronomical tide. This difference is most often caused by weather conditions. The bora and high air pressure decrease the tide, and the southern and south-eastern winds and low air pressure influence the increase in sea level.

Sea level monitoring operates with hourly (momentary values at full hours) and extreme values (usually two high and two low tides per day). Hourly data is the basis for calculating the mean daily value (SDV in Table D.3), which is consequently the basis for calculating the mean monthly value (SMV in Table D.3) and the mean annual value (SLV in Table D.3).

In high-water monitoring, we determine which of the high water values in the day was the highest (VVV), and then calculate the average (SVVV in Table D.2). We also calculate the mean high water value, which is the average of both high water values in the day, or in a month or year, respectively (SVV in Table D.2), and determine the highest sea level in the month or year (NVVV in Tables D.2 and D.4).

The same applies to low water where the lower of the two extremes (NNV) is determined and used as the basis for calculating the average (SNNV in Table D.2). The mean low water value (SNV in Table D.2) is the average value of all low waters in a day, month, or year. The lowest sea level in a month or year is marked as NNNV and is found in Tables D.2 and D.4.

The table with the data is published in the third part of the Yearbook.

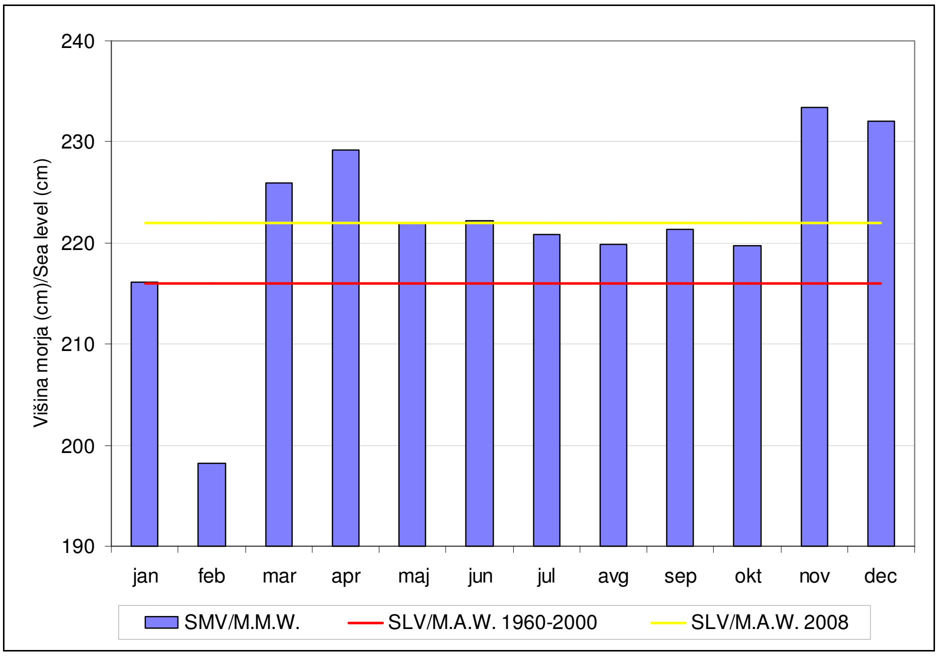
Sea levels in 2008

The features of 2008 included the above-average decembra je bila druga najvišja višina morja v celotnem opazovalnem obdobju. Najnižja višina, 110 cm, je bila med najnižjimi v dolgoletnem obdobju.

Vse srednje mesečne višine morja, razen srednje mesečne višine morja v februarju, so bile višje od srednje višine morja v dolgoletnem obdobju 1961–2000 (slika 1). V februarju je bila srednja mesečna višina morja 198 cm izjemno nizka. Januarska mesečna višina je bila podobna srednji obdobni vrednosti, ostali meseci pa so bili precej nad povprečjem. Najvišja je bila srednja mesečna višina morja 233 cm novembra, decembrska je bila le centimeter nižja. Višji od srednje letne višine morja v letu 2008 sta bili še mesečni vrednosti za marec in april.

mean annual sea level, extremely high maximum and low minimum sea level. The mean sea level in 2008 was 221 cm, which is 5 cm higher than the multi-annual average. The maximum annual sea level, 372 cm, recorded on 1 December, was the second highest sea level during the entire observation period. The minimum level, 110 cm, was among the lowest in the multi-annual period.

All the mean monthly sea levels, save for the mean monthly sea levels in February, were higher than the mean sea level recorded in the multi-annual period 1961-2000 (Figure 1) In February the mean monthly sea level of 198 cm was extremely low. The January monthly level was similar to the mean periodical value, while the other months were quite above the average. The mean monthly sea level was the highest in November (233 cm) and only 1 cm lower in December. The monthly values for March and April were also higher than the mean annual sea level in 2008.



Slika 1: Srednje mesečne višine morja v letu 2008 (modri stolpci), srednja letna višina morja v letu 2008 (rumena linija) in srednja višina morja v obdobju 1961–2000 (rdeča linija)
Figure 1: Mean monthly sea levels in 2008 (blue columns) compared to the mean annual sea level of 2008 (yellow line) and mean value of the 1961–2000 period (red line)

Morje je 14-krat preseglo poplavno višino 300 cm: enkrat januarja, dvakrat marca, enkrat oktobra, trikrat novembra in sedemkrat v decembru.

Prvega decembra 2008 ob 10. uri je bila višina morja 372 cm, kar je bila druga najvišja izmerjena višina morja v celotnem opazovalnem obdobju. Astronomsko plimovanje 251 cm ob nastopu najvišje višine morja ni bilo izjemno visoko. Visoko višino morja so povzročili predvsem meteorološki dejavniki in lastno nihanje Jadranskega morja. V

The sea exceeded the flood level of 300 cm 14 times: once in January, twice in March, once in October, three times in November and seven times in December.

At 10 a.m. on 1 December 2008 the sea level rose to 372 cm, which was the second highest recorded sea level in the entire observation period. The astronomic tide of 251 cm upon the occurrence of the maximum sea tide was not exceptionally high. The high sea level was mainly caused by meteorological factors and fluctuation of the dneh pred nastopom najvišje višine morja so Jadran prešla štiri ciklonska območja, ki so močno vplivala na višino lastnega nihanja Jadranskega morja. V času najvišje višine morja je veter na boji Vida pred Piranom pihal s povprečno hitrostjo 10–12 m/s in največjo trenutno hitrostjo 20 m/s. Zaradi močnega južnega vetra, ki je pihal po Jadranu, je dolgoperiodični lastni val imel višino okoli pol metra. Tudi zračni tlak 996 mb je bil izjemno nizek. Celotna residualna višina (razlika med merjeno višino morja in astronomsko višino morja), ki jo pripisujemo vplivu narivanja vetra morja v severni del Jadranskega morja, zniževanju zračnega tlaka in vzpostavljenemu lastnemu nihanju Jadranskega morja, je znašala kar 121 cm. Morje je poplavilo velik del obale v obmorskih mestih ter povzročilo precej škode v Sečoveljskih solinah in obalnih mestih.

