I. del: PREGLED HIDROLOŠKIH RAZMER V LETU 2004

Part I: A REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2004

A. POVRŠINSKE VODE

A. SURFACE WATERS

VODOSTAJI IN PRETOKI REK

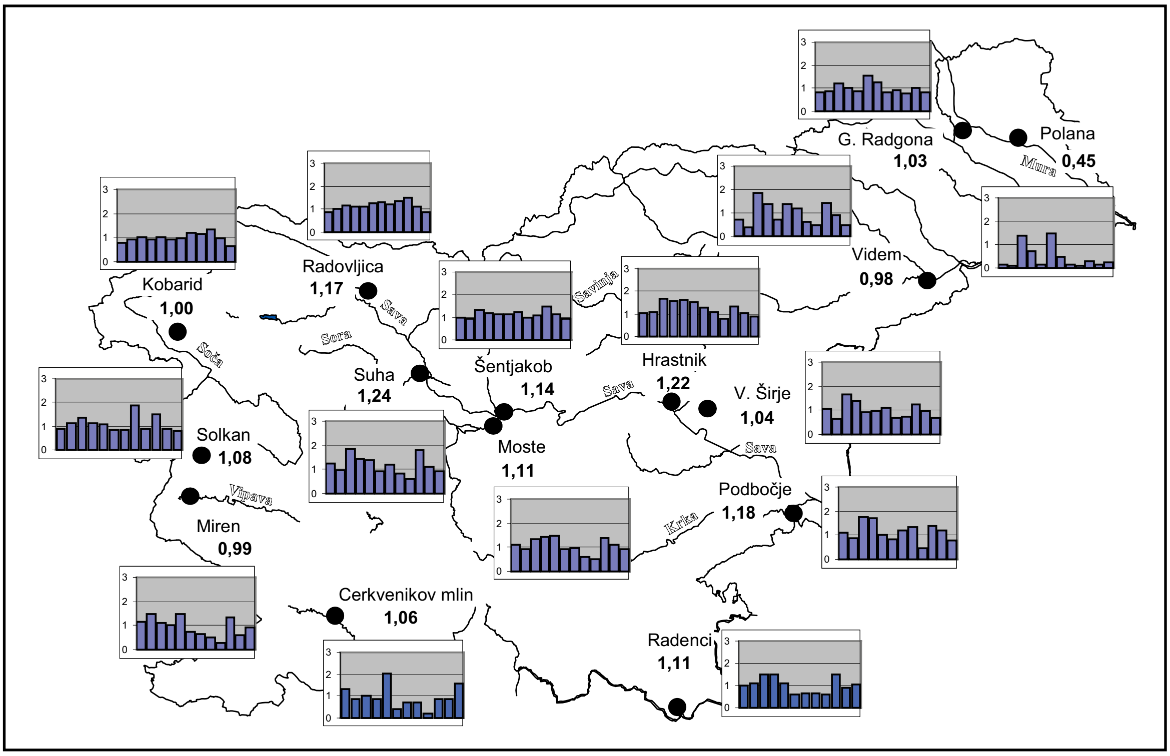
Igor Strojan

RIVER STAGES AND DISCHARGES

Igor Strojan

Pretoki so bili leta 2004 v celoti nekoliko večji kot v primerjalnem obdobju 1971-2000. Na Savi, Ljubljanici, Sori, Krki in Kolpi so bili v povprečju okoli 15 odstotkov večji od dolgoletnih povprečij, v ostalih povodjih pa so od njih odstopali le nekaj odstotkov. Izjema je povodje Ledave, kjer so bili pretoki leta 2004 več kot polovico manjši kot v dolgoletnem obdobju (karta 1).

The discharges in 2004 were slightly higher in total than in the 1971-2000 reference period. On the Sava, Ljubljanica, Sora, Krka and Kolpa Rivers, these were around 15 percent higher on average than the multi-annual means, while in the other river catchment areas they deviated by only a few percent from the multi-annual means. The exception was the Ledava River catchment basin, where the discharges in 2004 were lower by more than a half compared to the multi-annual reference period (Map 1).

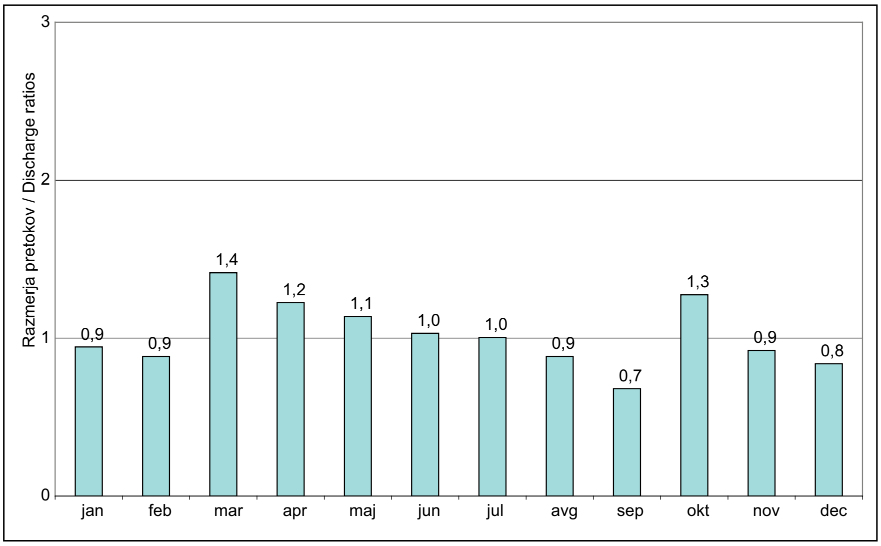


Karta 1: Razmerja med srednjimi letnimi pretoki leta 2004 in obdobja 1971-2000 ter grafični prikazi razmerij med srednjimi mesečnimi pretoki leta 2004 in obdobja 1971-2000. Razmerje 1 pomeni, da je bil pretok leta 2004 enak povprečju dolgoletnega obdobja.

Map 1: The ratios between the mean annual discharges in 2004 and the 1971-2000 period, as well as graphic representations of the ratios between the mean monthly discharges in 2004 and the 1971-2000 period. A ratio value of 1 means that the discharge in 2004 was the same as the multi-annual mean.

Vodnatost je bila marca, aprila in maja ter oktobra večja kot navadno. Septembra je bila vodnatost rek 30 odstotkov manjša kot v dolgoletnem primerjalnem obdobju (graf 1).

The water discharges in March, April, May and October were greater than usual. The river discharges in September were lower by 30% than in the multi-annual reference period (Graph 1).



Graf 1: Razmerja med srednjimi mesečnimi pretoki v letu 2004 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah (glej karto1).
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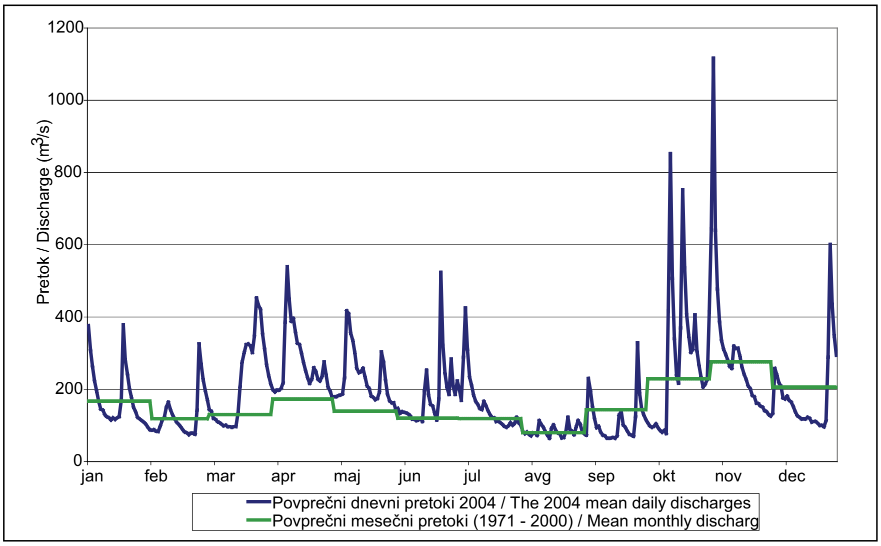
Graph 1: The ratios between the mean monthly discharges in 2004 and the multi-annual mean monthly discharges. The ratios are calculated as average values of the ratios at selected stations (see Map 1).



Graf 2: Srednji dnevni pretoki v letu 2004 in srednji mesečni pretoki v obdobju 1961 - 2000 na reki Savi v Hrastniku.

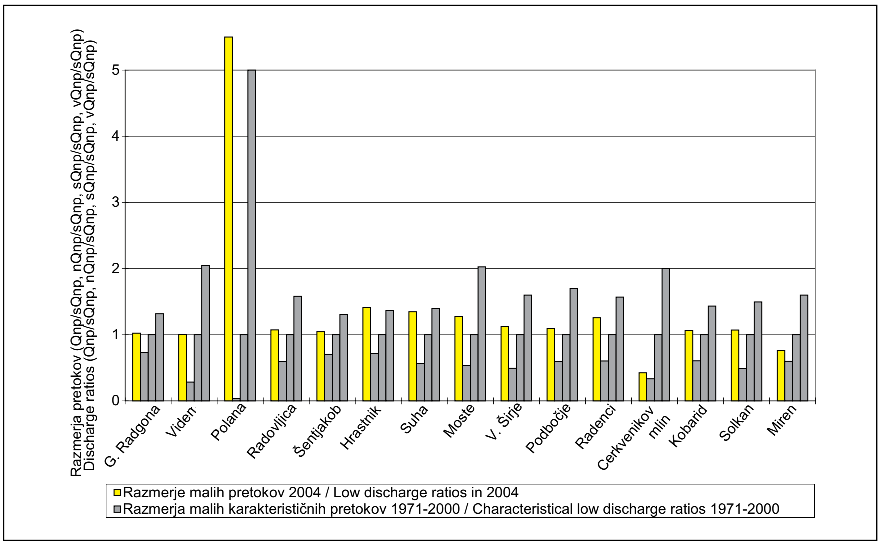
Graph 2: The mean daily discharges in 2004 and the mean monthly discharges in the 1961-2000 period on the Sava River at Hrastnik.

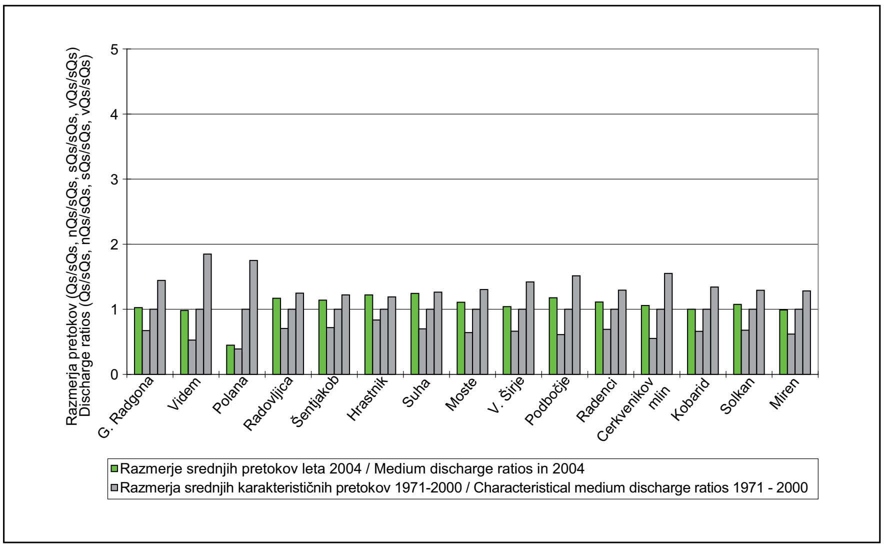
Visokovodne letne konice so bile le na nekaterih rekah nekoliko večje kot navadno (graf 3 in preglednica 8). Največji pretoki rek, pri katerih so reke poplavljale, večinoma niso presegli 2- do 5-letne povratne dobe. V širšem območju so reke poplavljale oktobra, v pomladanskih mesecih so poplavljali hudourniki.

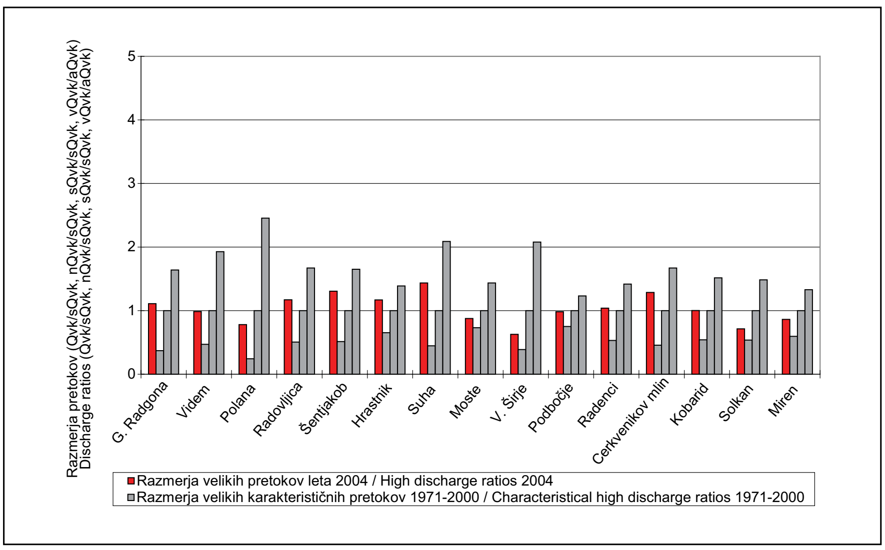
Po treh predhodnih izrazito sušnih letih, izrazitih in daljših hidrološko sušnih obdobij leta 2004 ni bilo. Najmanjši pretoki so bili bistveno manjši od obdobnih le na Reki in Vipavi. Pretoki so bili najmanjši februarja, avgusta in septembra (graf 3 in preglednica 8). Podrobneje so visokovodne in sušne razmere v letu 2004 opisane v posebnih poglavjih te publikacije.

The high-water annual peaks were slightly higher than usual on only some rivers (Graph 3 and Table 8). The highest river discharges, at which rivers flooded, did not generally exceed the 2- to 5-year return periods. There were extensive river floods in October, while torrents flooded in the spring months.

After three years of distinctive drought, there were no prominent and extended hydrological drought periods in 2004. The minimum discharges were significantly only lower than the multi-annual mean discharges on the Reka and Vipava Rivers. Discharges were the lowest in February, August and September (Graph 3 and Table 8). The high-water and drought conditions in 2004 are described in detail in the special chapters of this publication.







Graf 3: Razmerja malih, srednjih in velikih pretokov v letu 2004 ter razmerja karakterističnih pretokov obdobja 1971-2000. Vrednosti so podane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.

Graph 3: The ratios of low, mean and high discharges in 2004 and the ratios of the characteristic discharges in the 1971-2000 reference period. The values are given in relation to the mean values of the all-time low, mean and high discharges.

Preglednica 8: Značilni pretoki v letu 2004 in obdobju 1971-2000.

Table 8: Characteristic discharges in 2004 and in the 1971-2000 reference period.