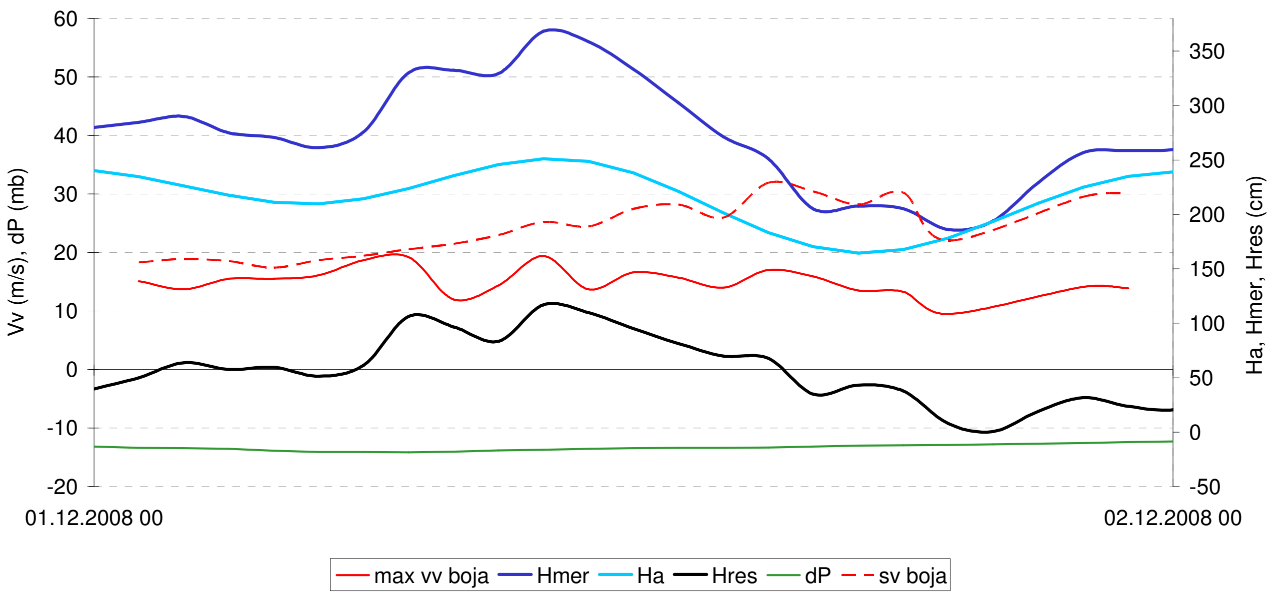
Najnižja višina morja v letu 2008, 110 cm, je bila izmerjena 18. februarja. V primerjavi z obdobjem je ta vrednost podpovprečna. Za vse Jadransko morje so bile med 5. in 9. ter 16. in 20. februarjem značilne nizke oseke, ki so povzročile tudi manjše nevšečnosti. V Benetkah je bil promet po stranskih kanalih nekaj časa celo onemogočen. Eni najnižjih osek v zadnjih letih je botrovala nizka astronomska višina oseke, višino morja pa je še dodatno niževal zelo visok zračni tlak (celo do 1045 mb), ki je bil posledica močnega anticiklona, ki se je več dni zadrževal nad Sredozemljem. Zaradi meteoroloških dejavnikov je bilo morje 50 cm nižje od napovedanega.

Adriatic Sea itself. In the days leading up to the highest sea level the four cyclone areas passed the Adriatic, which significantly influenced the level of fluctuation of the Adriatic Sea. During the highest sea level the wind at the Vida buoy in front of Piran blew with the average velocity of 10-12 m/s and the highest current velocity of 20 m/s. Due to the strong south wind blowing from the Adriatic the long periodical wave came in at the height of around half a metre. Even the air pressure of 996 mb was extremely low. The total residual level, (difference between the measured sea level and the astronomical sea level) attributed to the thrusting of the sea wind through the northern part of the Adriatic Sea, decrease in air pressure and established own fluctuation of the Adriatic Sea, amounted to 121 cm. The sea flooded a large part of the coast in coastal towns and caused considerable damage to the Sečovlje salines and coastal areas.

The lowest sea level in 2008 was 110 cm, recorded on 18 February. This value is below average compared to the periodical average. Low tides also causing minor trouble were characteristic for the entire Adriatic Sea between 5-9 and 16-20 February. Transportation through the side canals in Venice was made impossible for a certain time period. One of the lowest tides in recent years was caused by a low astronomical tide, while the sea levels were additionally decreased by the very high air pressure (even above 1045 mb) resulting from the strong anticyclone, which remained for several days above the Adriatic. The sea was 50 cm lower than the forecast due to meteorological factors.

Ob nizkem pritisku, ki se je še zniževal, in ob vztrajnem južnem vetru je bila najvišja višina morja, 306 cm, izmerjena 30. oktobra zjutraj. Morje je za kratek čas poplavilo nižje ležeče dele obale. Vtis poplav so povečali še do 2,5 m visoki valovi. (foto: Sokol, zbirka slik MOP – ARSO)

The highest monthly sea level was measured on 30 October and was caused by low air pressure and southern wind. Lower parts of shore were flooded for a short time (photo: Sokol, EARS).



Slika 2: Prvega decembra 2008 je bila višina morja izredno visoka. Na sliki so prikazane vrednosti izmerjenih višin morja (Hmer), astronomske višine morja (Ha) ter residualne višine morja (Hres). V času dogodka so bile izmerjene tudi najvišje hitrosti (maxvvboja), smeri (svboja) ter odstopanja od normalnega zračnega tlaka (dP).

Figure 2: The sea level was extremely high on 1 December 2008. The figure demonstrates the values of measured sea levels (Hmer), astronomic sea levels (Ha) and residual sea levels (Hres). Also the highest wind velocities (maxvvboja), wind directions (svboja) and deviations from the normal air pressure (dP) were recorded during the occurrence.

Najvišja gladina morja 372 cm je bila izmerjena 1. decembra 2008. Morje je močno preplavilo obalno cesto v Piranu (foto Mojca Robič).

The highest sea level of 372 cm was measured on 1 December 2008. The sea flooded the coastal street in Piran (photo: Mojca Robič)

Najnižja gladina morja 110 cm je bila izmerjena 18. februarja 2008. Nekatera plovila v Jernejevem kanalu ob Sečoveljskih solinah so ostala na suhem (foto Mojca Robič).

The lowest sea level of 110 cm was measured on 18 February 2008. Some vessels in the Jernejev canal next to the Sečovlje salines remained on land (photo: Mojca Robič).

Kronološki pregled po mesecih

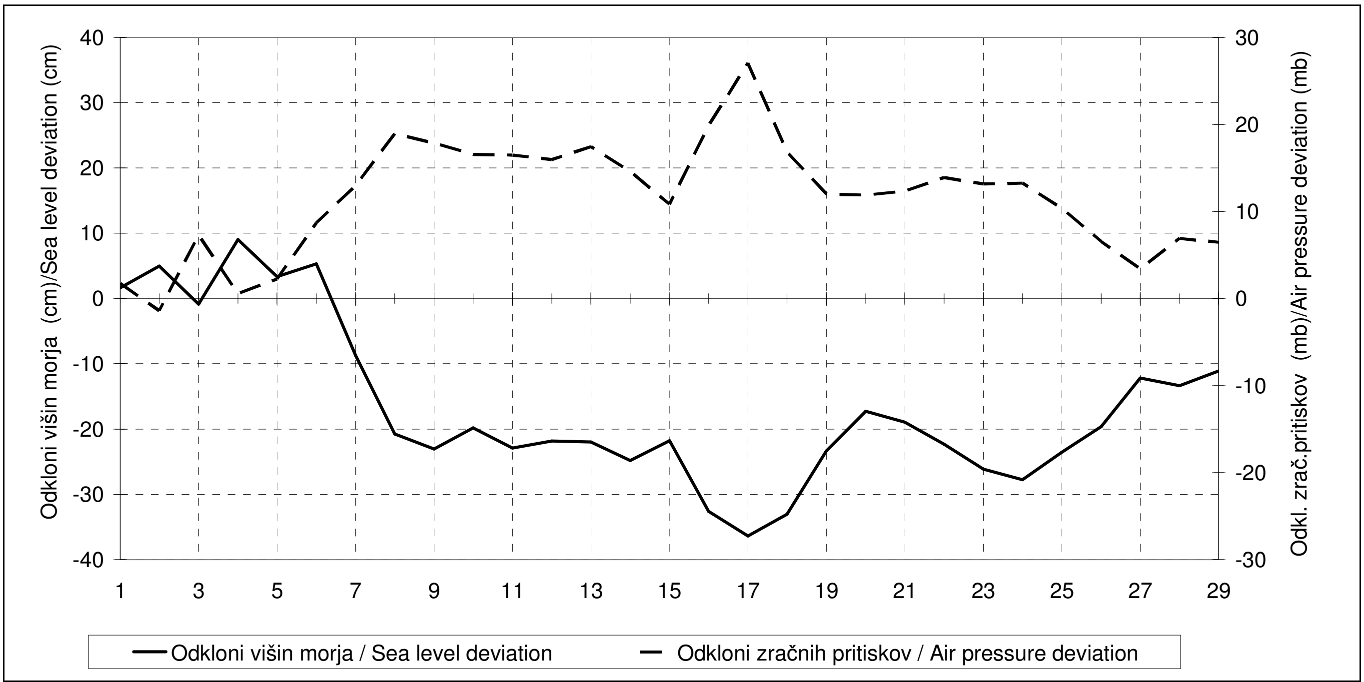
Srednja mesečna višina morja v **januarju**, 222 cm, je bila nad dolgoletnim povprečjem, tudi najvišja in najnižja mesečna višina sta bili nadpovprečni. Morje je bilo prvo polovico meseca povprečno visoko, v drugi polovici pa znatno povišano.

Srednja mesečna višina morja v **februarju**, 198 cm, je bila močno podpovprečna. Vse značilne vrednosti višin morja so bile nižje od dolgoletnega povprečja. Posebej je izstopala nizka oseka 17. in 18. februarja. Podrobneje so razmere ob najnižji oseki 18. februarja opisane v prejšnjem poglavju.

Chronological monthly review

The mean monthly sea level in **January**, 222 cm, was above the multi-annual average. The maximum and minimum monthly levels were also above average. The sea level in the first half of the month was average and increased its level significantly during the second half.

The mean monthly sea level in **February**, 198 cm, was significantly below average. All the characteristic values of the sea level were lower compared to the multi-annual average. Low tide stood out especially during 17 and 18 February. The conditions at low tide on 18 February are described in detail in the previous section.



Slika 3: Odkloni srednjih dnevnih višin morja v februarju 2008 od povprečne višine morja v obdobju 1960–1990 in odkloni srednjih dnevnih zračnih pritiskov od dolgoletnih povprečnih vrednosti. Večino februarja so bile višine morja nižje od pričakovanih astronomskih višin morja.
Figure 3: Differences between mean daily sea levels and the mean sea level for the period of 1960–1990; differences between mean daily air pressure and the mean air pressure for the reference period in February 2008.

Marca in aprila je bila gladina morja močneje povišana. Srednja mesečna višina je marca za 5 cm, aprila pa za 6 cm presegla najvišjo srednjo obdobno vrednost za marec oziroma april. Vse značilne vrednosti višin morja so bile višje od dolgoletnega povprečja. Aprila je bila višina morja razen v prvih in zadnjih dneh v mesecu večimoma povišana.

V naslednjih mesecih, **maju, juniju, juliju, avgustu in septembru**, so bile srednje mesečne višine nižje kot marca in aprila, a še vedno nadpovprečne. Septembra je bila najnižja mesečna višina, 158 cm, med najvišjimi v dolgoletnem primerjalnem obdobju.

The sea level increased significantly in **March** and **April**. The mean monthly level exceeded the highest mean periodical value for March or April by 5 cm in March and 6 cm in April. All the characteristic values of the sea levels were higher compared to the multi-annual average. The sea level, save for the first and last few days in the month, mostly increased in April.

During the following months, **May, June, July, August and September**, the mean monthly sea levels were lower than in March and April, however still above average. September's minimum monthly level of 158 cm was amongst the highest in the multi-annual reference period.

Srednja mesečna višina morja v **oktobru** je bila povprečna. Izmenjevala so se obdobja znižanih in povišanih višin morja. Morje je bilo močneje povišano v zadnjih dneh meseca, ko je doseglo tudi mesečni maksimum 306 cm.

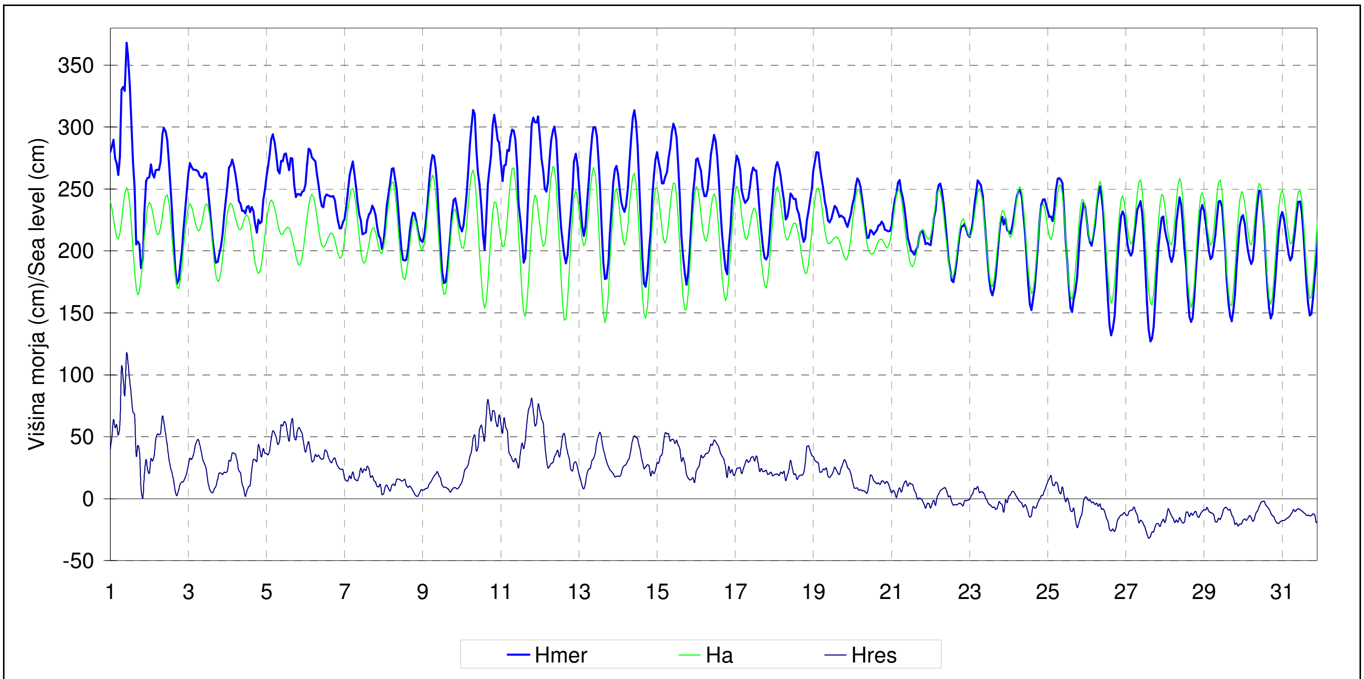
Srednja mesečna višina morja v **novembru** je bila nad dolgoletnim povprečjem. Morje je bilo močno povišano predvsem v zadnji tretjini meseca, vendar je doseglo najvišjo gladino 1. novembra. Poplavna višina morja 300 cm je bila presežena trikrat.