Vodotok Stream	Vodomerna postaja Gauging station	2004		1971-2000		
		Qnp m³/s	DD dan	nQnp m³/s	sQnp m³/s	vQnp m³/s
MURA	G. RADGONA	63.6	1.2.	45.3	62.1	81.7
DRAVINJA	VIDEM	2.1	20.8.	0.6	2.1	4.3
LEDAVA	POLANA	0.6	27.9.	0.004	0.1	0.5
SAVA	RADOVLJICA	9.0	18.2.	5.0	8.4	13.3
SAVA	ŠENTJAKOB	28.3	19.2.	19.1	27.1	35.3
SAVA	HRASTNIK	64.3	13.8.	32.8	45.6	62.2
SORA	SUHA	5.1	19.8.	2.14	3.8	5.3
LJUBLJANICA	MOSTE	9.8	23.9.	4.1	7.7	15.6
SAVINJA	V. ŠIRJE	10.7	20.8.	4.7	9.5	15.2
KRKA	PODBOČJE	11.4	20.9.	6.2	10.4	17.7
KOLPA	RADENCI	7.3	13.8.	3.5	5.8	9.1
REKA	CERKVENIKOV MLIN	0.3	8.9.	0.2	0.6	1.2
SOČA	KOBARID	8.1	3.2.	4.6	7.6	10.9
SOČA	SOLKAN	21.0	17.2.	9.6	19.6	29.3
VIPAVA	MIREN	1.5	14.9.	1.2	2	3.2
Vodotok Stream	Vodomerna postaja Gauging station	Qsr m3/s		nQsr m3/s	sQsr m3/s	vQsr m3/s
MURA	G. RADGONA	157.0		103	153	221
DRAVINJA	VIDEM	11.0		5.9	11.2	20.7
LEDAVA	POLANA	0.5		0.47	1.2	2.1
SAVA	RADOVLJICA	50.4		30.4	43.1	53.8
SAVA	ŠENTJAKOB	97.1		61.2	85.1	104
SAVA	HRASTNIK	193.0		132	158	188
SORA	SUHA	24.0		13.5	19.3	24.4
LJUBLJANICA	MOSTE	61.6		35.7	55.6	72.5
SAVINJA	V. ŠIRJE	45.8		29.2	44	62.5
KRKA	PODBOČJE	61.1		31.7	51.9	78.6
KOLPA	RADENCI	56.4		35.1	50.7	65.6
REKA	CERKVENIKOV MLIN	8.3		4.3	7.8	12.1
SOČA	KOBARID	33.1		21.9	33.1	44.4
SOČA	SOLKAN	96.6		60.9	89.8	116
VIPAVA	MIREN	17.1		10.7	17.3	22.2
Vodotok Stream	Vodomerna postaja Gauging station	Qvk m3/s	DD dan	nQvk m3/s	sQvk m3/s	vQvk m3/s
MURA	G. RADGONA	815	21.6.	273	735	1205
DRAVINJA	VIDEM	149	25.3.	71.1	151	291
LEDAVA	POLANA	26	24.3.	8	32.8	80.5
SAVA	RADOVLJICA	481.0	31.10.	208	411	687
SAVA	ŠENTJAKOB	1124.0	1.11.	442	861	1422
SAVA	HRASTNIK	1404.0	1.11.	786	1202	1668
SORA	SUHA	472.0	31.10.	147	329	687
LJUBLJANICA	MOSTE	247	11.10.	206	282	405
SAVINJA	V. ŠIRJE	450	17.10.	278	717	1490
KRKA	PODBOČJE	284.0	18.10.	217	289	356
KOLPA	RADENCI	695.0	31.10.	355	669	949
REKA	CERKVENIKOV MLIN	235.0	27.10.	83.3	182.6	305
SOČA	KOBARID	439.0	31.10.	237	438	664
SOČA	SOLKAN	993.0	1.11.	747	1391	2066
VIPAVA	MIREN	207.0	24.2.	143	240	319

Qnp .... najmanjši pretok v letu - dnevno povprečje
nQnp... najmanjši mali pretok v obdobju
sQnp... srednji mali pretok v obdobju
vQnp... največji mali pretok v obdobju
Qs....... srednji pretok v letu - dnevno povprečje
nQs..... najmanjši srednji pretok v obdobju
sQs..... srednji pretok v obdobju
vQs..... največji srednji pretok v obdobju
Qvk..... največji pretok v letu – konica
nQvk... najmanjši veliki pretok v obdobju
sQvk... srednje veliki pretok v obdobju
vQvk... največji veliki pretok v obdobju

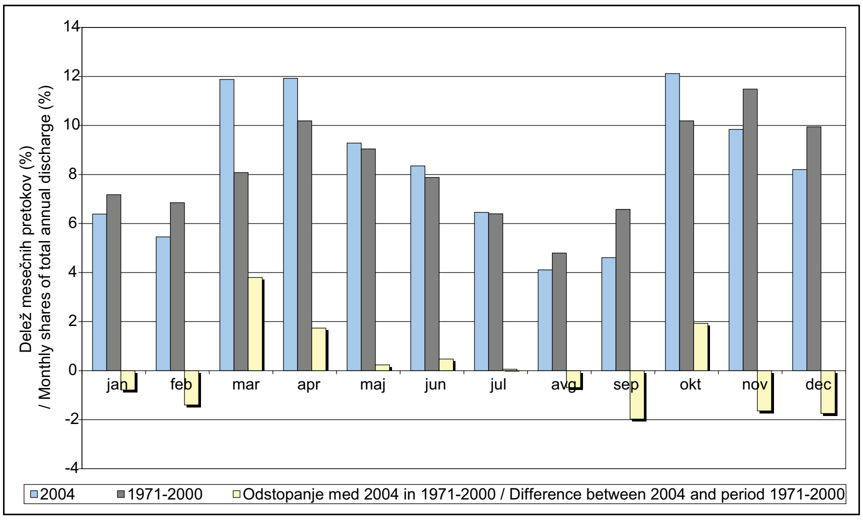
Mesečni deleži letnih pretokov in pretočni režimi na izbranih merilnih mestih

Mesečni deleži pretokov so glede na celoletno količino v celoti najbolj odstopali od ustaljenih pretočnih režimov marca, aprila in oktobra, ko so bili deleži od dva do štiri odstotke večji ter septembra, novembra in decembra, ko so bili deleži dva odstotka manjši kot v dolgoletnem primerjalnem obdobju (graf 4).

Qnp...... the minimum discharge in the year – daily average
sQs..... the mean discharge in the period
nQnp... the minimum low discharge in the period
vQs..... the maximum mean discharge in the period
sQnp... the mean low discharge in the period
Qvk..... the maximum discharge in the year – peak
vQnp... the maximum low discharge in the period
nQvk... the minimum high discharge in the period
Qs....... the mean discharge in the year – daily average
sQvk... the mean high discharge in the period
nQs..... the minimum mean discharge in the period
vQvk... the maximum high discharge in the period

The Monthly Shares of the Annual Discharges and the Discharge Regimes at Selected Gauging Sites

In total, the monthly shares of discharges deviated the most in respect of the annual quantity from the normal discharge regimes in March, April and October when the shares were from two to four percent higher and in September, November and December when the shares were two percent lower than in the multi-annual reference period (Graph 4).

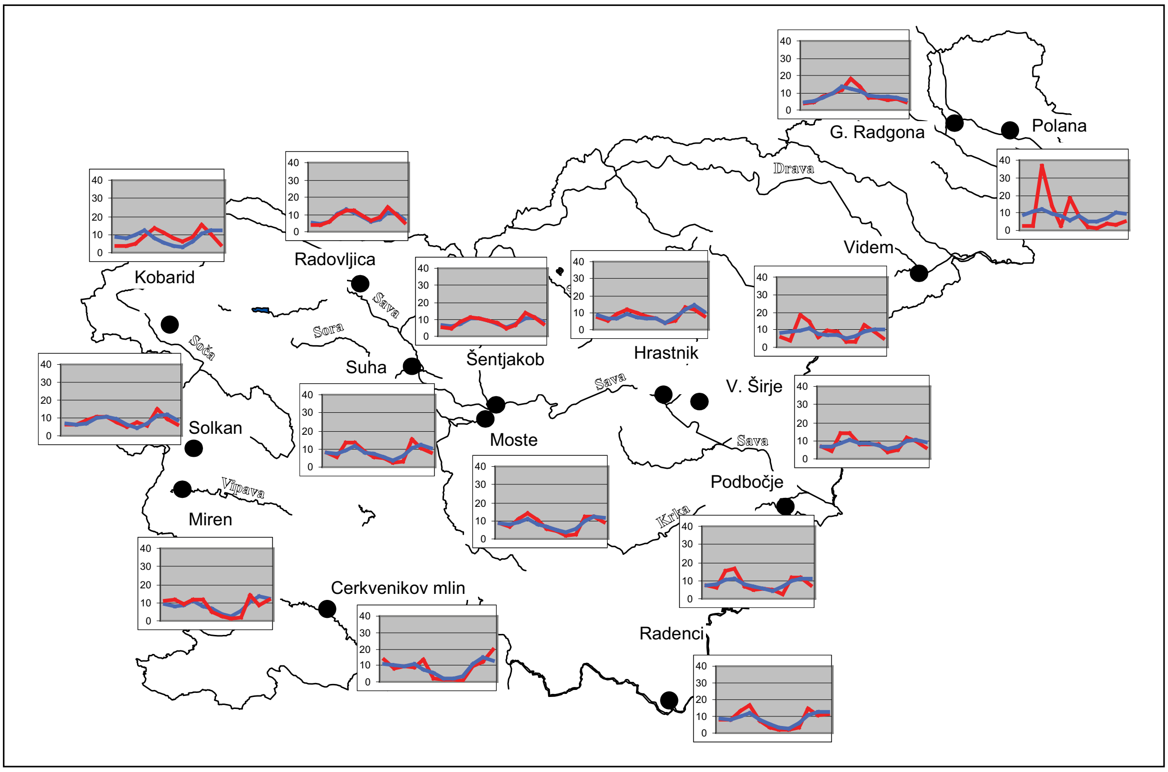


Graf 4: Mesečni deleži letnih pretokov v odstotkih v letu 2004 in obdobju 1971-2000. Na grafu je podano tudi odstopanje mesečnih deležev pretokov v letu 2004 od mesečnih deležev v obdobju 1971-2000.

Graph 4: The monthly shares of the annual discharges in percentages in 2004 and in the 1971-2000 reference period. The graph also indicates the deviation of the monthly shares of discharges in 2004 from the monthly shares in the 1971-2000 reference period.

Odstopanja od ustaljenih režimov rek so bila večja v vzhodnem in osrednjem delu države, kjer je najbolj izrazito odstopanje spomladanskih povečanih deležev pretokov, manjša pa v severnem in zahodnem delu, kjer je opazno povečanje deležev v oktobru. Pretočni režim v letu 2004 je najmanj odstopal od ustaljenega (obdobje 1971-2000) v zgornjem toku Save. Manjši vodotoki v severovzhodnem delu države (v.p. Polana na Ledavi) izkazujejo veliko spremembo spomladanskih deležev pri sicer relativno majhnih pretokih.

Deviations from the normal river regimes were greater in the eastern and central parts of the country, where the most pronounced deviation was that of the springtime increase in the shares of discharges. The deviations were lower in the northern and western areas, where the increase of shares in October was noticeable. The discharge regime in 2004 deviated the least from the normal discharge regime (the 1971-2000 reference period) in the headwaters of the Sava River. Smaller watercourses in the northeastern part of the country (Polana na Ledavi hydrometric station) were exhibiting considerable changes in the springtime shares in otherwise relatively low discharges.



Karta 2: Delež mesečnih pretokov v letu 2004 (rdeče linije) in v obdobju 1971-2000 (modra linija) kot ponazoritev odstopanj od ustaljenih režimov pretokov rek na izbranih reprezentativnih lokacijah v letu 2004.

Map 2: The share of monthly discharges in 2004 (red lines) and in the 1971-2000 reference period (blue line) to illustrate the deviation from the normal river discharge regimes at the selected representative locations in 2004.

Časovni pregled hidroloških razmer na rekah po mesecih

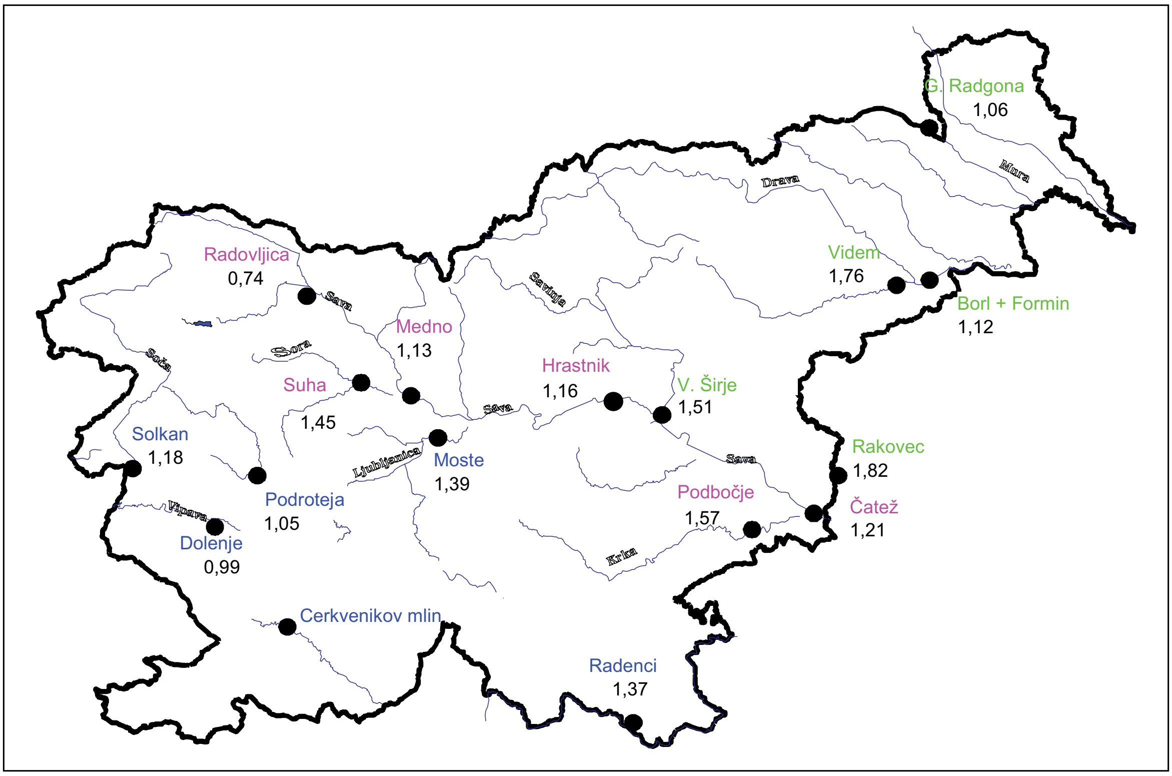
Januarja in februarja so bili pretoki nekoliko manjši kot navadno. Manj vode kot običajno je preteklo predvsem v severovzhodni Sloveniji.

Marec, april in maj so bili hidrološko mokri meseci. Marca so bili pretoki v povprečju obravnavanih rek štirideset odstotkov večji kot v primerjalnem dolgoletnem obdobju (graf 1). V prvi polovici marca so bili pretoki rek majhni in so se postopoma zmanjševali. Daljše deževno obdobje v drugi polovici meseca je povečalo pretoke do srednjih in ponekod velikih vrednosti. Poplavljali so hudourniki. Srednji mesečni pretoki rek so bili polovico večji kot v dolgoletnem primerjalnem obdobju na Dravinji v Vidmu, Sotli v Rakovcu, Krki v Podbočju in Savinji v Velikem Širju. Srednji mesečni pretok na Savi v Radovljici je bil 26 odstotkov manjši kot navadno v marcu (karta 3) .

Timeline of the Hydrological Conditions on Rivers by Month

In January and February, the discharges were somewhat lower than usual. There was less water than usual running off primarily in northeastern Slovenia.

March, April and May were hydrologically wet months. In March, the discharges of the rivers monitored were forty percent higher on average than in the multi-annual reference period (Graph 1). In the first half of March, the river discharges were low and decreased gradually. A longer period of rain in the second half of the month increased the discharges up to the mean and somewhere even up to high values. There were torrential floods. The mean monthly river discharges were higher by a half than in the multi-annual reference period on the Dravinja River at Videm, the Sotla at Rakovec, the Krka at Podbočje and the Savinja at Veliko Širje. The mean monthly discharge on the Sava River at Radovljica was 26 percent lower than usual for the month of March (Map 3).

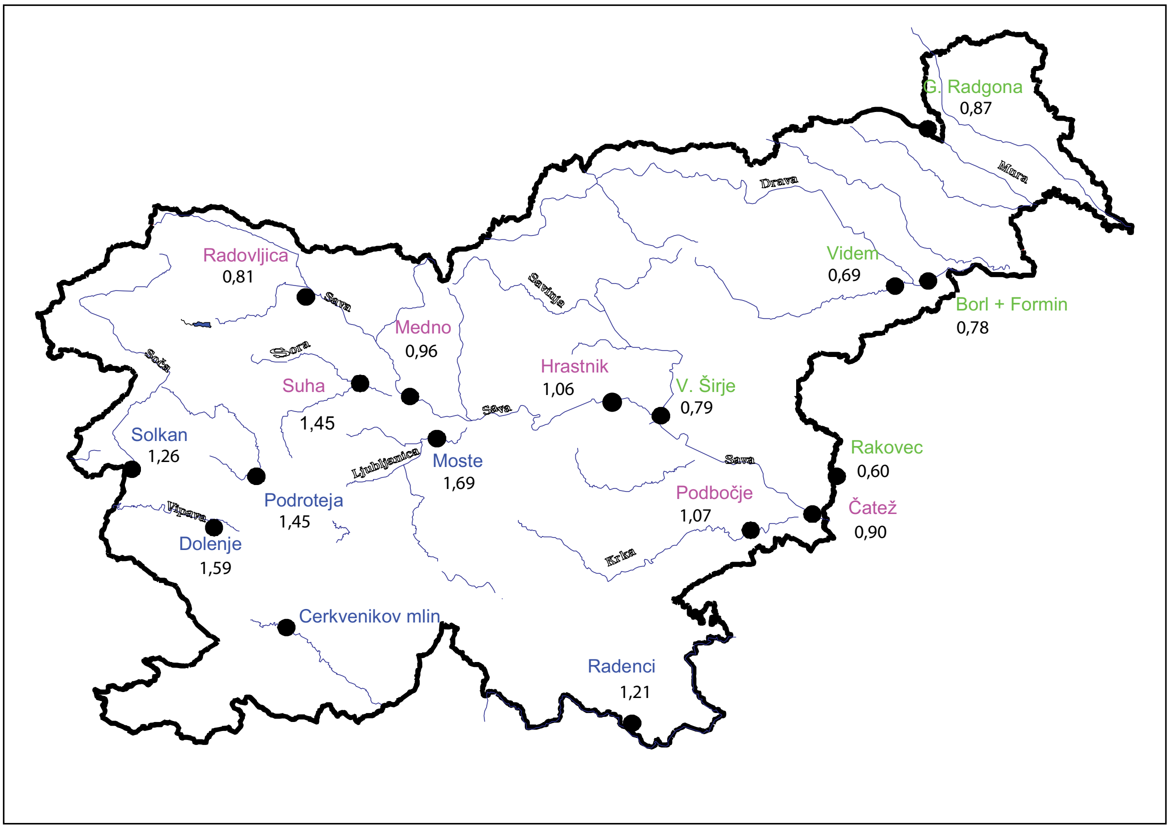


Karta 3: Razmerja med srednjimi pretoki marca 2004 in povprečnimi srednjimi marčevskimi pretoki v dolgoletnem obdobju na slovenskih rekah.