Srednja mesečna višina morja v **decembru** je bila nad dolgoletnim povprečjem. Izredno visoko gladino, 372 cm, ki je bila le 20 cm nižja od najvišje izmerjene višine 25. novembra 1969, je morje doseglo 1. decembra. Morje je močno poplavljalo. V Piranu so bili poplavljeni dovozna ulica v mesto, številne stavbe in lokali ob obali. Tartinijev trg z okoliškimi ulicami je bil preplavljen s pol metra visoko vodo, prav tako številne stanovanjske stavbe, hotel Tartini, občina in knjižnica. Težave zaradi poplav so imeli tudi v drugih obmorskih mestih. Ta poplava je bila dolgotrajna, saj se je morje umaknilo z najnižjih delov obale šele po sedmih urah. Decembra je bilo morje močno povišano tudi od 10. do 16. tega meseca. Poplavna višina morja 300 cm je bila presežena kar sedemkrat.

The mean monthly sea level in **October** was average. Periods of low and high sea levels interchanged one after the other. The sea significantly increased in the last days of the month when it also reached the monthly maximum of 306 cm.

The mean monthly sea level in **November** was above the multi-annual average. The sea increased dramatically mainly in the last third of the month reaching the maximum level on 1 November. The flood level of the sea, 300 cm, was exceeded three times.

The mean monthly sea level in **December** was above the multi-annual average. The extremely high water level of 372 cm, only 20 cm lower than the maximum recorded sea level on 25 November 1969, was achieved on 1 December. The sea flooded extensively. The access route into the town of Piran, several buildings and taverns by the sea were flooded. Tartini Square with surrounding streets was flooded with high water half a metre in height, as well as residential buildings, the Hotel Tartini, township and library. Difficulties because of the flooding were also experienced by other coastal towns. The flood lasted for some time, as the sea retreated from the lowest coastal areas only after seven hours. The sea increased significantly during 10-16 December. The flood level of the sea, 300 cm, was exceeded no less than seven times.



Slika 4: Izmerjene urne (Hmer) in astronomske (Ha) višine morja decembra 2008 ter razlika med njimi (Hres). Izhodišče izmerjenih višin morja je mareografska "ničla" na mareografski postaji v Kopru, ki je 3955 mm pod državnim geodetskim reperjem R3002 na stavbi Uprave za pomorstvo. Srednja letna višina morja v dolgoletnem obdobju je 215 cm.
Figure 4: Measured (Hmer) and prognostic "astronomical" (Ha) sea levels in December 2008 and the difference between them (Hres).

Na m.p. Koper je bila 1. decembra 2008 izmerjena druga najvišja gladina morja v opazovalnem obdobju. V Kopru je bilo poplavljeno parkirišče za tržnico, Ukmarjev trg in stavba Luške kapitanije v neposredni bližini mareografske postaje (foto: Jernej Peroša).

The second highest sea level during the period of observation was recorded on 1 December. The sea flooded Ukmar square in Koper (photo: Jernej Peroša)

Tartinijev trg v Piranu je bil poplavljen s preko pol metra globoko vodo. Poplavljene so bile tudi okoliške ulice. Morje je vdiralo v pritlične prostore objektov (foto: Mojca Robič).

The depth of water on flooded Tartini Square in Piran was nearly half a metre (photo: Mojca Robič).

E. VODNA BILANCA

VODNA BILANCA POREČIJ

Peter Frantar

Izračun vodne bilance temelji na konceptu vodnega kroga, na primerjavi odtoka, padavin, izhlapevanja ter sprememb vodnih zalog. Iz trenutno razpoložljivih hidroloških in meteoroloških podatkov sprememb vodnih zalog ne moremo količinsko ovrednotiti, zato za izračun uporabljamo poenostavljeno enačbo vodne bilance, ki predpostavlja ravnovesje padavin z odtokom in izhlapevanjem:

Padavine (P) = Odtok (Q) + Izhlapevanje (ET)

Analizo vodne bilance smo izvedli za jadransko in črnomorsko povodje, ki smo ju pri računanju odtokov še notranje razdelili. Jadransko povodje smo razdelili na porečje Soče, ki zajema pritoke Soče in Vipave, ter na povodje jadranskih rek, ki zajema preostanek povodja Jadranskega morja, črnomorsko povodje pa na Pomurje, Podravje in Posavje. Izhlapevanje enačimo s pojmom evapotranspiracija, ki zajema evaporacijo (izhlapevanje z vodnih površin) in transpiracijo (izhlapevanje iz rastlin).

Členi vodne bilance

Letno količino padavin smo izračunali iz padavinske karte korigiranih padavin, katere osnova so podatki merilnih mest za padavine po Sloveniji. Za korekcijo podatkov o padavinah so se upoštevali temperatura, veter in intentizeta padavin. Izhlapevanje smo izračunali s pomočjo bilančne formule po enačbi P – Q = ET.

Odtoki so praviloma najzanesljivejši člen vodne bilance porečij. Na reprezentativnih vodomernih postajah se odtok določenega območja zbere na enem vodomernem profilu. Pri izračunavanju smo upoštevali pretoke vodomernih postaj, ki zajamejo večino dotokov v državo in iztokov iz nje, ter ocene pretokov za vodotoke, ki imajo v Sloveniji le povirja. Za območja brez meritev smo pretoke določili z upoštevanjem specifičnih odtokov q (l/km^2/s) hidrološko primerljivih vodomernih postaj oziroma s korelacijskimi vrednostmi na osnovi srednjih letnih vrednosti pretokov.

E. WATER BALANCE

WATER BALANCE OF THE RIVER BASINS

Peter Frantar

The calculation of the water balance is based on the water cycle concept, on the comparison of runoff, precipitation, evaporation and changes in water storage. Changes in water storage cannot be evaluated in quantity from the currently available hydrological and meteorological data; therefore, a simplified equation of water balance which implies balance between the precipitation, runoff and evaporation is used for the calculation:

Precipitation (P) = Runoff (Q) + Evaporation (ET)

The water balance analysis was performed for the Adriatic and Black Sea drainage basins, which were internally divided in the calculation of runoffs. The Adriatic drainage basin was divided into the Soča River basin encompassing the tributaries of the Soča and Vipava rivers and the drainage basin of Adriatic rivers encompassing the rest of the Adriatic Sea drainage basin. The Black Sea basin was divided into Pomurje, Podravje and Posavje. The term “evaporation” is equivalent to the term “evapotranspiration”, which includes evaporation (evaporation from water surfaces) and transpiration (evaporation from plants).

Water balance elements

The annual quantity of precipitation was calculated from the precipitation map of corrected precipitation based on the data from the gauging stations across Slovenia. Temperature, wind and the intensity of precipitation were observed for the correction of data on precipitation. Evaporation was calculated using the balance formula using the equation P - Q = ET.

Generally, runoffs are the most reliable elements of the river basin water balance. At representative gauging stations, the runoff of a certain area is gathered in a single hydrometric profile. Our calculations observed the discharges of the gauging stations covering most inflows into and outflows from the country, as well as the estimated discharges for watercourses with headwaters in Slovenia. For those areas without relevant measurements, the discharges were determined by observing specific runoffs q (l/km^2/s) of gauging

Vodna bilanca po glavnih slovenskih porečjih

Pomurje je hidrogeografska regija s površino 1390 km^2 in z najmanjšo povprečno količino padavin v Sloveniji. Leta 2008 je v Pomurju padlo v povprečju 886 mm padavin (v obdobju 1971–2000: 897 mm), kar je enako 39,1 m^3/s. Bilančno izhlapevanje je bilo 762 mm oziroma 33,7 m^3/s. Najmanj padavin je leta 2008 padlo na jugovzhodu Pomurja. V predelu jugovzhodno od Lendave (okolica Lendavskih goric) manj kot 700 mm. Največ padavin je padlo na severozahodnem delu Slovenskih goric, na Apaškem polju ter v osrednjem delu Goričkega, okrog 1000. Preostali deli Goričkega in Slovenskih goric so prejeli okrog 900 mm padavin, osrednji del Prekmurskega polja pa okoli 800 mm. Pri vtoku površinskih voda v Slovenijo smo upoštevali Muro in dela porečij Kučnice in Ledave, ki ležita zunaj Slovenije. Pri odtoku iz države smo upoštevali Muro, Veliko Krko, Ledavo, Ščavnico ter odtok s preostalega območja, ki ga ne zajamemo z našimi vodomernimi postajami. Vsi dotoki v Pomurje so leta 2008 prispevali 136,8 m^3/s, z območja Pomurja pa je odteklo skupaj 142,3 m^3/s. Količina vode, ki je leta 2008 odtekla samo s površine Pomurja, je bila v povprečju 5,44 m^3/s.