Map 3: The ratios between the mean discharges in March 2004 and the average mean March discharges in the multi-annual reference period on Slovenian rivers.

V prvih dneh aprila so bili pretoki rek srednji, v naslednjih dneh so se povečali do velikih vrednosti. Visokovodne konice so bile najvišje na Sotli, Krki, Kolpi ter Savinji in Dravinji, kjer so nekoliko presegle dolgoletno povprečje. V južni in osrednji Sloveniji je bila vodnatost rek velika vse do sredine aprila, ko so se pretoki zmanjšali do srednjih in ob koncu meseca do malih pretokov. Pretoki v maju so bili v celoti le nekoliko večji od dolgoletnih povprečij. Prostorska porazdelitev pretokov je bila dokaj izrazita. Pretoki so bili večji kot navadno v jugozahodni in južni, manjši pa v severni in severovzhodni Sloveniji (karta 4).

In the first days of April, the river discharges exhibited mean values, but increased to high values in the subsequent days. The high-water peaks were the highest on the Sotla, Krka, Kolpa, Savinja and Dravinja where they even somewhat exceeded the multi-annual mean. In southern and central Slovenia, the water discharges of rivers were high until the middle of April, when the discharges diminished down to the mean values and then to the low values at the end of the month. Discharges in May were only slightly higher than the multi-annual mean in total. The spatial distribution of discharges was rather pronounced. Discharges were higher than usual in southwestern and southern Slovenia and lower in northern and northeastern Slovenia (Map 4).



Karta 4: Razmerja med srednjimi pretoki maja 2004 in povprečnimi srednjimi majskimi pretoki v dolgoletnem obdobju na slovenskih rekah.

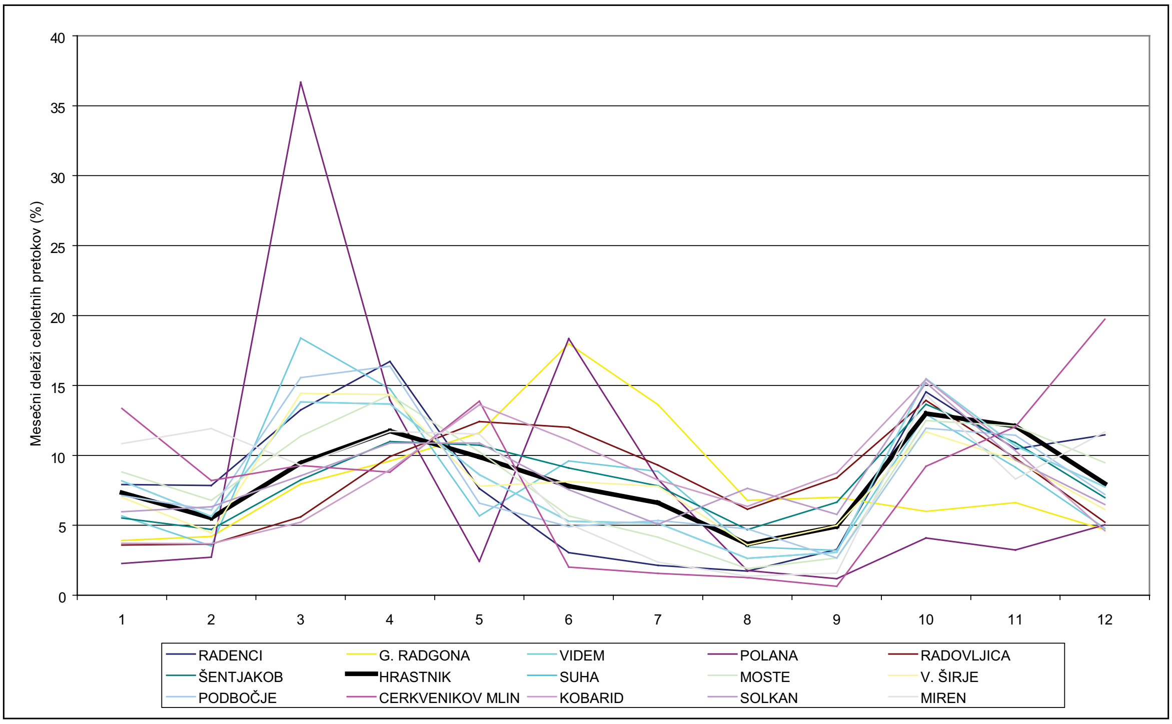
Map 4: The ratios between the mean discharges in May of 2004 and the average mean May discharges in the multi-annual reference period on Slovenian rivers.

Junija in julija so bile razmere na slovenskih rekah podobne povprečnim dolgoletnim hidrološkim razmeram. Podobno kot v maju so bili tudi v juniju pretoki porazdeljeni dokaj neenakomerno. V celoti so bili okoli deset odstotkov manjši kot navadno. Največ vode je preteklo po Muri in Dravi, najmanj pa po Kolpi in Sotli. V zadnjih dveh dekadah meseca so pretoke povečevale večinoma kratkotrajne in intenzivnejše padavine. Julija je bila vodnatost rek, za razliko od julijev zadnjih nekaj let, ko so bili to hidrološko izrazito suhi meseci, povsem običajna. Omenjeno vodnatost v juliju je potrebno pripisati dokaj visoki vodnatosti v začetku meseca, saj so se sicer pretoki večji del julija zmanjševali. Pretoki so bili tokrat prostorsko dokaj enakomerno razporejeni. Nekaj manj vode kot v ostalih predelih je preteklo po rekah v zahodnem in južnem delu države.

Avgust je bil hidrološko suh mesec. Vodnatost rek je bila tretjino manjša kot navadno. Pretoki so bili nekoliko večji v zgornjem toku Save ter na Krki. Male pretoke rek so občasno povečevale manjše količine padavin, ki so preprečevale zmanjšanje pretokov do izredno majhnih vrednosti. Najmanjši pretoki rek so bili avgusta nekaj več kot dvajset odstotkov manjši kot v primerjalnem obdobju.

In June and July, the conditions on the Slovenian rivers were similar to the average multi-annual hydrological conditions. Similarly to May, the discharges in June were also distributed rather unevenly. On the whole, they were around ten percent lower than usual. The most water flowed through the Mura and Drava Rivers and the least through the Kolpa and Sotla Rivers. In the last two thirds of the month, the discharges were increased predominantly by the short but intensive precipitation. In July, the abundance of river water discharges was quite ordinary, as opposed to the past few Julys, which were pronounced dry months hydrologically. This abundance of river water discharges in July should be attributed to the rather high discharges at the beginning of the month as the discharges otherwise decreased for the major part of July. The discharges at this time were fairly evenly distributed spatially. Somewhat less water flowed through the rivers in the western and southern parts of the country than in other parts.

August was a hydrologically dry month. The abundance in river water discharges was by a third lower than usual. Discharges were slightly higher in the upstream part of the Sava River and on Krka. Low river discharges were occasionally boosted by lower quantities of precipitation, which prevented the reduction of watercourses to extremely low values. The lowest river discharges in August were slightly more than twenty percent lower than in the reference period.



Graf 5: Srednji dnevni pretoki nekaterih slovenskih rek v avgustu 2004. Značilni so pogosti manjši porasti pretokov rek.

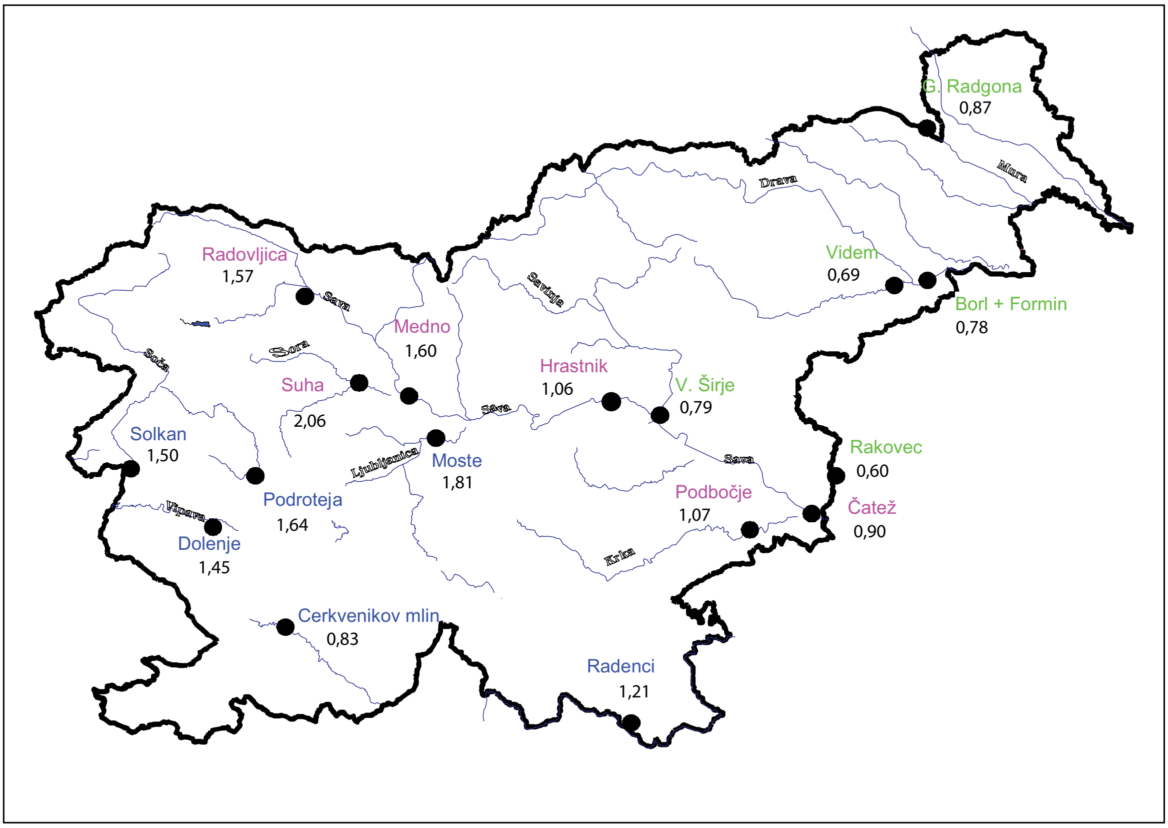
Graph 5: The mean daily discharges of some Slovenian rivers in August of 2004. Frequent smaller increases in river discharges are characteristic.

Primanjkljaj iz avgusta se je nadaljeval v september. Zopet je bila vodnatost rek v povprečju tretjino manjša kot navadno. Pretoki so bili nekoliko večji v zgornjem toku Save, na Soči, Muri in Dravi. V večjem delu države so se pretoki zmanjševali vse do sredine meseca, ko so jih padavine povečale od malih do srednjih vrednosti. V naslednjih dneh so se pretoki zmanjševali ter 25. septembra ponovno, tokrat nekoliko izraziteje, povečali.

Po hidrološko suhem avgustu in septembru, ko je bila vodnatost rek tretjino manjša kot navadno, je bil oktober hidrološko izrazito moker. V povprečju so bili v oktobru pretoki 61 odstotkov večji kot v dolgoletnem primerjalnem obdobju. Oktobra so se pretoki močneje povečali v štirih zaporednih obdobjih, ki so bila prekinjena s šest do sedem dnevnimi cikli. Visokovodne konice so bile v povprečju 45 odstotkov višje kot navadno. Reke so poplavljale večinoma območja 2- do 5-letnih poplav, v osrednjem delu države (Sava Šentjakob, Sora Suha) tudi do desetletna.

The deficit in August continued into September. The abundance of river water discharges was again a third lower than usual on average. Discharges were somewhat higher in the upstream part of the Sava River as well as on the Soča, Mura and Drava Rivers. In the major part of the country, discharges decreased up until the middle of the month when precipitation increased them from low to the mean values. In the days that followed, discharges were decreasing and, on 25 September, again increased, with the increase being slightly more pronounced this time.

After the hydrologically dry August and September when the river discharge rates were lower than usual by a third, October was a markedly wet month hydrologically. On average, discharges in October were 61 percent higher than in the multi-annual reference period. In October, discharges increased more intensively in four consecutive periods, interrupted by six- to seven-day cycles. High-water peaks were 45 percent higher than usual on average. Rivers primarily flooded the flood plains that experience 2- to 5-year return period floods and, in the central part of the country (Sava Šentjakob and Sora Suha), flood plains with ten-year return period floods.



Karta 5: Razmerja med srednjimi pretoki oktobra 2004 in povprečnimi srednjimi oktobrskimi pretoki v dolgoletnem obdobju na slovenskih rekah.

Map 5: The ratios between the mean discharges in October 2004 and the average mean October discharges in the multi-annual reference period on Slovenian rivers.

Prvega novembra so bili pretoki rek veliki. Po visokovodnih konicah so se pretoki zmanjševali. Naslednje povečanje pretokov, ki je bilo manjše kot v začetku meseca, je bilo sredi novembra. Do konca meseca so se pretoki večinoma zmanjševali. Pretoki so bili novembra nekoliko večji v osrednji in jugovzhodni Sloveniji ter na Muri in Dravi. V zahodnem delu države so bili pretoki manjši kot navadno v tem času. Decembra so bili pretoki rek v povprečju 13 odstotkov manjši kot v dolgoletnem primerjalnem obdobju. V osrednjem in južnem delu države so bili povprečni mesečni pretoki večji in so presegali dolgoletna povprečja. Pretoki so bili večji del meseca mali, v zadnjih dneh pa so jih padavine povečale do velikih vrednosti. Reke v osrednjem in južnem delu države so poplavljale na območjih vsakoletnih poplav.

Podrobneje so hidrološke razmere na rekah v letu 2004 opisane v Mesečnih biltenih Agencije Republike Slovenije za okolje.

On the first of November, the river discharges were high. After the high-water peaks, the discharges diminished. The next increase in discharges, one that was lower than at the beginning of the month, occurred in the middle of November. The discharges had largely diminished by the end of the month. The discharges in November were slightly higher in central and southeastern Slovenia and on the Mura and Drava Rivers. In the western part of the country, the discharges were lower than usual for this time of year. The river discharges in December were 13 percent lower on average compared with the multi-annual reference period. In the central and southern parts of the country, the average monthly discharges were higher and exceeded the multi-annual reference period means. The discharges were low for the greater part of the month, but were increased to high values by the precipitation in the last days of the month. Rivers in the central and southern parts of the country flooded those floodplains characterised by annual flooding.

The 2004 hydrological conditions on the rivers are described in greater detail in the Monthly Bulletins of the Environmental Agency of the Republic of Slovenia.

TEMPERATURE REK IN JEZER

Barbara Vodenik

Leta 2004 je bilo povprečje srednjih letnih temperatur Mure, Ledave, Save, Kamniške Bistrice, Ljubljanice, Soče, Krke, Vipave, Dravinje in Savinje 10,0 °C, kar je za 0,1 °C manj kot v večletnem primerjalnem obdobju, povprečna temperatura Blejskega in Bohinjskega jezera pa je znašala 10,8 °C, kar je za 0,4 °C manj kot v primerjalnem obdobju. Odstopanje od večletnega primerjalnega obdobja je bilo opaziti v maju, juniju in juliju, ko je bila povprečna temperatura rek za 0,9 °C, povprečna temperatura jezer pa za 0,8°C nižja od dolgoletnega povprečja.

Časovno spreminjanje temperatur rek

Temperatura rečne vode na posameznih vodomernih postajah v letu 2004 ni kazala večje časovne spremenljivosti (graf 6). Temperaturna nihanja so bila med letom najbolj izrazita na Krki in Ledavi. Obe reki sta bili v poletnih mesecih v povprečju tudi najtoplejši. Najmanj izrazita pa so bila temperaturna nihanja zaradi bližine izvira na Kamniški Bistrici v Kamniku. Temperature rek se v prvih dveh mesecih v povprečju niso bistveno spreminjale. V marcu in naslednjih mesecih so temperature z manjšimi nihanji polagoma naraščale in dosegle najvišje vrednosti ob koncu julija oziroma v začetku avgusta. Nato so temperature z nekaj lokalnimi ekstremi vse do sredine decembra upadale. Savinja in Krka sta takrat dosegli tudi najnižji letni vrednosti, medtem ko so bile ostale reke z izjemo Ljubljanice najhladnejše v januarju.

Časovno spreminjanje temperatur jezer

Temperatura Blejskega jezera je bila v prvih dveh mesecih skoraj nespremenljiva, pri Bohinjskem pa je bila sredi januarja nagla ohladitev na 0 °C, ki je trajala do sredine marca. Obe jezeri sta se začeli postopoma segrevati v drugi polovici marca in sta dosegli najvišje letne vrednosti v začetku avgusta. Nato se je temperatura postopno zniževala do konca leta. Najnižja letna vrednost Blejskega jezera je bila izmerjena konec februarja in sicer 3,0 °C, Bohinjskega jezera pa v drugi polovici januarja in sicer 0 °C. Bohinjsko jezero je bilo vse leto hladnejše od Blejskega in sicer v celoletnem povprečju za 3,5 °C .

THE TEMPERATURES OF RIVERS AND LAKES

Barbara Vodenik

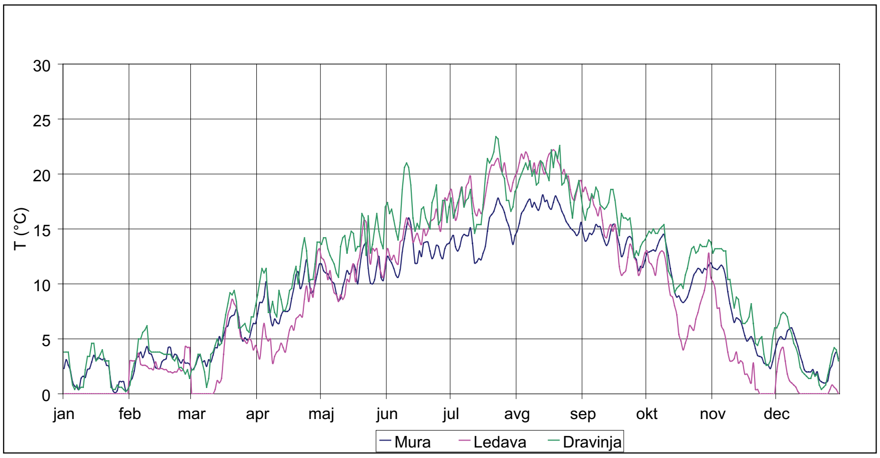
In 2004, the average of the mean annual temperatures of the Mura, Ledava, Sava, Kamniška Bistrica, Ljubljanica, Soča, Krka, Vipava, Dravinja and Savinja Rivers was 10.0 °C, which is by 0.1 °C less than in the multi-annual reference period. The average temperature of lakes Bled and Bohinj amounted to 10.8 ºC, which is by 0.4 °C less than in the reference period. The deviation from the multi-annual reference period was noticeable in May, June and July, when the average temperature of the rivers was lower by 0.9 ºC and the average temperature of lakes lower by 0.8 ºC compared to the multi-annual mean.

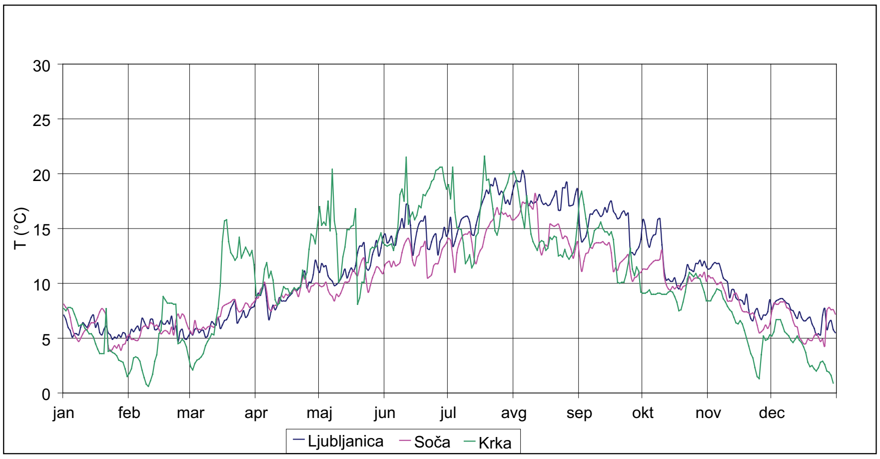
Timeline of River Temperature Changes

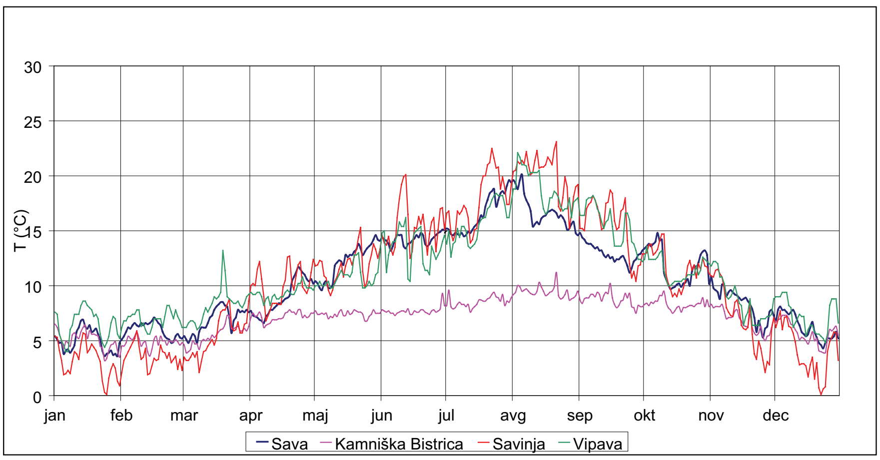
The river water temperature in the individual hydrometric stations in 2004 did not exhibit substantial temporal variability (Graph 6). The temperature oscillations were most prominent during the year on the Krka and Ledava Rivers. On average, both rivers were also the warmest in the summer months. The least distinctive were the temperature oscillations on the Kamniška Bistrica River at Kamnik, due to the proximity of the spring. River temperatures in the first two months have on average not changed significantly. In March and in the following months, the temperatures slowly increased with smaller oscillations, reaching the highest values at the end of July or the beginning of August. Then the temperatures were decreasing up until the middle of December, exhibiting some local extremes. The Savinja and Krka also reached the lowest annual temperatures then, while the other rivers, with the exception of the Ljubljanica, were at their coldest in January.

Timeline of Lake Temperature Changes

The temperature of Lake Bled hardly changed in the first two months while Lake Bohinj experienced a swift cooling to 0 °C in the middle of January, which lasted until the middle of March. Both lakes began to warm up gradually in the second half of March, reaching the peak annual values at the beginning of August. Then the temperature decreased towards the end of the year. The lowest annual value for Lake Bled was measured at the end of February and was 3.0 °C, while the lowest annual temperature of Lake Bohinj was measured at 0 °C in the second half of January. Lake Bohinj was cooler then Lake Bled throughout the year, by 3.5 °C on an annual average.

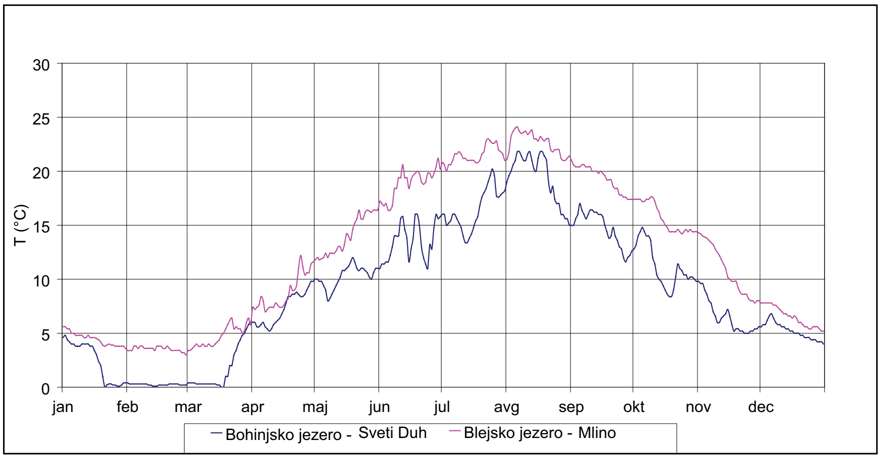






Graf 6: Temperature vode slovenskih rek leta 2004: Mure v Gornji Radgoni, Ledave v Polani, Dravinje v Vidmu, Ljubljanice v Mostah, Krke v Podbočju, Soče v Solkanu, Save v Litiji, Kamniške Bistrice v Kamniku, Savinje v Celju in Vipave v Dornberku.

Graph 6: The water temperatures of Slovenian rivers in 2004: the Mura at Gornja Radgona, the Ledava at Polana, the Dravinja at Videm, the Ljubljanica at Moste, the Krka at Podbočje, the Soča at Solkan, the Sava at Litija, the Kamniška Bistrica at Kamnik, the Savinja at Celje and the Vipava at Dornberk.



Graf 7: Temperature vode Blejskega in Bohinjskega jezera leta 2004.

Graph 7: The water temperature of Lake Bled and Lake Bohinj in 2004.

Primerjava značilnih temperatur rek in jezer z večletnim obdobjem

Januarja 2004 se srednje mesečne temperature izbranih rek niso razlikovale od dolgoletnega povprečja. Povprečna temperatura 4,0 °C je bila enaka kot v primerjalnem obdobju. Februarja je bila povprečna temperatura rek 4,8 °C, kar je 0,3 °C več kot v večletnem primerjalnem obdobju. Marca in aprila je povprečna temperatura rek znašala 6,0°C oz. 8,9 °C. Tako so bile reke 0,6 °C oz. 0,1 °C hladnejše kot v večletnem primerjalnem obdobju. Največje odstopanje od dolgoletnega povprečja je bilo v maju, povprečne mesečne temperature so bile za 1,1 °C nižje kot v primerjalnem obdobju. Povprečna temperatura rek v juniju in juliju je 13,8 °C oz. 15,8 °C, kar je za 0,8 °C manj kot v primerjalnem obdobju. Avgusta in septembra so bile temperature podobne obdobnim, saj so obdobno povprečje v avgustu presegle za 0,2 °C, v septembru pa so bile za 0,1 °C nižje. Povprečna temperatura v oktobru je bila 11,1 °C in je primerjalno obdobje presegla za 0,4 °C. Novembra je bila povprečna temperatura enaka obdobni temperaturi, v decembru pa jo je presegla za 0,3 °C (graf 8). Pri posameznih rekah je najvišja odstopanja od dolgoletnega povprečja opaziti na Dravinji. Povprečna temperatura v juliju je bila za 2,9 °C nižja kot v večletnem primerjalnem obdobju.

Pri Kamniški Bistrici, Dravinji in Muri so bile srednje mesečne temperature večji del leta nižje od vrednosti v primerjalnem obdobju, pri Savi v Litiji pa višje od vrednosti primerjalnega obdobja (karta 6). Na Soči v Solkanu srednje mesečne temperature skoraj ne odstopajo od dolgoletnega povprečja. Pri ostalih rekah so odstopanja bolj ali manj izrazita in precej individualna.

Januarja 2004 je bilo povprečje srednjih mesečnih temperatur obeh največjih slovenskih jezer enako obdobni vrednosti. Povprečna temperatura je bila 3,5 °C, kar je enako kot v primerjalnem obdobju. Februarja in marca je bila povprečna temperatura jezer 1,9 °C oz. 3,2 °C. Tako sta bili jezeri v povpre-

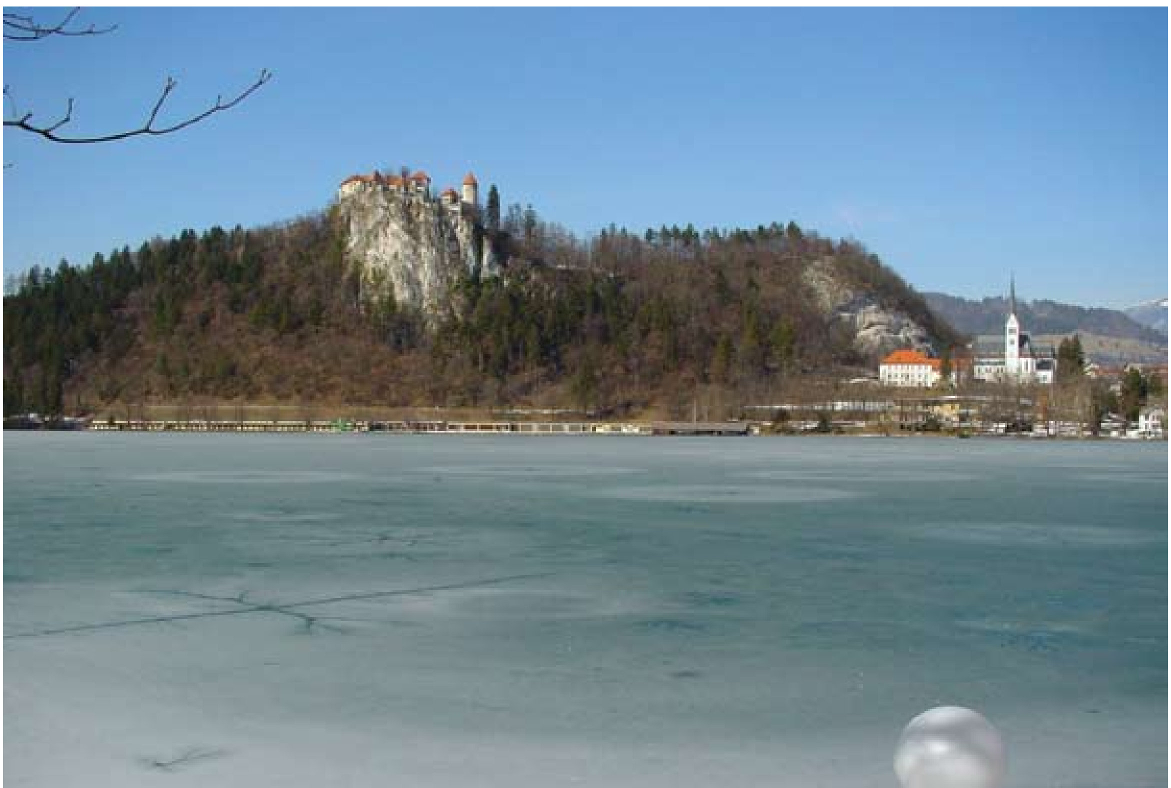
Comparison of the Characteristic Temperatures of Rivers and Lakes with the Normals

In January of 2004, the mean monthly temperatures of the selected rivers did not differ from the normals. The average temperature of 4.0 °C was the same as that of the reference period. In February, the average temperature of the rivers was 4.8 °C, which is 0.3 °C more than in the reference period. In March and April, the average temperature of the rivers was 6.0°C and 8.9 °C respectively. Thus, the rivers were 0.6 °C or 0.1 °C cooler than in the multi-annual reference period. The greatest deviation from the multi-annual reference period occurred in May with the average monthly temperatures being 1.1 °C lower than in the reference period. The average temperature of rivers in June and July was 13.8 °C and 15.8 °C respectively, which is 0.8 °C less than in the reference period. In August and September, the temperatures were similar to the multi-annual average temperatures as they exceeded the multi-annual average by 0.2 °C in August and were lower by 0.1 °C in September. The average temperature in October was 11.1 °C, which exceeded the reference period average by 0.4 °C. In November, the average temperature was the same as the multi-annual average temperature, while in December it exceeded it by 0.3 °C (Graph 8). With the individual rivers, the greatest deviations from the multi-annual average could be observed on the Dravinja River. The mean temperature in July was 2.9 °C lower than in the multi-annual reference period.

For the major part of the year, the mean monthly temperatures of the Kamniška Bistrica, Dravinja and Mura Rivers were lower than the values in the reference period, while those of the Sava River at Litija were higher (Map 6). The mean monthly temperatures of the Soča River at Solkan barely deviate from the normals. The deviations in the other rivers are more or less distinctive and fairly individualistic.

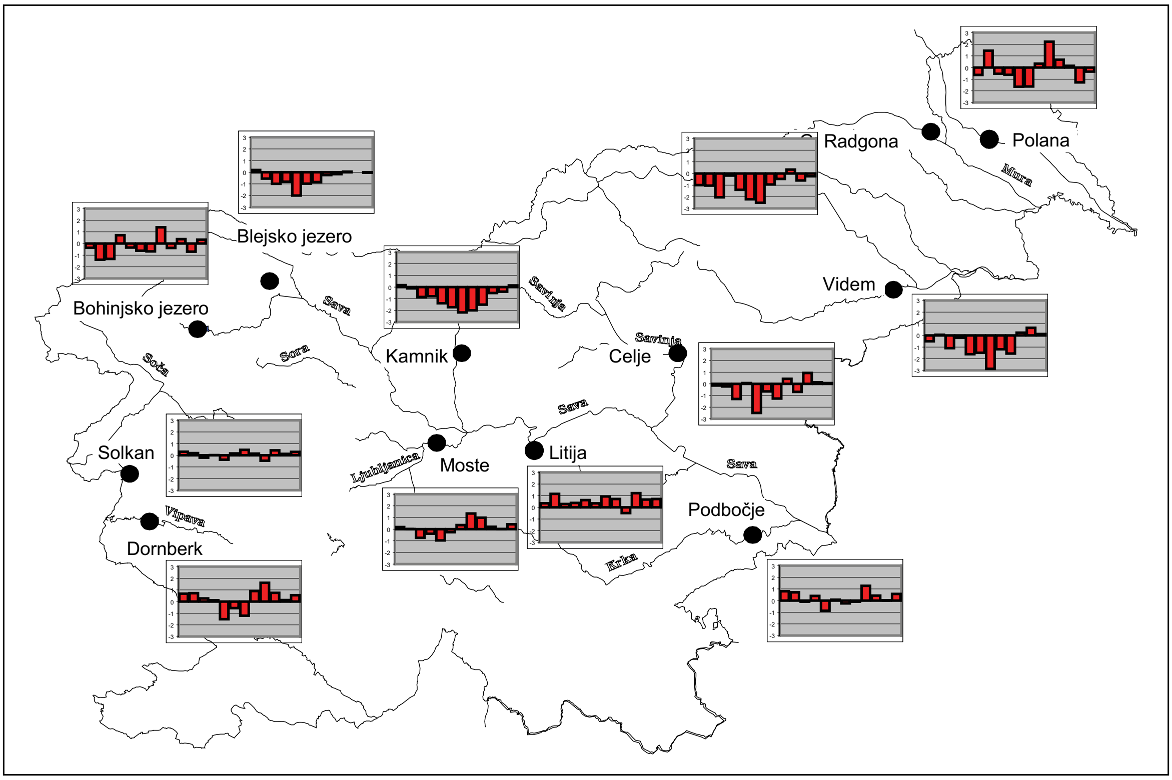
čju 0,9 °C oz. 1,2 °C hladnejši kot v večletnem primerjalnem obdobju. Aprila je bila temperatura enaka obdobni vrednosti. Tudi v maju, juniju in juliju so bile temperature nižje kot navadno in to 1,1 °C, 0,8 °C in 0,6 °C pod dolgoletnim povprečjem. Avgusta je bila povprečna temperatura 21,1 °C, kar je za 0,6 °C več kot v primerjalnem obdobju. Septembra in novembra je bila povprečna temperatura za 0,3 °C nižja kot navadno. Oktobra in decembra pa je presegala povprečje za 0,2 °C, oz.0,1 °C.