Podravje meri 3265 km2 in skozenj teče naša največja prehodna reka Drava. Podravje je imelo leta 2008 nekoliko več padavin, kot je obdobno povprečje. Leta 2008 je bilo tu v povprečju 1311 mm padavin (v obdobju 1971–2000: 1244 mm), kar je 136 m^3/s. Najmanj padavin v Podravju je bilo leta 2008 na jugovzhodu Slovenskih goric – okrog 900 mm. Osrednji del Goric je prejel okrog 950 mm, severni pa okrog 1000 mm padavin. Količina padavin raste proti višjim predelom in proti zahodu. Vzhodni predeli Haloz so dobili med 1500 mm padavin, najvišji predeli Haloz (Donačka gora) pa okrog 1350 mm padavin. V pogorju Boča je količina padavin dosegla 1500 mm. Osrednji del Dravskega in Ptujskega polja je imel med 1100 in 1200 mm padavin, Kozjansko pa okoli 1300 mm. Na Pohorju je količina padavin rasla skladno z nadmorsko višino in na najvišjih predelih v letu 2008 dosegla 2100 mm. Tu je bilo tega leta v Podravju tudi največ padavin. Vzhodni predeli Karavank, ki segajo v Podravje, dobijo zaradi zavetrne lege manj padavin in tako jih je leta 2008 na Uršlji gori padlo 2000 mm, na Olševi pa 2050 mm. Dravska dolina ter dolini Meže in Mislinje so prejele okoli 1400 mm padavin, na pogorju Kozjaka pa je v najvišjih predelih padlo 1600 mm padavin. Količino dotoka vode iz Avstrije smo določili s pretoki na Dravi v Dravogradu, na Bistrici v Muti ter na povirju Pesnice. Skupni odtok vsega Podravja je Drava na iztoku iz Slovenije pri Ormožu. V Podravje je leta 2008 v povprečju

stations comparable in hydrological terms, or by correlation values on the basis of mean annual discharge values.

Water balance by principal Slovenian river basins

Pomurje (the Mura River Basin) is a hydro-geographical region with an area of 1,390 km^2 and the lowest average precipitation level in Slovenia. In 2008, the average precipitation level of Pomurje was 886 mm (897 mm in the 1971-2000 period) equalling 39.1 m^3/s. Balance evaporation was 762 mm or 33.7 m^3/s. The precipitation level in 2008 was lowest in the south-eastern part of Pomurje. Less than 700 mm of precipitation was recorded south-east of Lendava (in the surrounding area of Lendavske (Lendava) gorice). The majority of precipitation fell in the north-western part of Slovenske gorice, on the Apače Field and in the central part of Goričko, roughly 1,000 mm. Other parts of Goričko and Slovenske gorice received around 900 mm of precipitation, while the central part of the Prekmurje Field received around 800 mm. With regards to the inflow of surface waters to Slovenia, we considered the Mura River and parts of the Kučnica and Ledava river basins located outside of Slovenia. With regards to the outflow from Slovenia, we considered the Mura, Velika Krka, Ledava, Ščavnica rivers and the outflow from the remaining area not covered by our gauging stations. All inflows to Pomurje in 2008 contributed 136.8 m^3/s, while the outflow from the Pomurje area represented 142.3 m^3/s in total. The average quantity of water flowing just from Pomurje in 2008 amounted to 5.44 m^3/s.

Podravje (the Drava River Basin) covers the area of 3,265 km^2 and is a part of the biggest transitional river in Slovenia, the Drava River. In 2008, the precipitation level of Podravje was slightly higher than the periodical average. In 2008, the average precipitation level of Pomurje was 1,311 mm (1,244 mm in the 1971-2000 period) equalling 136 m^3/s. In 2008, the precipitation level of Podravje was the lowest in the south-eastern part of Slovenske gorice – around 900 mm. The central part of the Slovenske gorice received roughly 950 mm and 1,000 mm in the north. The quantity of precipitation rose towards higher areas and towards the west. The eastern parts of Haloze received 1,500 mm of precipitation, and the highest parts of Haloze (Donačka gora) around 1,350 mm. The Boč mountain area reached 1,500 mm of precipitation. The central part of the Drava and Ptuj fields received between 1,100 and 1,200 mm of precipitation, while Kozjansko recorded around 1,300 mm. In 2008, the level of precipitation grew priteklo slabih 229 m^3/s vode, iz njega pa je odteklo 290 m^3/s. Neto prispevek Podravja k odtoku Drave je bil 60,6 m^3/s. Z upoštevanjem padavin ter neto odtoka dobimo, da je iz Podravja bilančno izhlapelo 75,3 m^3/s vode.

Posavje zajema dobro polovico (11.750 km^2) Slovenije. Leta 2008 je bilo na območju slovenskega Posavja v povprečju 1829 mm (v obdobju 1971–2000: 1589 mm) padavin oziroma za 682 m^3/s. To je 15 % več kot v dolgoletnem obdobju. V porečju imamo velik razpon v količini padavin, ki je bil leta 2008 od 1000 mm v Brežiški kotlini pa vse do 4000 mm na pobočjih južnih in zahodnih Bohinjskih gora v Julijcih. Količina padavin raste od vzhoda proti zahodu ter z nadmorsko višino. Večina vzhodnega dela Posavja (SV Bela krajina, spodnji tok Krke, vzhodni del Posavskega hribovja, vzhodni deli Posavinja) je imela manj kot 1500 mm padavin. Zahodni del Posavskega hribovja ter vzhod Ljubljanske kotline je prejel do 1800 mm padavin. Od tod je količina padavin rasla na vse strani. Na jugu so jih predeli Goteniške gore in Kočevske male gore prejeli do 2300 mm, najvišji predeli Snežnika pa skoraj 3000 mm. Na zahodu je bilo v Škofjeloškem hribovju med 2200 in 2800 mm, v Polhograjskem hribovju med 1900 mm in 2200 mm, v Idrijskem hribovju in predelih Javornika do 2700 mm padavin, v Hrušici okoli 2100 mm, v porečju Pivke več kot 1700 mm padavin. Vsi Julijci so tega leta dobili več kot 3000 mm padavin, prav tako je po grebenih Karavank padlo več kot 3000 mm in do 3300 mm padavin. Na Voglu in Komni je padlo skoraj 5000 mm padavin. Po najvišjih predelih Kamniških Alp je padlo med 2500 pa do skoraj 3000 mm padavin. Pritoki v slovensko Posavje iz hrvaškega dela porečja Ljubljanice, Kolpe, Krke in Sotle so prispevali 34,3 m^3/s, skupen iztok iz Slovenije pa je bil 347 m^3/s. Neto odtok iz slovenskega Posavja je bil 313 m^3/s. Izhlapevanje, izračunano po bilančni enačbi, je bilo 369 m^3/s.