In January of 2004, the average of the mean monthly temperatures of the two largest Slovenian lakes was identical to the reference period values. The average temperature was 3.5 °C, which is the same as in the reference period. In February and March, the average temperature of the lakes was 1.9 °C and 3.2 °C respectively. Thus, the lakes were 0.9 °C and 1.2 °C cooler on average than in the multi-annual reference period. In April, the temperature was the same as the multi-annual period value. In May, June and July, the temperatures were lower than usual and were below the normals by 1.1 °C, 0.8 °C and 0.6 °C respectively. The average temperature in August was 21.1 °C, which is 0.6 °C higher than in the reference period. In September and November, the average temperature was 0.3 °C lower than usual, while it exceeded the average by 0.2 °C in October and by 0.1 °C in November.



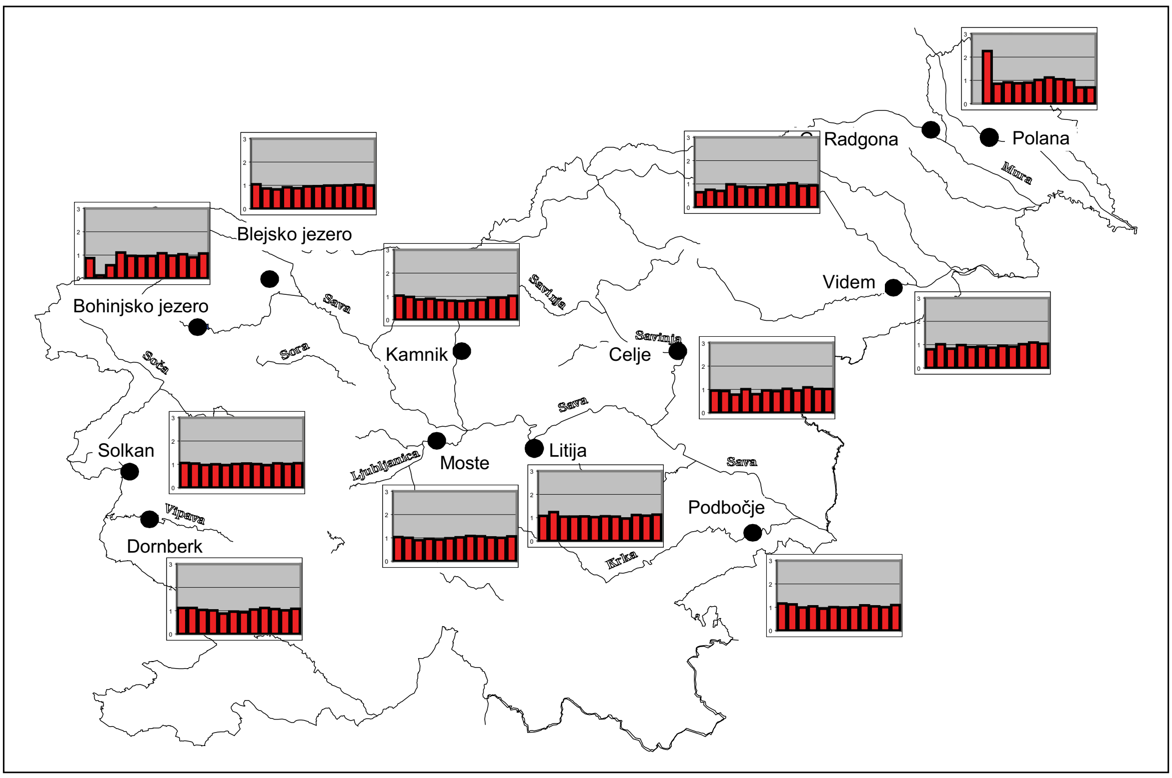
Led na Blejskem jezeru
(foto: Marko Burger).

Ice on Bled lake
(photo: Marko Burger).



Karta 6: Odstopanja srednjih mesečnih temperatur v letu 2004 od srednjih mesečnih temperatur obdobja (°C).

Map 6: The deviations of the mean monthly temperatures in 2004 from the mean monthly temperatures of the reference period (ºC).



Karta 7: Grafični prikaz razmerij med srednjimi mesečnimi temperaturami leta 2004 in obdobja. Vrednost razmerja 1 pomeni enako temperaturo leta 2004 kot v povprečju dolgoletnega obdobja.

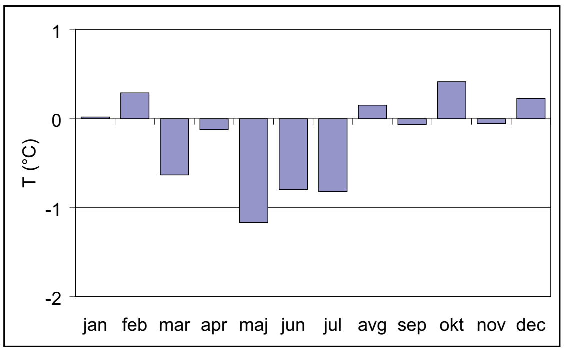
Map 7: The ratios between the mean monthly temperatures in 2004 and those in the reference period. A ratio value of1 means the same temperature in 2004 as the normals.

Najnižje temperature rečnih voda v letu 2004 so bile večinoma nekoliko višje kot v primerjalnem obdobju. Najnižja temperatura Blejskega jezera, 3,0 °C v februarju, je bila od najnižje obdobne temperature za februar višja za 1,8 °C. Najnižja temperatura Bohinjskega jezera, 0 °C v januarju, pa je bila enaka najnižji obdobni temperaturi za januar za Bohinjsko jezero.

Srednje temperature izbranih rek so bile za 0,1 °C, srednje temperature obeh jezer pa za 0,4 °C višje od povprečja. Srednja letna temperatura rek na izbranih postajah je bila 10,0 °C, jezer pa 10,8 °C. Srednje mesečne temperature rek so bile glede na primerjalno obdobje višje februarja, avgusta, oktobra in decembra, nižje pa marca, aprila, maja, junija, julija, septembra in novembra (graf 8). Srednje mesečne temperature jezer so bile glede na primerjalno obdobje nižje v vseh mesecih razen avgusta, oktobra in decembra (graf 9).

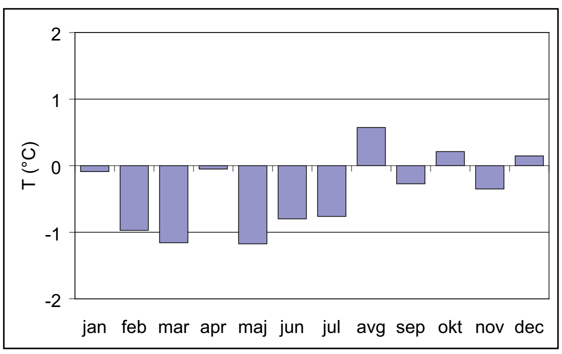
The lowest river water temperatures in 2004 were for the most part somewhat higher than in the reference period. The lowest temperature of Lake Bled was 3.0 °C in February, which exceeded the lowest reference period temperature for the month of February by 1.8 °C. The lowest temperature of Lake Bohinj was 0 °C in January, which was identical to the lowest temperature for January of the reference period.

The mean temperatures of the selected rivers were higher than average by 0.1 °C and the mean temperatures of both lakes higher by 0.4 °C. The average annual temperature of the rivers at the selected stations was 10.0 °C and that of the lakes was 10.8 °C. In comparison with the reference period, the average monthly river temperatures were higher in February, August, October and December and lower in March, April, May, June, July, September and November (Graph 8). The mean monthly lake temperatures were lower with respect to the reference period in all months except for August, October and December (Graph 9).



Graf 8: Odstopanja srednjih mesečnih temperatur v letu 2004 od srednjih mesečnih temperatur primerjalnega obdobja na izbranih rekah. Odstopanja so izračunana kot povprečja odstopanj na desetih rečnih merilnih postajah.

Graph 8: The deviations of the average monthly temperatures in 2004 from the average monthly temperatures of the reference period on the selected rivers. The deviations are calculates as deviation averages from ten river gauging stations.



Graf 9: Odstopanja srednjih mesečnih temperatur v letu 2004 od srednjih mesečnih temperatur primerjalnega obdobja na Bohinjskem in Blejskem jezeru.

Graph 9: The deviations of the mean monthly temperatures in 2004 from the mean monthly temperatures of the reference period on Lakes Bled and Bohinj.

Preglednica 9: Najnižje temperature izbranih rek in jezer v letu 2004 in v obdobju.

Table 9: The lowest temperatures of the selected rivers and lakes in 2004 and in the reference period.

Vodotok Stream	Vodomerna postaja Gauging Station	Leto 2004 Year 2004		Obdobje/Period		
		Tnk	Datum Date	Tnk	Datum Date	Časovni niz
MURA	GORNJA RADGONA	0.1	25.1	0	4.1.1997	1989-2003
LEDAVA	POLANA	0	1.1.	0	28.12.1973	1962-2003
SAVA	LITIJA	3.6	24.1.	0	3.2.1954	1953-2003
KAMN. BISTRICA	KAMNIK	3.2	24.1.	1.0	2.2.1991	1954-2003
LJUBLJANICA	MOSTE	4.7	24.2.	1.0	11.2.1956	1954-2003
SOČA	SOLKAN	3.8	23.1.	0	15.2.1956	1953-2003
KRKA	PODBOČJE	3.4	24.12.	0	10.2.1956	1953-2003
VIPAVA	DORNBERK	4.0	6.1	0.1	6.1.1985	1980-2003
DRAVINJA	VIDEM	0.2	30.1.	0	17.2.1983	1982-2003
SAVINJA	CELJE	0.1	22.12.	0	1.12.1973	1973-2003
BLEJSKO JEZERO	MLINO	3.0	29.2.	1.2	29.1.1987	1985-2003
BOHINJSKO JEZERO	SVETI DUH	0	21.1.	0	14.2.1952	1951-2003

Preglednica 10: Najvišje temperature izbranih rek in jezer v letu 2004 in v obdobju.

Table 10: The highest temperature of the selected of selected rivers and lakes in 2004 and in the reference period.

Vodotok Stream	Vodomerna postaja Gauging Station	Leto 2004 Year 2004		Obdobje / Period		
		Tvk	Datum Date	Tvk	Datum Date	Časovni niz
MURA	GORNJA RADGONA	18.1	13.8	23.3	23.7.2003	1989-2003
LEDAVA	POLANA	22.2	18.8	25.9	12.8.2003	1962-2003
SAVA	LITIJA	20.1	5.8	24.6	8.8.2003	1953-2003
KAMN. BISTRICA	KAMNIK	11.2	21.8.	18.4	28.8.1992	1954-2003
LJUBLJANICA	MOSTE	20.3	5.8.	23.8	16.8.1988	1954-2003
SOČA	SOLKAN	18.2	11.8.	20.0	9.8.1994	1953-2003
KRKA	PODBOČJE	24.4	23.7.	26.4	22.7.2003	1953-2003
VIPAVA	DORNBERK	22.1	3.8.	24.0	13.8.2003	1980-2003
DRAVINJA	VIDEM	23.4	22.7	28.6	2.8.1994	1982-2003
SAVINJA	CELJE	20.0	23.7.	24	10.8.1994	1973-2003
BLEJSKO JEZERO	MLINO	24.1	6.8.	25.4	9.8.1998	1985-2003
BOHINJSKO JEZERO	SVETI DUH	21.8	6.8.	24.1	31.7.1983	1951-2003

Preglednica 11: Srednje mesečne in letne temperature izbranih rek ter njihovo povprečje (Tpovp) v letu 2004.

Table 11: The mean monthly and annual temperatures of the selected rivers and their average (Tpovp) in 2004.

Vodotok Stream	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts 2004 Annual Ts
MURA	1.8	3.1	4.8	8.9	10.9	13.0	14.6	16.5	13.8	11.3	6.4	3.3	9.0
LEDAVA	0.0	2.6	3.1	6.4	11.4	14.8	18.7	20.5	14.4	9.1	2.9	0.8	8.8
DRAVINJA	2.0	3.4	5.2	10.2	13.8	16.9	18.4	19.9	16.1	12.8	7.9	3.4	10.9
SAVA	4.9	6.0	6.8	8.9	12.2	14.2	16.5	16.7	12.9	11.8	8.4	6.2	10.5
KAMN. BISTRICA	5.0	4.9	5.5	7.2	7.4	7.7	8.5	9.4	8.8	8.3	6.8	5.7	7.1
LJUBLJANICA	5.8	6.0	6.6	9.2	11.7	14.5	16.7	18.0	15.5	12.1	9.0	7.0	11.0
SAVINJA	2.7	3.0	4.5	8.5	9.7	13.9	15.6	17.2	13.7	11.7	7.0	4.0	9.3
KRKA	5.8	6.5	8.2	11.1	13.4	17.1	18.9	19.5	17.0	12.1	8.6	6.7	12.1
VIPAVA	6.5	6.9	8.2	9.3	10.8	13.6	15.7	18.7	15.4	11.5	8.6	7.2	11.1
SOČA	5.7	5.9	7.1	9.1	10.2	12.4	14.5	15.1	12.3	10.7	8.1	6.4	9.8
Povprečje Average	4.0	4.8	6.0	8.9	11.2	13.8	15.8	17.2	14.0	11.1	7.4	5.1	10.0

Preglednica 12: Srednje mesečne in letne temperature izbranih rek ter njihovo povprečje (Tpovp) za večletno obdobje.

Table 12: The mean monthly and annual temperatures of the selected rivers and their average (Tpovp) for the multi-annual period.

Vodotok Stream	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts obdobja Annual Ts in period
MURA	2.8	4.1	6.8	9.1	12.3	15.2	17.1	17.4	14.3	11.0	7.0	3.5	10.1
LEDAVA	0.6	1.2	3.6	7.0	13.0	16.4	18.4	18.3	13.7	8.9	4.2	1.2	8.9
DRAVINJA	2.5	3.3	6.3	10.4	15.4	18.4	21.3	21.1	17.7	12.6	7.2	3.3	11.6
SAVA	4.6	4.8	6.5	8.5	11.6	13.9	15.6	16.0	13.4	10.6	7.7	5.5	9.9
KAMN. BISTRICA	4.8	5.0	6.4	8.0	8.8	9.4	10.7	11.4	10.3	8.8	7.2	5.6	8.0
LJUBLJANICA	5.6	6.0	7.3	9.6	12.7	14.8	16.4	16.7	14.5	11.9	9.0	6.6	10.9
SAVINJA	2.8	3.2	5.8	8.4	12.2	14.6	16.9	16.8	14.4	10.8	6.9	3.9	9.7
KRKA	5.0	5.8	8.3	10.7	14.3	17.0	19.1	19.6	15.7	11.7	8.6	6.1	11.8
VIPAVA	5.8	6.2	7.9	9.2	12.3	14.2	16.9	17.8	13.8	10.8	8.5	6.7	10.9
SOČA	5.4	5.7	7.3	9.1	10.6	12.2	14.0	15.0	12.8	10.3	8.0	6.1	9.7
Povprečje Average	4.0	4.5	6.6	9.0	12.3	14.6	16.6	17.0	14.1	10.7	7.4	4.8	10.1

Preglednica 13: Srednje mesečne in letne temperature obeh jezer ter njihovo povprečje (Tpovp) v letu 2004.

Table 13: The mean monthly and annual temperatures of the two lakes and their average (Tpovp) in 2004.

Jezero Lake	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts 2004 Annual Ts
BLEJSKO J.	4.5	3.5	4.7	8.7	14.0	18.9	21.5	22.7	19.3	15.7	10.8	6.5	12.6
BOHINJSKO J.	2.4	0.2	1.7	7.3	10.3	13.5	16.4	19.5	14.7	11.2	6.5	5.2	9.1
Povprečje Average	4.0	4.5	6.6	9.0	12.3	14.6	16.6	17.0	14.1	10.7	7.4	4.8	10.1

Preglednica 14: Srednje mesečne in letne temperature obeh jezer ter njihovo povprečje (Tpovp) za večletno obdobje.

Table 14: The mean monthly and annual temperatures of the two lakes and their average (Tpovp) for the multi-annual period.