Posočje meri 2320 km^2 in je po specifičnih odtokih naše najbolj vodnato porečje. Tudi leta 2008 je tu padlo največ padavin v Sloveniji: 2890 mm oziroma 213 m^3/s. Letna količina padavin je bila za petino nad dolgoletnim povprečjem obdobja 1971–2000 z 2386 mm. Največ padavin je bilo v Julijcih. Severno od Bače je bilo padavin povsod več kot 3000 mm. Grebeni južnobohinjskih gora so dobili do 5000 mm padavin, pogorje Mangarta do 4700 mm, Breginjske gore do 4800 mm, največ pa Kaninsko pogorje, tudi več kot 5100 mm padavin. Visoke dinarske planote Banjšice in Trnovski Gozd sta dobili med 2500 in 3100 mm padavin, Nanos do 2500 mm. Doline v zaledju planot so zaradi zavetrne lege prejele

in line with the altitude and in the higher areas reached 2,100 mm. This was also the area with the most precipitation in Podravje in 2008. The eastern areas of the Karavanke mountain range which extend to Podravje received less precipitation due to their lee side, receiving 2,000 mm on Uršlja gora and 2,050 mm on Olševa in 2008. The Drava Valley and Meža and Mislinja valleys received around 1,400 mm of precipitation, while the Kozjak mountain range received 1,600 mm of precipitation at higher altitudes. The quantity of the water inflow from Austria was determined through discharges on the Drava River in Dravograd, on the Bistrica River in Muta and at the headwaters of the Pesnica River. The total runoff of the entire Podravje area is the Drava River at the outflow from Slovenia near Ormož. In 2008, the average inflow was slightly under 229 m^3/s, while the outflow amounted to 290 m^3/s. The net contribution of Podravje to the Drava River runoff was 60.6 m^3/s. By taking the precipitation and the net runoff into account it is possible to calculate the balance evaporation from Podravje, which in 2008 amounted to 75.3 m^3/s.

Posavje (the Sava River Basin) covers over half (11,750 km^2) of Slovenia. In 2008, the average precipitation level of Posavje was 1,829 mm (in the 1971-2000 period: 1,589 mm) equalling 682 m^3/s. This is 15% more compared to the multi-annual reference period. The basin has a broad span in terms of precipitation quantity, which ranged from 1,000 mm (Brežice basin) to 4,000 mm on the slopes of the southern and western Bohinj mountains in the Julian Alps. The quantity of precipitation increased from east to west also with the rise in altitude (above sea level). The precipitation in most parts of east Posavje (NE Bela Krajina – White Carniola, the lower reach of the Krka River, eastern part of Posavje Hills, the eastern parts of Posavinje) was below 1,500 mm. The western part of the Posavje Hills and eastern part of the Ljubljana Basin received up to 1,800 mm of precipitation. From there, the quantity of precipitation grew everywhere. The precipitation level in some parts of Goteniška gora (mountain) and the Kočevje Mala Gora amounted to 2,300 mm, and in the highest parts of Snežnik almost 3,000 mm. The precipitation level in the west in the Škofja Loka Hills was between 2,200 and 2,800 mm, in the Polhogradec Hills between 1,900 mm and 2,200 mm, in the Idrija Hills and parts of Javornik up to 2,700 mm of precipitation, 2,100 mm in Hrušica, while more than 1,700 mm in the Pivka River basin. All the Julian Alps received more than 3,000 mm of precipitation, while the Karavanke ridges received between 3,000 mm and 3,300 mm. Almost 5,000 mm of precipitation fell on Vogel and Komna. Between 2,500 and manj padavin – najmanj v okolici Cerkna – več kot 1900 mm. V Vipavski dolini je bilo padavin med 1700 in 2000 mm, v Goriških brdih pa jih je bilo med 1800 in 2100 mm. Najmanj padavin v Posočju, manj kot 1700 mm, je bilo med Podnanosom in Vipavo v zgornji Vipavski dolini. Visoka količina padavin ni veliko prispevala k odtoku iz porečja. Skoraj vse Posočje pripada Sloveniji. Izjeme so povirja Učje, Nadiže ter deloma Idrije, ki so dodali v Slovenijo 8,6 m^3/s. Iz slovenskega Posočja voda odteka v največji meri po Soči, Vipavi in Nadiži, nekaj pa tudi po Idriji, Reki (v Goriških brdih) in Korenu. Skupaj je odteklo 138 m^3/s. Bilančno izhlapevanje je bilo v Posočju leta 2008 83,3 m^3/s, neto odtok v Posočju pa je bil 129,4 m^3/s.

Povodje preostalih jadranskih rek zajema 1530 km^2, največji vodotok je reka Reka. Tu je leta 2008 padlo nekoliko več padavin od dolgoletnega povprečja. Bilo jih je 1790 mm (v obdobju 1971–2000: 1619 mm), kar je slabih 64,7 m^3/s. Najmanjše količine padavin, med 1250 in 1300 mm, so bile v Koprskem primorju v zaledju Kopra ter na območju Sečoveljskih solin z okolico. Drugod po Koprskem gričevju je bilo padavin med 1400 in 1600 mm, od tod pa je bilo padavin več proti vzhodu in severu. Pogorje Slavnika je prejelo do 2200 mm mm padavin, Brkini okrog 1700 mm, Snežnik pa do 3100 mm. V dolini Reke in Košanski dolini je bilo padavin okoli 1700 mm, do 2000 mm pa je bilo padavin na Vremščici. Planota Krasa je na vzhodu imela 1700 mm padavin, na zahodu pa do 2150 mm. Tekoče vode v Slovenijo pritečejo prek povirij Rižane, Reke ter Dragonje. Skupaj je priteklo v Slovenijo 0,9 m^3/s vode. Iztokov je več: poleg večine Krasa (s podzemnim odtokom) ter obale se v Italijo odtaka tudi Osapska reka, na Hrvaško pa teče voda iz povirja porečja reke Mirne. Leta 2008 je bil skupni odtok 27,3 m^3/s, neto odtok pa je 26,1 m^3/s. Leta 2008 je po bilančni metodi izhlapelo 60,7 m^3/s.

Primerjava z obdobno vodno bilanco

Vse člene vodne bilance leta 2008 smo primerjali z referenčno obdobno vodno bilanco 1971–2000, in sicer za črnomorsko in jadransko povodje (Vodna bilanca Slovenije 1971–2000). **V slovenskem delu črnomorskega povodja** je leta 2008 padlo več padavin, kot je obdobno povprečje. Med letoma 1971 in –2000 je bila povprečna količina padavin 1462 mm, leta 2008 pa jih je padlo 1646 mm. Leta 2008 je bilančno izhlapelo kar 918 mm vode, v obdobju 1971–2000 pa 713 mm. V obdobju 1971–2000 smo z ozemlja Slovenije v črnomorsko povodje prispevali 390 m^3/s vode oziroma 749 mm, v letu 2008 je bila ta količina precej manjša: 379 m^3/s oziroma 728 mm.

almost 3,000 mm of precipitation was received by the highest parts of the Kamnik Alps. The inflows to the Slovenian Posavje from the Croatian parts of the Ljubljanica, Kolpa, Krka and Sotla river basins contributed 34.3 m^3/s, while the total outflow from Slovenia was 347 m^3/s. The net outflow from the Slovenian Posavje was 313 m^3/s. The evaporation calculated using the balance equation was 369 m^3/s.