Jezero Lake	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts obdobja Annual Ts in period
BLEJSKO J.	4.3	4.0	5.7	9.5	16.0	19.9	22.3	22.9	19.5	15.7	10.5	6.5	13.0
BOHINJSKO J.	2.8	1.6	3.0	6.6	10.6	14.1	17.1	18.1	15.1	10.8	7.2	4.9	9.3
Povprečje Average	3.5	2.8	4.4	8.0	13.3	17.0	19.7	20.5	17.3	13.2	8.8	5.7	11.2

VSEBNOST IN TRANSPORT SUSPENDIRANEGA MATERIALA V REKAH

mag. Florjana Ulaga

Material, ki se pod vplivom turbulence premešča po reki imenujemo rečni transport. Glede na velikost delcev in hitrost prenosa ga delimo na lebdeče plavine v suspendirani obliki in na prod, ki se premika po rečnem dnu s kotaljenjem. Na Agenciji RS za okolje (ARSO) izvajamo monitoring skupne količine suspendiranega materiala, ki se premesti skozi izbrani prečni prerez vodotoka v določeni časovni enoti. Dinamiki gibanja plavin v vodi sledimo z merjenjem vsebnosti suspendiranega materiala, iz katere pri izmerjenem pretoku izračunamo količino transportiranega materiala. Večina materiala se transportira ob visokih vodah, zaradi česar je potrebno pogosto vzorčenje prav v času visokovodnih valov.

THE CONCENTRATION AND TRANSPORT OF SUSPENDED MATERIAL IN RIVERS

Florjana Ulaga

The material that is transported in the river by the turbulent river flow is called sediment transport. Depending on the size of the particles and the transfer velocity, it is classified as suspended material and bed load, which consists of gravel rolling along the river bed. The Environmental Agency of the Republic of Slovenia (ARSO) is carrying out monitoring of the total quantity of suspended material that is transported through a selected transverse cross-section of the watercourse within a defined time unit. The dynamics of the suspended material transported in the rivers are monitored through measurement of the concentration of suspended material from which the quantity of material transported can be calculated using the measured river discharge. The majority of material is transported during high water and therefore sampling needs to be performed frequently during periods of high-water waves.

Prelivanje vzorcev iz avtomatskega vzorčevalnika na vodomerni postaji Radovljica na Savi (foto: Marko Burger).

Decanting the samples from the automatic sampler at the Radovljica on Sava gauging station (Photo: Marko Burger).

Redna merjenja vsebnosti suspendiranega materiala izvajamo na šestih vodomernih postajah: v Gornji Radgoni na Muri, v Radovljici in v Hrastniku na Savi, v Velikem Širju na Savinji, v Mirnu na Vipavi in v Suhi na Sori. Na teh merilnih mestih se enkrat dnevno odvzame vzorec vode s prostornino enega litra, ki ga analiziramo v laboratoriju po klasični filtracijski metodi. Rezultati analiz so izmerjene vsebnosti suspendiranega materiala (c), izražene v g/m^3 vode. Na postajah primarne mreže poteka odvzem vzorcev ročno. Izjemi sta postaja Suha na Sori, kjer poteka odvzem vzorcev z avtomatskim vzorčevalnikom in postaja Radovljica na Savi, kjer smo v oktobru pričeli z rednim odvzemom vzorcev z avtomatskim vzorčevalnikom WS Porti PP (WaterSam). Nekajkrat letno se na vseh vodomernih postajah monitoringa suspendiranega materiala opravljajo profilne meritve suspendiranega materiala: vzorci se odvzamejo v več točkah prečnega prereza. Na podlagi vsebnosti snovi v odvzetih vzorcih izračunamo srednjo vsebnost v prerezu, s pomočjo izmerjenega pretoka pa trenutni transport suspendirane snovi. Rezultati so objavljeni v drugem delu publikacije.

Regular measurements of the concentrations of suspended material are carried out at six hydrometric stations: in Gornja Radgona on the Mura River, in Radovljica and Hrastnik on the Sava River, in Veliko Širje on the Savinja River, in Miren on the Vipava River and in Suha on the Sora River. One litre water samples are taken at these gauging stations once daily and are analysed at the laboratory using classic filtration methods. The results of the analyses are the measured concentrations of suspended material (c) in g/m^3 of water. At the stations of the primary gauging station network, the collection of samples is carried out manually. The exceptions to this rule are the Suha gauging station on the Sora River, in which automatic sampling was introduced in 2002 with an automatic sampler, and the Radovljica gauging station on the Sava River where regular sampling was introduced with the WS Porti PP (WaterSam) automatic sampler in October. Several times annually, cross-section measurements of suspended material are performed at all the water gauging stations with suspended material monitoring. This is where samples are taken at a number of points along the transverse cross-section. Based on the material concentrations in the samples taken, the mean cross-section concentration is calculated and, with the river discharge values, the instantaneous transport of suspended material can be calculated.

Otežen ročni odvzem vzorca vode ob visoki vodi (foto: Florjana Ulaga).

Figure: Difficult manual sampling of water in periods of high water (Photo: Florjana Ulaga).

Poleg rednega odvzema vzorcev poteka tudi odvzem vzorcev ob izrednih hidroloških razmerah na šestih dopolnilnih vodomernih postajah. S pomočjo analiz vzorcev dopolnilne mreže lažje in pravilneje vrednotimo podatke rednih meritev, hkrati pa rezultati predstavljajo pregled stanja ob visokovodnih razmerah po vsej Sloveniji. Izredni odvzemi vzorcev so bili leta 2004 na Dravinji v Vidmu, na Pesnici v Zamušanih, na Sotli v Rakovcu, na Soči v Kobaridu, na Idrijci v Hotešku in na Bači v Bači pri Modreju.

Mreža vodomernih postaj, na katerih poteka odvzem vzorcev, je prikazana na karti A v III. delu publikacije.

Rezultati meritev vsebnosti suspendiranega materiala v letu 2004

Ob pregledu izmerjenih vsebnosti suspendiranega materiala na postajah z dnevnim odvzemom vzorcev ugotovimo, da so za leto 2004 najbolj zanimivi podatki za Vipavo in Savo. Vsebnost suspendiranega materiala je bila v Vipavi presenetljivo visoka oktobra, saj je 1105 g/m^3 (27.10.) največja do sedaj izmerjena vsebnost na merilnem mestu. Nadpovprečne vsebnosti smo izmerili tudi večkrat v januarju in marcu. V Savi, na vodomerni postaji v Hrastniku, je bila v novembru izmerjena največja vsebnost v osmih letih opazovanj. 1. novembra je dosegla 885 g/m^3, to je kar 400-krat presežena srednja obdobna vsebnost. V ostalih mesecih v Savi nismo izmerili izrednih vsebnosti suspendiranega materiala. Vsebnosti suspendiranega materiala v Muri so bile nekoliko povečane v skladu s pretočnim režimom v maju, juniju in juliju. Največja vrednost, 2039 g/m^3 je bila izmerjena 20. novembra. Uvršča se med deset največjih izmerjenih vsebnosti suspendiranega materiala v vzorcih na Muri od leta 1956. Vsebnosti suspendiranega materiala v Savinji v letu 2004 niso bile izjemne. Na Sori je v letu 2004 prav tako potekal dnevni odvzem vzorcev. Vsebnosti so bile majhne, največja je bila izmerjena oktobra in je dosegla 809 g/m^3.

In addition to regular sampling, extraordinary samples are also taken during extreme hydrological conditions at six supplemental hydrometric stations. Through analyses of these samples taken by the supplementary network, the data from the regular measurements can be more easily and accurately evaluated while the results give an overview of the high-water conditions throughout Slovenia. Extraordinary sampling was performed in 2004 on the Dravinja River at Videm, the Pesnica River at Zamušani, the Sotla River at Rakovec, the Soča River at Kobarid, the Idrijca River at Hotešk and the Bača River at Bača near Modrej.

Gauging stations with water sampling are indicated on map A in part III.

The Results of Suspended Material Concentration Measurements in 2004

Upon review of the measured concentrations of suspended material at the stations through daily sampling, it was determined that the most interesting data in 2004 was from the Vipava and Sava Rivers. The concentration of suspended material was surprisingly high in the Vipava River in October as, with 1105 g/m^3 (27 October), it was the highest measured concentration at a gauging site to date. Above-average values were also measured several times in January and March. In November, the highest concentration in all eight years of monitoring was measured at the Hrastnik water gauging station on the Sava River. On 1 November, it reached 885 g/m^3, exceeding the mean value for the multi-annual period by 400 times. In the remaining months, there were no extraordinary concentrations of suspended material recorded in the Sava River. The concentrations of suspended material in the Mura River were slightly elevated in comparison with the discharge regime in May, June and July. The highest value of 2039 g/m^3 was measured on 20 November, ranking among the ten highest measured concentrations of suspended material in the samples from the Mura River since 1956. The suspended material concentrations in the Savinja River in 2004 were not extraordinary. Daily sampling was also carried out on the Sora River in 2004. The concentration here was small, with the highest measured value reaching 809 g/m^3 in October.

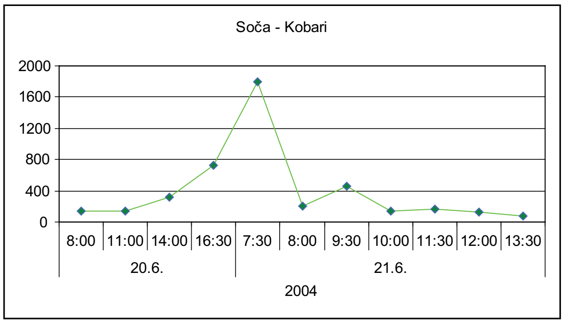
Preglednica 15: Največje vsebnosti suspendiranega materiala vzorcev izbranih postaj z enkrat dnevnim odvzemom v letu 2004 in v obdobju 1985-2003.

Table 15: The maximum concentration of suspended material in samples from selected stations with daily samplings from 2004 and from the 1985-2002 period.

Vodotok Vodomerna postaja / Stream Gauging station	2004		1985 - 2003		
	Vsebnost c (g/m^3) Concentration	Datum odvzema vzorca Date of sampling	Največja obdobna vsebnost c (g/m^3) The highest concentration in the period	Datum največje obdobne vsebnosti Date of the highest concentration in the period	Srednja obdobna vsebnost Mean concentration in the period
MURA – G. RADGONA	2039	20.11.	2364	16.5.1996	49
SAVINJA - VELIKO ŠIRJE	1074	29.6.	6026	7.11.2000	71
VIPAVA- MIREN	1105	27.10.	1066	14.9.1997	32

Na postajah dopolnilne mreže so bili vzorci z veliko vsebnostjo suspendiranega materiala odvzeti 15. marca v Dravinji, 3098 g/m³. V Bači je bilo v vzorcu, odvzetem 10. oktobra, preko 3000 g/m³ suspendiranih snovi. To je največja doslej izmerjena vsebnost v Bači. Zanimiva je tudi povečana vsebnost suspendiranih snovi v Soči, saj je bil višek izmerjen junija in ne v jesenskih mesecih kot običajno. V novembru je bilo v času visokovodnega stanja v dveh dnevih odvzetih 11 vzorcev (graf 10). S pomočjo tako pogostega vzorčenja ugotavljamo odvisnost dinamike vsebnosti suspendiranega materiala v vodi od količine padavin v zaledju.

In the supplementary network, samples with high concentrations of suspended material amounting to 3098 g/m³ were taken from the Dravinja River on 15 March. In a sample taken at Bača on 10 October, there were over 3000 g/m³ of suspended materials. This is the highest concentration measured at Bača to date. The increased suspended material concentration measured in the Soča River is also interesting as its peak was measured in June and not in the autumn months as usual. In November, during the period of high water, 11 samples were taken in two days (Graph 10). With the aid of such frequent sampling, the dependence of the suspended material concentration dynamics on the quantity of precipitation in the catchment area can be determined.



Graf 10: Pretok in vsebnosti suspendiranega materiala v Soči na vodomerni postaji Kobarid, 20. in 21. junija 2004.

Graph 10: The discharge and suspended material concentration in the Soča at the Kobarid water gauging station on 20 and 21 of June 2004.

Preglednica 16: Največje vsebnosti suspendiranega materiala vzorcev odvzetih ob izrednih hidroloških razmerah (max c1- največja obdobna vsebnost, max c2- druga največja obdobna vsebnost).

Table 16: The maximum concentrations of suspended material in samples taken during extreme hydrological conditions (max c1- maximum concentration in the reference period, max c2- the second highest concentration in the reference period)

Vodomerna postaja Gauging station	Vodotok Stream	2004		1990 - 2003			
		Vsebnost c (g/m3)	Datum odvzema vzorca	Največja obdobna vsebnost The highest concentration in the period			
		Concentration	Date of sampling	max c1	datum/date	max c2	datum/date
VIDEM	DRAVINJA	3098	15.3.	4832	22.5.1999	4627	26.1.2001
ZAMUŠANI	PESNICA	532	12.6.	4780	25.6.1997	3729	25.4.1999
RAKOVEC	SOTLA	423	16.3.	1818	14.4.2002	758	11.7.1999
KOBARID	SOČA	1801	21.6.	8112	17.11.2000	3200	5.10.2003
HOTEŠK	IDRIJCA	279	12.10.	3743	9.10.1993	2988	1.11.1990
BAČA PRI MODREJU	BAČA	3086	10.10.	1959	27.10.1990	1223	4.10.2003

Transport suspendiranega materiala

Z množenjem vsebnosti suspendiranega materiala in pretoka vode določimo količino prenesenega suspendiranega materiala oz. transport plavin S (v kg/s). Iz dnevnih vrednosti izračunamo mesečne in letne vrednosti transportiranega materiala. V preglednici 17 so zbrani podatki o srednjih pretokih, vsebnosti in transportu suspendiranega materiala za postaje z daljšim opazovanim nizom. Z njihovo pomočjo lažje vrednotimo podatke tekočega leta. Srednje vrednosti v letu 2004 izkazujejo povprečen transport na Muri. V Savinji, Savi, Sori in Vipavi je bil transport le nekoliko nadpovprečen.

The Transport of Suspended Material

By multiplying the suspended material concentration and the water discharge, the quantity of suspended material transported, or the transport of the suspended load S (in kg/s) is determined. The monthly and annual values of the transported material are calculated from the daily values. In Table 17, the data is gathered on the mean discharges, concentrations and the transport of suspended materials from the gauging stations with the longer time series. They enable easier evaluation of the data from the current year. The mean values in 2004 exhibit average transport values for the Mura River, while in the Savinja, Sava, Sora and Vipava Rivers, the transport was only slightly above-average.

Preglednica 17: Srednje letne in obdobne vrednosti pretokov rek, vsebnosti in transporta suspendiranega materiala.

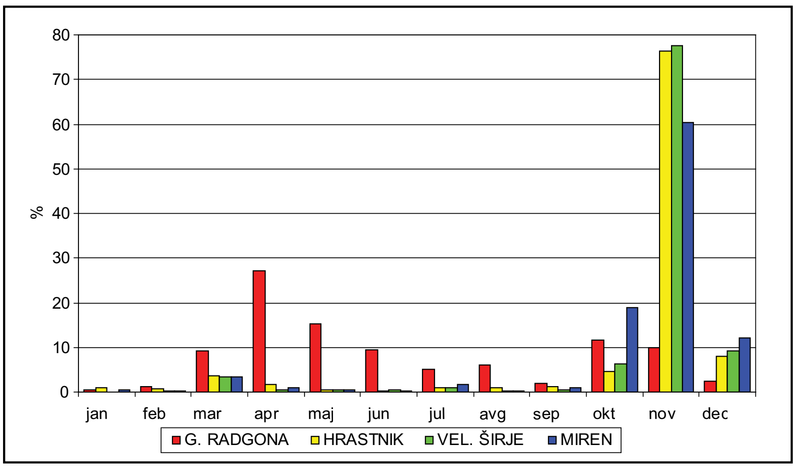
Table 17: The monthly and annual transport of discarge, concentration and suspended material.

Vodotok Stream	2004			1985 - 2003		
Vodomerna postaja Gauging station	Qsr (m³/s)	csr (g/m³)	Ssr (kg/s)	Qsr (m³/s)	csr (g/m³)	Ssr (kg/s)
MURA G.RADGONA	157	49	13,3	146	46,1	12,8
SAVINJA VELIKO ŠIRJE	45,8	71	6,36	43,1	55	7,3
VIPAVA MIREN	17,1	32	1,21	16,8	18,4	0,9

Preglednica 18: Mesečni in letni transport suspendiranega materiala v letu 2004.

Table 18: The monthly and annual transport of suspended material in 2004.

2003	MURA – G. RADGONA		SAVA – HRASTNIK		SAVINJA – V. ŠIRJE		VIPAVA – MIREN	
Mesec/month	ton	%	ton	%	ton	%	ton	%
jan / Jan	1231	0.39	10617	0.97	4240	0.11	4261	0.47
feb / Feb	3746	1.32	3752	0.85	1168	0.16	6953	0.19
mar / Mar	31731	9.29	13371	3.56	16169	3.27	2806	3.36
apr / Apr	3773	27.14	13085	1.72	18579	0.47	1824	1.05
maj / Maj	57697	15.34	25995	0.42	1623	0.60	1406	0.53
jun / Jun	195007	9.43	13114	0.20	23859	0.40	1009	0.20
jul / Jul	69433	4.97	9313	0.95	13230	1.06	166	1.76
avg / Avg	5406	6.11	2088	0.87	3965	0.35	99	0.23
sep / Sep	8277	1.96	7842	1.16	11232	0.58	145	0.89
okt / Okt	12429	11.73	75927	4.71	70980	6.19	14816	18.89
nov / Nov	28338	9.96	109383	76.47	30136	77.70	1255	60.41
dec / Dec	1757	2	23111	8	5828	9	3305	12
Letni transport Yearly transport	418822	100	307598	100	201009	100	11945	100



Graf 11: Delež transportiranega materiala po mesecih v letu 2004.

Graph 11: The share of transported material by month in 2004.

Mesečne in letne vrednosti transportiranega materiala so za postaje z dnevnim odvzemom vzorcev prikazane v preglednici 18. Ker je bilo leto 2004 hidrološko povprečno, je tudi skupna vsota transportiranega material v rekah primerljiva s preteklimi leti. Največ, dobrih 418 tisoč ton materiala, je v letu 2004 prenesla Mura, od tega 27% v mesecu aprilu. Savi-

The monthly and annual transported material values for stations with daily sampling is shown in Table 18 Because 2004 was a hydrologically average year, the total amount of transported material in the rivers was comparable to those of the previous years. The most material in 2004, more than 418 thousand tons, was transported by the Mura River, nja, Sava in Vipava so največ materiala transportirale novembra, med njimi največ Sava v Hrastniku, dobrih 307 tisoč ton.

Zanimivi pa so tudi podatki zbrani v preglednici 19. Vsota letnih vrednosti transportiranega materiala je v 10 letih na Muri dosegla kar dobre 3,2 milijone ton, kar je veliko ob upoštevanju dejstva, da gre le za suspendiran material. Savinja je v istem obdobju transportirala skozi profil v Velikem Širju dobre 3 milijone ton, Vipava pa v Mirnu 260 tisoč ton.

27% of which was transported in April. The Savinja, Sava and Vipava transported the most material in November, with the Sava at Hrastnik transporting the most, with more than 307 thousand tons.

The data in *Table 9* is also interesting. The total annual values of material transported over 10 years by the Mura River reached over 3.2 million tons, which is a lot considering the fact that this only involves the suspended material. In the same period, the Savinja transported well over 3 million tons through the cross-section at Veliko Širje and the Vipava transported 250 thousand tons at Miren.

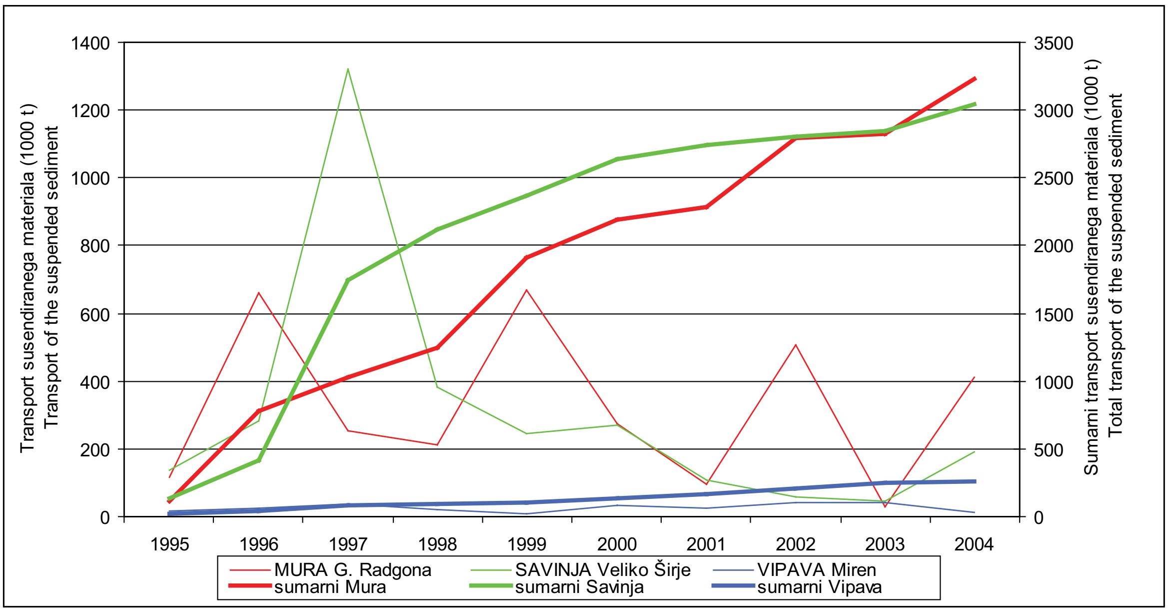
Preglednica 19: Letne vrednosti prenešenega suspendiranega materiala za obdobje 1994-2004 (tisoč ton).

Table 19: The annual values of suspended material transported for the 1994-2004 period (in thousand tons).

Vodomerna postaja Gauging station	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Vsota sum
MURA – G. RADGONA	116	661	255	211	670	275	96	508	31	412	3235
SAVINJA - VELIKO ŠIRJE	136	283	1322	381	244	269	109	57	47	191	3039
VIPAVA- MIREN	16	25	37	20	9	32	24	42	43	12	260

Razlike v količini transportiranega materiala med porečji, ki imajo izpolnjen desetletni niz, so precejšnje (graf 12). V letu 2004 je Mura prenesla 13 odstotkov desetletnega transporta, Savinja 6 odstotkov, Vipava pa slabih 5 odstotkov desetletnega transporta. Savinja je največ materiala v zadnjih desetih letih transportirala leta 1997, kar 38 odstotkov, Mura 1996 in 1999 po 23 odstotkov, Vipava pa leta 2003, ko je letni transport predstavljal dobrih 16 odstotkov desetletnega transporta, kar je največji delež v obdobju.

The differences visible in the amounts of material transported in the various river basins with uninterrupted ten-year time series are significant (Graph 12). In 2004, the Mura transported 13 percent of the ten-year transport, the Savinja 6 percent and the Vipava somewhat less than 5 percent of the ten-year transport. The Savinja transported the most material of the last ten years in 1997, namely as much as 38 percent. The Mura also peaked at 23 percent in both 1996 and 1999 and the Vipava in 2003, when the annual transport represented over 16 percent of the ten-year transport, which is the greatest share of the period.



Graf 12: Količina transportiranega suspendiranega materiala v desetletnem obdobju (tisoč ton).

Graph 12: The quantity of suspended material transported in the ten-year period (in thousands of tons).

VISOKE VODE REK IN POPLAVE

Janez Polajnar

V letu 2004 so bile visoke vode spomladi, hudourniške vode pozno poleti in obsežnejše poplave jeseni. Podobno kot ob zadnjih večjih povodnjih v Sloveniji, leta 1990 in 1998, so bile tudi poplave leta 2004 konec oktobra in v prvih dneh novembra. Narasla Gradaščica je zahtevala smrtno žrtev. V tem času so nekatere reke poplavljale tudi na območjih, kjer poplave niso pogoste, večje reke pa so poplavljale v manjšem obsegu, večinoma na območjih vsakoletnih poplav.

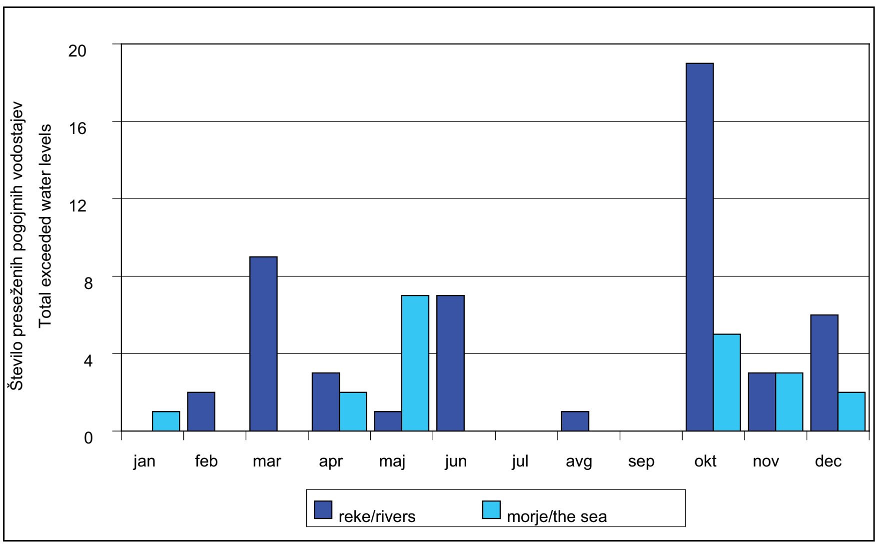
Leta 2004 je bilo zabeleženih 71 pojavov visokih voda, ko so reke na vodomernih postajah in gladina morja ob slovenski obali presegle pogojne vodostaje. Leta 2004 je bilo število takih primerov podobno kot v zadnjih letih prejšnjega desetletja, pred letom 2001. Največ visokih voda je bilo konec oktobra in v začetku novembra (skupaj 30), marca (9), decembra (8) in junija (7). Junija so poplavljali hudourniki v osrednji, vzhodni in jugovzhodni Sloveniji, jeseni pa so bile visoke vode po vsej državi, zlasti v osrednji Sloveniji.

RIVER HIGH WATERS AND FLOODS

Janez Polajnar

In 2004, high waters occurred in the spring and torrential waters in late summer, while extensive flooding occurred in the autumn. Similarly to the last great flooding in Slovenia, in 1990 and 1998, the flooding of 2004 also occurred at the end of October and in the first days of November. The swollen Gradaščica River claimed a victim. During this period, some rivers also flooded in areas where flooding is not frequent, but the larger rivers flooded to a lesser extent and were restricted to the floodplains characterised by annual flooding.

In 2004, there were 71 instances of high waters recorded when the river levels at the gauging stations or the sea level along the Slovenian Coast exceeded the critical water levels when warnings are issued to the public. In 2004, the number of these cases was similar to that of the last years of the previous century, namely prior to 2001. The most instances of high waters were at the end of October and the beginning of November (with 30 in total), March (9), December (8) and June (7). In June, there were torrential floods in the central, eastern and southeastern Slovenia, while autumn saw high water conditions throughout the country, especially in central Slovenia.



Graf 13: Število preseženih pogojnih vodostajev slovenskih rek na opazovanih vodomernih postajah in gladine morja ob slovenski obali leta 2004.

Graph 13: The number of instances in 2004 where the Slovenian river levels at the monitored gauging stations and the sea levels along the Slovenian Coast exceeded the critical water levels where warnings are issued to the public.

Reke, potoki in hudourniki so skupno 38-krat prestopili bregove. Reke so poplavljale povečini na območjih vsakoletnih poplav, potoki in hudourniki na območju vzhodne in jugovzhodne Slovenije pa so se razlili in nanašali plavine na območja, kjer poplave niso pogoste (preglednica 20). Poplave Gradaščice,

Rivers, streams and torrents have together spilled over 38 times. The rivers predominantly flooded the floodplains, while the streams and torrents in the area of eastern and southeastern Slovenia spilled over and deposited their suspended load in areas where flooding is infrequent (table 20). The floods

Poljanske Sore in hudourniške poplave so povzročile gmotno škodo na stanovanjskih in gospodarskih objektih, prometnicah in kmetijskih površinah, narasla Gradaščica je zahtevala smrtno žrtev.

of the Gradaščica River, the Poljanska Sora River and the torrential flooding caused collateral damage to residential and commercial facilities, traffic routes and farming areas, while the swollen Gradaščica River even claimed a victim.

Preglednica 20: Visoke vode in njihovo razlitje leta 2004; razlitja manjših hudournikov niso upoštevana (Vir podatkov: ARSO, CORS).

Table 20: The high waters and their spillage in 2004; the spillages of smaller torrents have not been taken into consideration (Source: ARSO, CORS).

Vodotok Stream	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec
DRAVA						x						
MURA						x						
SAVA										x		
VIPAVA		x								x		x
REKA											x	x
LJUBLJANICA		x	x	x		x				x	x	x
KRKA			x	x						x	x	x
TEMENICA				x						x		
GROSUPELJŠČICA										x		x
SORA										x		
POLJANSKA SORA										x		
BOHINJSKA BISTRICA										x		
GRADAŠČICA										x		
DRVINJA			x									
SOTLA			x							x		
KOLPA										x		
VOGLAJNA			x									
PESNICA			x									
ŠČAVNICA			x									
BUKOVNIŠKI POTOK			x									
Hudourniki v SV in JV Sloveniji Torrents of NE and SE Slovenia						x		x				
Morje ob slovenski obali The sea on the Slovenian coast	x			xx	xxxx xxx					xxxx x	xxx	xx

Visoke vode marca leta 2004

Zaradi odjuge, taljenja snega in dežja v drugi polovici meseca, so 22. marca, v noči z nedelje na ponedeljek, narasle reke v zahodni Sloveniji. Največje pretoke so dosegle isti dan v popoldanskih urah, Kolpa in Sava v srednjem toku pa v noči na 23. marec. Pretoki rek na tem območju niso presegli 2-letne povratne dobe velikih pretokov. Naslednje dni so naraščale reke v vzhodni Sloveniji. Med njimi najbolj Dravinja, ki je pričela poplavljati že 24. marca v jutranjih urah. Največji pretok Dravinje je ta dan dosegel 2- do 5-letno povratno dobo velikih pretokov. Poplavljale so tudi Voglajna, Sotla in manjši potoki v Prekmurju.

Krka je zaradi zadrževanja voda v kraškem podzemlju (kraška retinenca) pričela naraščati pozneje in dosegla v Podbočju največji pretok 290 m^3/s šele 25. marca. Pri tem pretoku z 2- do 5-letno povratno dobo je poplavila območja, ki bistveno ne presegajo vsakoletnih poplavišč.

High Waters in March of 2004

Because of the thaw, the melting of snow and the rain in the second half of the month, on 22 March in the night from Sunday to Monday, the rivers in western Slovenia swelled. They reached the maximum discharges in the afternoon hours of the same day, while the midstream parts of the Kolpa and Sava reached their highest discharge values on the night of 23 March. River discharges in this area did not exceed the 2-year return period of high discharges. In the days that followed, the rivers in eastern Slovenia were swelling. The Dravinja River was the one that swelled the most among them, beginning to flood in the early morning hours of 24 March. The largest discharge of the Dravinja on that day reached the 2- to 5-year return period for large discharges. The Voglajna and Sotla Rivers and smaller streams in Prekmurje also flooded.

The Krka began to swell later because the karstic underground retained the water (karstic retinence), reaching its maximum discharge of 290 m^3/s

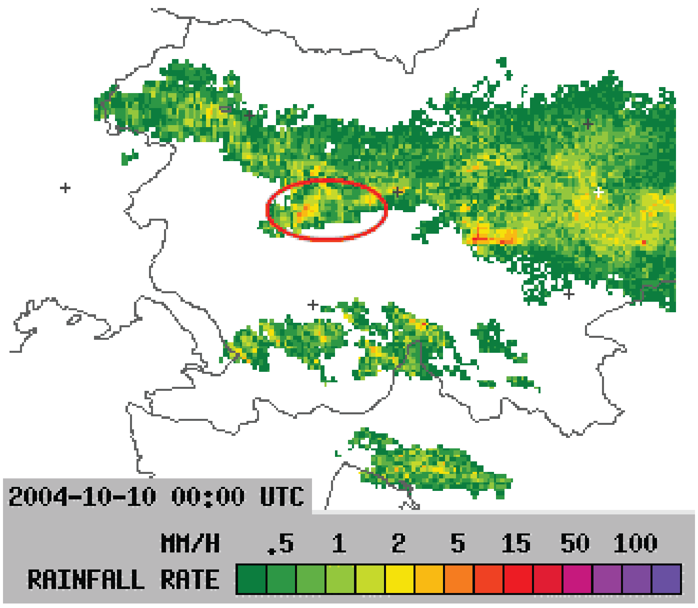
Visoke vode oktobra in novembra leta 2004

V noči s sobote na nedeljo, 10. oktobra 2004, je v zahodni in osrednji Sloveniji v dveh padavinskih območjih padla velika količina dežja. Največ padavin je bilo med 22. in 6. uro. Izraziti padavinski območji sta bili v Julijskih Alpah, zlasti na Bohinjskem grebenu, kjer je v 48 urah padlo 330 mm dežja, in na območju Polhograjskega hribovja, kjer je v 48 urah padlo 181 mm dežja. Drugod je bilo padavin manj, med 35 mm in 80 mm. Glavnina padavin na omenjenih območjih je padla v manj kot 12 urah.

at Podbočje only on 25 March. At this discharge rate, with a 2- to 5-year return period, it inundated the areas that do not significantly exceed the areas that are flooded annually.

High Waters in October and November of 2004

On the night from Saturday to Sunday, 10 October 2004, a large amount of rain fell in western and central Slovenia in two precipitation areas. The most precipitation was between 10 p.m. and 6 a.m. The areas of most pronounced precipitation were the Julian Alps, especially in the Bohinj Ridge where 330 mm of rain fell in a period of 48 hours, and the area of the Polhograjsko hribovje hills where 181 mm of rain fell in 48 hours. Elsewhere, there was less precipitation, namely between 35 and 80 mm. The majority of the precipitation in the areas mentioned fell in less than 12 hours.



Radarska slika padavin 10. oktobra 2004 ob 0:00 UTC.

Radar image of the precipitation on 10 October 2004 at 0:00 UTC.

V nedeljo, 10. oktobra 2004, okoli 2. ure sta zelo hitro narasli Poljanska Sora v Žireh in Gradaščica v Dvoru. Ob izdatnih padavinah v povirjih obeh rek je bil čas odtoka padavin v struge rek izjemo kratek, okoli tri ure. Sora je v Žireh že ob 4.20 dosegla največji pretok 130 m^3/s, s povratno dobo velikih pretokov med 10 in 20 let, Gradaščica pa je v Dvoru ob 5.30 dosegla največji pretok 45 m^3/s s povratno dobo 2 do 5 let.