Posočje (the Soča River Basin) covers an area of 2,320 km^2 and is the most water abundant river basin in Slovenia in terms of the specific runoffs. Also in 2008, it had the highest precipitation level in Slovenia: 2,890 mm or 213 m^3/s. This is a fifth above the multi-annual average of the 1971-2000 period, i.e. 2,386 mm. The highest level of precipitation was in the Julian Alps. The precipitation level exceeded 3,000 mm north of Bača. The ridges of the South Bohinj Mountains received up to 5,000 mm of precipitation, the Mangart Mountain Range up to 4,700 mm, Breginj Mountains up to 4,800 mm, while the most precipitation (also over 5,100 mm) was recorded in the Kanin Mountains. The high Dinaric plateaus Banjšice and Trnovski gozd received between 2,500 mm and 3,100 mm of precipitation compared to Nanos, which received up to 2,500 mm. The valleys in the hinterland of the plateaus due to their lee side received less precipitation – the least in the area surrounding Cerkno – more than 1,900 mm. Vipava Valley received between 1,700 and 2,000 mm, while Goriška brda received between 18,000 and 2,100 mm of precipitation. The lowest amount of precipitation in Posočje, less than 1,700 mm, was recorded between Podnanos and Vipava in the upper Vipava Valley. The higher amount of precipitation did not contribute significantly to the runoff from the river basin. Almost the entire area of Posočje is located in Slovenia. The exceptions are the headwaters of the Učja, Nadiža and partly Idrija rivers, which contributed 8.6 m^3/s to Slovenia. For the most part, the water of the Slovenian Posočje runs off through the Soča, Vipava and Nadiža rivers, and some also through the Idrija, Reka (in Goriška brda) and Koren rivers. The total runoff was 138 m^3/s. In 2008, the balance evaporation in Posočje was 83.3 m^3/s, while the net runoff amounted to 129.4 m^3/s.

The basin of other Adriatic rivers encompasses 1,530 km^2, with the Reka River as the largest watercourse. In 2008, the precipitation level was slightly higher compared to the multi-annual average. It amounted to 1,790 mm (in the 1971-2000 period: 1,619 mm) equalling slightly less than 64.7 m^3/s. The lowest precipitation level, between 1,250 and 1,300 mm, was recorded in

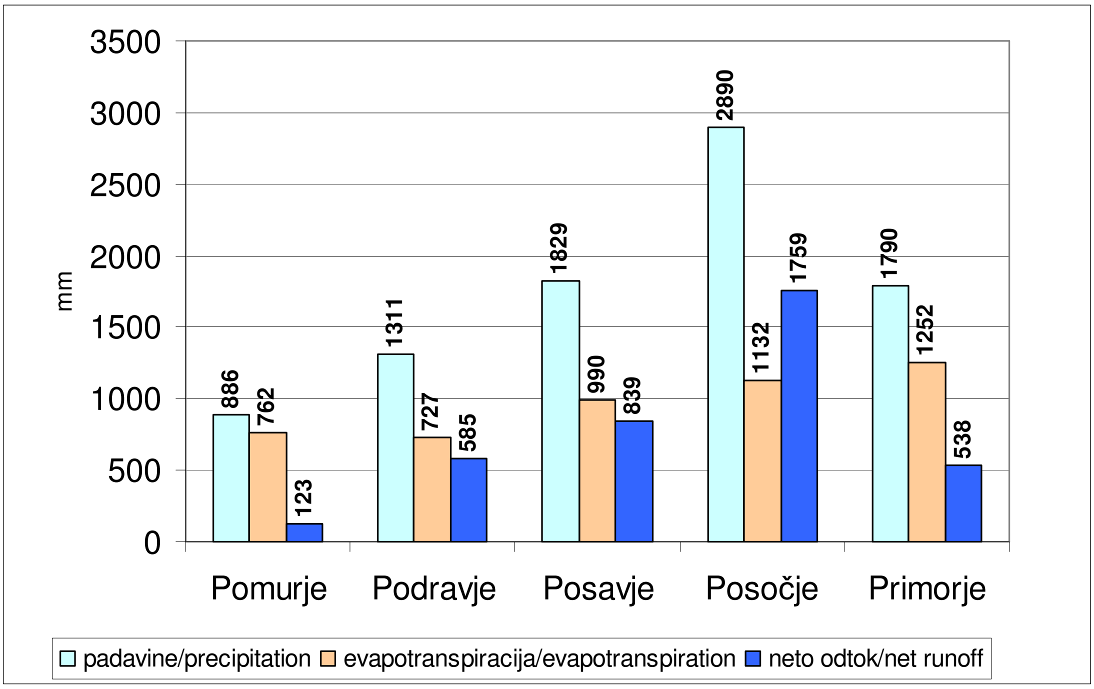
V slovenskem delu **jadranskega povodja** je v letu 2008 padlo znatno več padavin kot v dolgoletnem obdobju. V tem letu je bila količina padavin 2453 mm, obdobno povprečje pa je 2081 mm. Izhlapevanja je bilo po letnem vodnobilančnem izračunu kar 1179 mm, kar je 60 % več kot v obdobju 1971–2000. V letu 2008 je bil povprečni odtok v Jadran 156 m^3/s (1274 mm), medtem ko je dolgoletni povprečni odtok več kot 164 m^3/s (1346 mm). Odtok v letu 2008 je bil od povprečja manjši predvsem zaradi zelo povečanega izhlapevanja.

Leta 2008 je bilo v **Sloveniji** v primerjavi z referenčnim obdobjem 1971–2000 padavin za 14 % več, izhlapevanja je bilo več za 35 %, odtok pa je bil manjši za 4 %. V Podonavju je bilo tega leta 13 %, v jadranskem povodju pa 18 % več padavin. Glede na izmerjene odtoke se je tega leta povečalo zlasti izhlapevanje, v Podonavju za 29 % v jadranskem povodju pa kar za 60 % v primerjavi z obdobnim povprečjem 1971–2000. Odtoki so bili nekaj odstotkov pod dolgoletnim povprečjem.

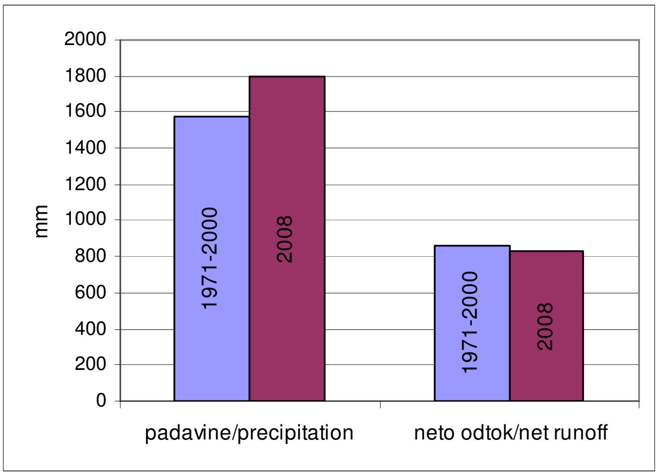
the Koper littoral in the hinterland of Koper and in the surrounding area of the Sečovlje salines. In other areas in the Koper Hills between 1,400 and 1,600 mm of precipitation was recorded, increasing towards the east and north. The Slavnik Mountains received up to 2,200 mm, Brkini around 1,700 mm and Snežnik up to 3,100 mm of precipitation. The precipitation level in the Reka and the Košana valleys was around 1,700 mm and up to 2,000 mm on the Vremščica Mountain. The Karst plateau received 1,700 mm of precipitation on the east side and 2,150 mm on the west side. Running waters enter Slovenia through the headwaters of the Rižana, Reka and Dragonja rivers. In total, 0.9 m^3/s of water entered Slovenia. There are several outflows: besides the waters from most parts of the Karst area (with underground runoff) and the coast, the Osap River also flows into Italy while Croatia receives water from the headwaters of the Mirna river basin. In 2008, the total runoff was 27.3 m^3/s, the net runoff amounted to 26.1 m^3/s and the evaporation calculated using the balance method was 60.7 m^3/s.

Preglednica 1: Člení vodne bilance leta 2008 glavnih porečjih Slovenije v mm
Table 1: Water balance elements in 2008 of the main river basins in Slovenia in mm

(mm)	Pomurje	Podravje	Posavje	Posočje	Primorje
padavine / precipitation	886	1311	1829	2890	1790
izhlapevanje / evapotranspiration	762	727	990	1132	1252
neto odtok / net runoff	123	585	839	1759	538
odtočni količnik / runoff coeficient	0,14	0,45	0,46	0,61	0,30



Slika 1: Člení vodne bilance leta 2008 po glavnih porečjih Slovenije v mm
Figure 1: Water balance elements in 2008 of the main river basins in Slovenia in mm



Slika 2: Padavine v Sloveniji in odtok z ozemlja Slovenije v referenčnem obdobju 1971–2000 ter v letu 2008 v mm
Figure 2: Precipitation in Slovenia and the runoff from the Slovenian territory in the 1971-2000 reference period and in 2008 in mm

Odtok, kot del vodne bilance, se začne na izviru. Izvir Save Dolinke v Zelencih. (foto: Peter Frantar)
Runoff, a water balance part, begins at spring. The Sava Dolinka spring in Zelenci. (photo: Peter Frantar)

Comparison with the reference period water balance

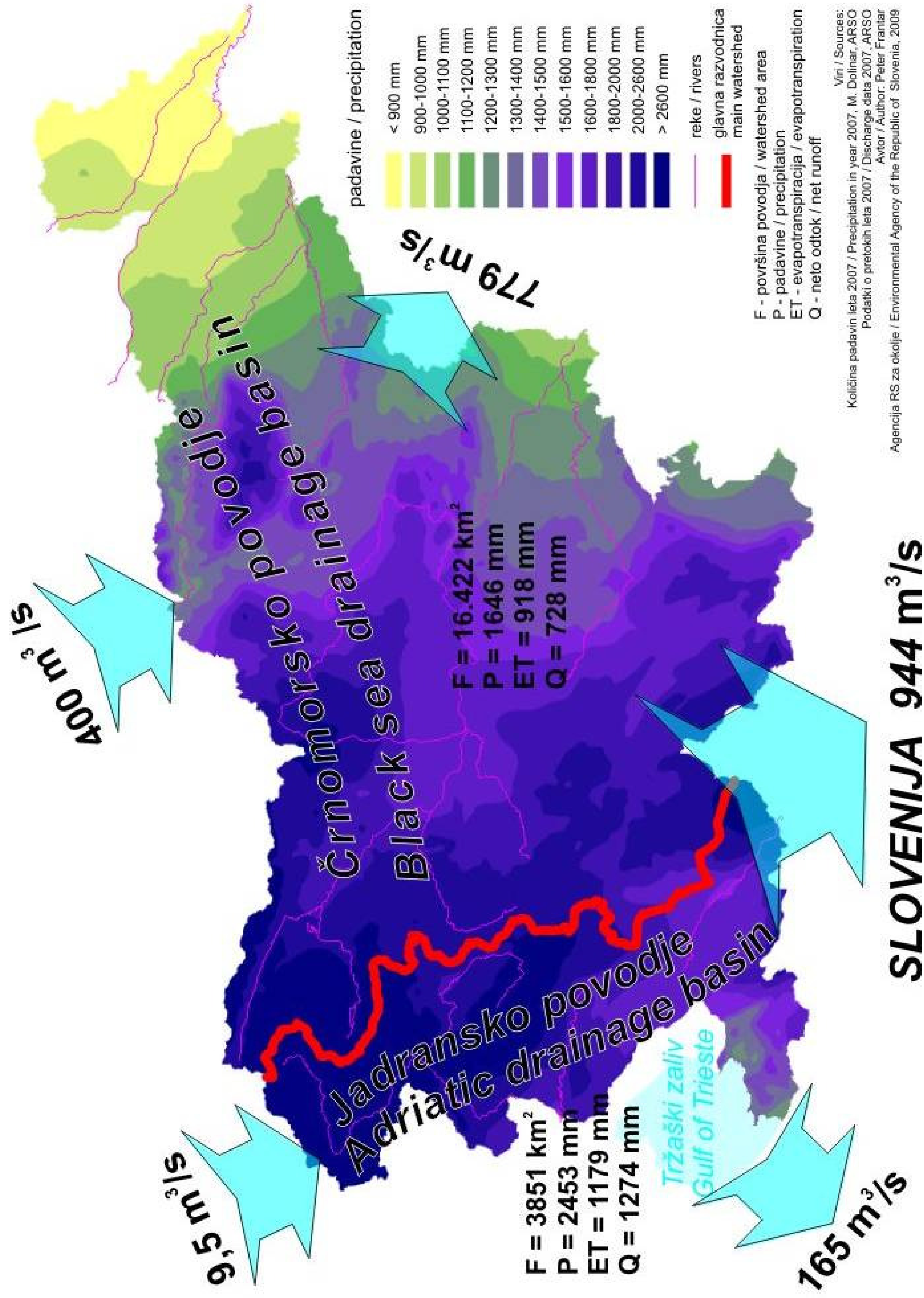
All elements of the 2008 water balance for the Black Sea and Adriatic Sea basins were compared to the water balance of the 1971-2000 reference period (Water Balance of Slovenia, 1971-2000). In the Slovenian part of the **Black Sea basin**, there was more precipitation in 2008 than the reference period average. Between 1971 and 2000, the average precipitation amount was 1,462 mm, while the amount in 2008 was 1,646 mm. In 2008, balance evaporation amounted to 918 mm of water compared to 713 mm in the 1971-2000 period. The Slovenian territory contributed 390 m3/s or 749 mm of water in the Black Sea basin in the 1971-2000 reference period, while in 2008 this amount was lower: 379 m3/s or 728 mm.

In the Slovenian part of the **Adriatic Sea basin** there was considerably more precipitation in 2008 than in the multi-annual reference period. The quantity of precipitation amounted to 2,453 mm compared to the periodical average of 2,081 mm. According to the annual water balance calculation, evaporation amounted to 1,179 mm, which is 60% more than in the 1971-2000 period. The average runoff into the Adriatic Sea in 2008 was 156 m3/s (1,274 mm), while the multi-annual average runoff exceeded 164 m3/s (1,346 mm). The runoff in 2008 was lower than the average mainly due to the greatly increased evaporation.

In comparison with the 1971-2000 reference period, **Slovenia** recorded 14% more precipitation in 2008, a 35% increase in evaporation and a 4% drop in runoff. In Podonavje (the Danube river basin) and in the Adriatic Sea basin there was 13% and 18% more precipitation, respectively. With regard to the recorded runoffs mainly evaporation increased this year, in Podonavje by 29% and in the Adriatic Sea basin by no less than 60% compared to the periodical average in the 1971-2000 period. The runoffs were a few percentage points below the multi-annual average.

Preglednica 2: Primerjava členov vodne bilance 2008 z dolgoletnim obdobjem 1971–2000
Table 2: Comparison of the water balance elements in 2008 with the 1971-2000 reference period

(mm)	Podonavje		Jadran		Slovenija	
	1971-2000	2008	1971-2000	2008	1971-2000	2008
padavine / precipitation	1462	1646	2081	2453	1579	1799
izhlapevanje / evapotranspiration	713	918	735	1179	717	968
neto odtok / net runoff	749	728	1346	1274	862	832
odtočni količnik	0,51	0,44	0,65	0,52	0,55	0,46



Slika 3: Vodnobilančni členi po povodjih v Sloveniji leta 2008
Figure 3: Water balance elements by river basins in Slovenia in 2008