Obe reki sta že v zgodnjih jutranjih urah pričeli poplavljati v svojem zgornjem toku. Gradaščica je poplavljala pri naselju Dvor ter med naselji Log pri Polhovem Gradcu in Hrastenicami, kjer je zalila glavno cesto. V dopoldanskih urah je poplavni val Gradaščice, skupaj z naraslo Horjulko, dosegel jugozahodni del Ljubljane. Mali Graben je pričel poplavljati na območju med Dolgim mostom in izlivom v Ljubljanico, predvsem na desnem bregu vzdolž Ceste

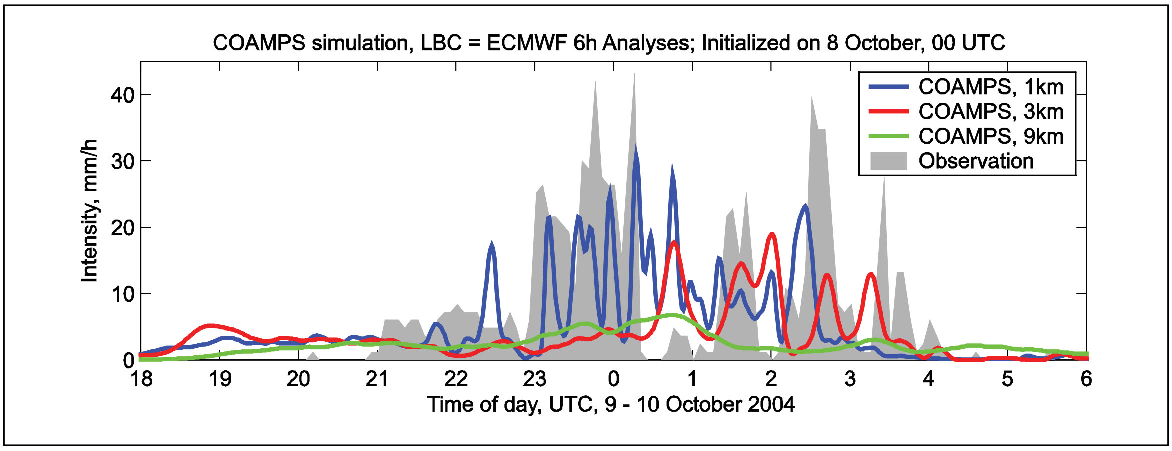
On Sunday, 10 October 2004, at around 2 a.m., the Poljanska Sora River at Žiri and the Gradaščica at Dvor swelled very rapidly. Alongside the abundant precipitation in the headwaters of both rivers, the time between the precipitation and the run-off in the river channels was extremely short, lasting around three hours. The Sora River at Žiri reached its maximum discharge of 130 m^3/s with a return period of between 10 and 20 years at 4.20 a.m. The Gradaščica River at Dvor reached its maximum discharge of 45 m^3/s with a 2-to 5-year return period at 5.30 a.m.

Both rivers began flooding in their upstream stretches in the early morning hours. The Gradaščica flooded near the Dvor residential settlement and between the settlements of Log pri Polhovem Gradcu and Hrastenice, where it inundated the main road. In the morning hours, the flood wave of the Gradaščica dveh cesarjev, na območju Bonifacije in ulice Malči Beličeve. Poplavljeni so bili vrtovi, kletni prostori hiš, garaže, Cesta dveh cesarjev, poplavljen pa je bil tudi del odlagališča kovinskih odpadkov Surovina.

Na osnovi rezultatov operativnih meteoroloških modelov (ALADIN/SI in ECMWF) ter splošne vremenske napovedi za ta dan ni bilo mogoče predvideti tako velike količine padavin in izdati predhodno opozorilo pred poplavami. Tako je bilo za Gradaščico in Mali Graben ter Poljansko Soro, za njen spodnji tok, izdano opozorilo le nekaj ur pred dogodkom. Nadaljnje raziskave v smeri razvoja meteorološkega modeliranja s prostorsko ločljivostjo 3 km in 1 km so pokazale možnost za natančnejšo napoved padavin nad omenjenim območjem. V primeru operativne uporabe tovrstnih meteoroloških modelov, s katerimi bi bilo možno predvideti večjo količino padavin, bi v primeru poplave 10. oktobra na Gradaščici, Malem grabnu in Poljanski Sori lahko izdali opozorilo že 24 ur pred poplavo.

River, together with the swollen Horjulka River, reached the southwestern part of Ljubljana. The Mali Graben began flooding in the area between Dolgi most and its mouth into the Ljubljanica, primarily on the right bank along the Cesta dveh cesarjev Road, in the area of Bonifacija and the Malči Beličeve Street. Gardens, basements, garages and the Cesta dveh cesarjev Road were all flooded, as was a part of the Surovina metal waste dump.

From the results of operative meteorological models (ALADIN/SI and ECMWF) and the general weather forecast for the day, it was impossible to foresee such a large amount of precipitation and issue a preliminary flood warning. Thus, warnings were issued just a few hours before the event for the rivers Gradaščica and Mali Graben and the Poljanska Sora in its downstream part. Further research into the direction of development of meteorological modelling with the spatial resolution of 3 km and 1 km has shown the possibility for a more accurate forecasting of precipitation over this area. If such meteorological models had been operative, which would enable the possibility of forecasting of greater amounts of precipitation, a warning could have been issued in the case of the flood on 10 October on the Gradaščica, Mali graben and Poljanska Sora Rivers as much as 24 hours prior to the flood.



Primerjava izmerjenih in izračunanih padavin s pomočjo gnezdenih modelov ob različni prostorski ločljivosti računskih točk.

Comparison of the measured and calculated precipitation amounts with the aid of nested models at different spatial resolutions of the model grid.

V času praznikov ob 1. novembru je Slovenijo zajelo ponovno poslabšanje vremena z obilnimi padavinami. 31. oktobra je že v jutranjih urah poplavljala Reka med Trpčanami in Ilirsko Bistrico. Preko dneva so ob izdatnih padavinah narasli hudourniki in manjši potoki na širšem območju Gorenjske, prožili so se zemeljski plazovi. Naraščali sta Sava Bohinjka (pretok v Bodeščah 368 m^3/s) in Sava v zgornjem toku (pretok v Radovljici 489 m^3/s) in dosegli 2- do 5-letno povratno dobo velikih pretokov. V popoldanskih urah sta na območju vsakoletnih poplav pričeli poplavljati Ljubljanica in Krka. V večernih urah sta najbolj narasli Sora (pretok v Suhi 479 m^3/s) in Sava

During the holidays on 1 November, Slovenia was again engulfed by deteriorating weather and abundant precipitation. On 31 October, the Reka River flooded in the early morning hours between Trpčane and Ilirska Bistrica. The abundant precipitation throughout the day made the torrents and smaller streams in the wider Gorenjska region swell and landslides were triggered. The Sava Bohinjka (where the discharge at Bodešče was 368 m^3/s) and the Sava Rivers in its upstream part (the discharge at Radovljica was 489 m^3/s) swelled and reached the discharge of a 2- to 5-year return period.. The Ljubljanica and Krka Rivers began flood-v srednjem toku (pretok v Mednem 1106 m^3/s) z 10- do 20-letno povratno dobo velikih pretokov. 1. novembra je v zgodnjih jutranjih urah Sava v Zasavju prestopila bregove in poplavila regionalno cesto. Ta dan so poplavljali tudi Gradaščica, Idrijca ter številni manjši potoki in hudourniki na Idrijskem in širšem območju Kanala ob Soči. Soča je v večernih urah v Solkanu dosegla pretok 1436 m^3/s z 2- do 5-letno povratno dobo velikih pretokov.

Visoke vode decembra leta 2004

Obilno deževje je 27. decembra povzročilo naraščanje rek na Notranjskem, v osrednji in južni Sloveniji. Najbolj je narasla Reka, ki je že zjutraj poplavljala v Topolcu in v okolici Ilirske Bistrice. Sredi dneva je pri Ribnici poplavila cesto Pivka - Ilirska Bistrica. Pri vodomerni postaji Cerkvenikov mlin je ta čas Reka dosegla največji pretok 232 m^3/s z 2- do 5-letno povratno dobo velikih pretokov.

ing their floodplains in the late morning hours. In the evening hours however, the Sora (where the discharge at Suha was 479 m^3/s) and Sava Rivers in its midstream part (where the discharge at Medno was 1106 m^3/s) began swelling and reached the discharge of 10- to 20-year return period. In the early morning hours on 1 November, the Sava River broke its banks at Zasavje and inundated the regional road. On that day, the Gradaščica River, the Idrijca River and numerous smaller streams and torrents in the Idrija region and the wider area of Kanal ob Soči also flooded. In the evening hours at Solkan, the Soča River reached a discharge of 1436 m^3/s with a 2- to 5-year return period.

High Waters in December of 2004

Abundant rain on 27 December caused swelling of the rivers in the Notranjska region and in central and southern Slovenia. The Reka River swelled the most, flooding in the morning at Topolec and in the surroundings of Ilirska Bistrica. At midday it flooded the Pivka/Ilirska Bistrica road at Ribnica. At the Cerkvenikov mlin gauging station, the Reka River reached its maximum discharge of 232 m^3/s with a 2- to 5-year return period.

Visoka voda Sore v Medvodah jeseni 2004 (foto: Peter Frantar).

Autumn high water on the Sora River in Medvode (photo: Peter Frantar).

NIZKE VODE REK IN HIDROLOŠKA SUŠA

dr. Mira Kobold

Medtem ko je bilo za leto 2003 značilno dolgotrajno neprekinjeno obdobje z malimi pretoki, ki je ponekod trajalo kar tretjino leta, in je bila hidrološka suša v tem letu ekstremen pojav, pa so bili najmanjši mesečni pretoki v letu 2004 večinoma v mejah srednjih malih obdobnih pretokov, srednji mesečni pretoki pa v mejah srednjih obdobnih mesečnih pretokov (graf 14). V prvih treh mesecih leta so se najmanjši pretoki le malo razlikovali od srednjih malih obdobnih vrednosti, v aprilu in maju pa so bili v glavnem povsod po državi najmanjši pretoki večji od srednjih malih obdobnih vrednosti, ponekod v osrednji Sloveniji so dosegli srednje obdobne mesečne pretoke. V juniju so bili pretoki zaradi kratkotrajnih in ponekod izrazitih padavin prostorsko neenakomerno porazdeljeni. Največ vode sta imeli Mura in Drava, kjer so bili najmanjši pretoki večji od srednjih malih obdobnih junijskih pretokov, najmanj pa reke v vzhodni Sloveniji, kjer so bili najmanjši pretoki nekoliko manjši od srednjih malih obdobnih junijskih pretokov. Tudi v poletnih mesecih julij, avgust in september, ko so pretoki, z izjemo Mure in Drave, najnižji, so bili najmanjši pretoki v mejah srednjih malih obdobnih pretokov. Hidrološko najbolj suh je bil september, ko so bili najmanjši pretoki večinoma manjši od srednjih malih obdobnih septembrskih pretokov, vendar niso nikjer dosegli najmanjših malih obdobnih vrednosti. Oktobra in novembra so bili najmanjši pretoki zopet v mejah srednjih malih obdobnih mesečnih pretokov, decembra pa večinoma pod srednjimi malimi obdobnimi decembrskimi pretoki (graf 14).

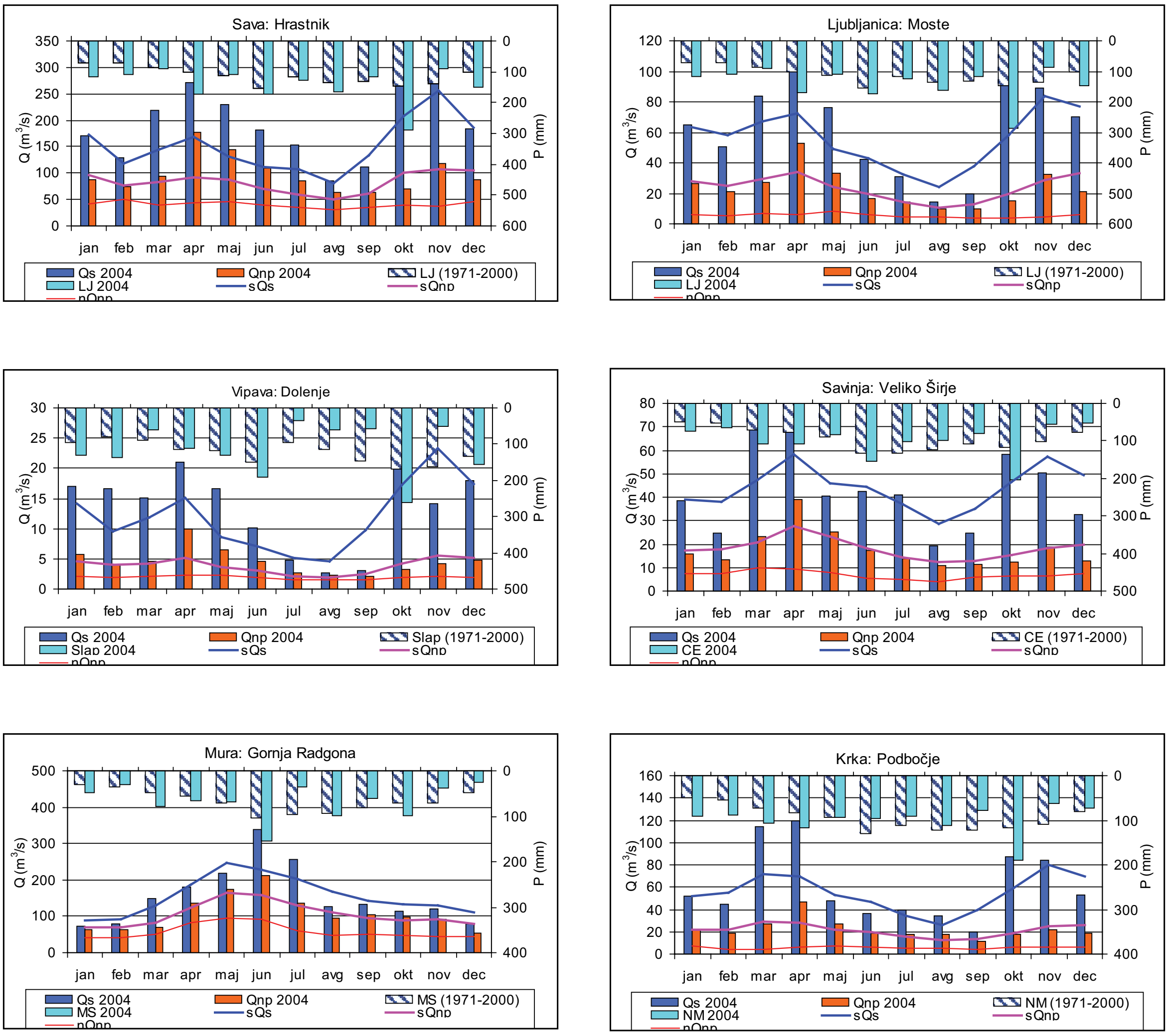
Mrzel pritok Kamniške Bistrice
(foto: Peter Frantar).

RIVER LOW WATERS AND THE HYDROLOGICAL DROUGHT

Mira Kobold

While the hydrological drought was an extreme phenomenon in 2003, characterised by the extended and uninterrupted period with low discharges lasting a third of the year in some places, the minimum monthly discharges of 2004 were predominantly within the limits of the mean low discharges in the reference period, while the mean monthly discharges were within the limits of the mean monthly discharges in the reference period (Graph 1). In the first three months of the year, the minimum discharges differed only slightly from the mean low values of the reference period, while in April and May, the majority of the country experienced minimum discharges that were greater than the mean low values of the reference period. In some places in central Slovenia, they reached the mean monthly discharges of the reference period. In June, the discharges were unevenly distributed spatially because of the short but, in some places, marked precipitation. The Mura and Drava Rivers had the most water. The minimum discharges of the two rivers were greater than the mean low June discharges of the reference period. The least water flowed in the rivers in eastern Slovenia where the minimum discharges were slightly lower than the mean low June discharges of the reference period. Also in the summer months of July, August and September when the discharges, with the exception of the Mura and Drava Rivers, were at their lowest, the minimum discharges were still within the limits of the mean low discharges of the reference period. Hydrologically, September was the driest month and here the minimum discharges were for the most part lower than the mean low September discharges of the reference period. However, they did not reach the minimum low discharges of the reference period anywhere. In October and November, the minimum discharges were once again within the limits of the mean low monthly discharges of the reference period. In December, they were predominantly below the mean low December discharges of the reference period (Graph 14).

Cold inflow stream of the Kamniška Bistrica River
(photo: Peter Frantar).



Graf 14: Srednji (Qs) in minimalni mesečni pretoki (Qnp) v letu 2004 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 2004 z reprezentativnih padavinskih postaj.

Graph 14: The mean (Qs) and minimum monthly discharges (Qnp) in 2004 and the monthly discharge values of the reference period: the mean discharges (sQs), the mean low (sQnp) and minimum low (nQnp) monthly discharges, the monthly precipitation amounts of the 1971-2000 period and the monthly precipitation amounts in 2004 from the representative precipitation stations.

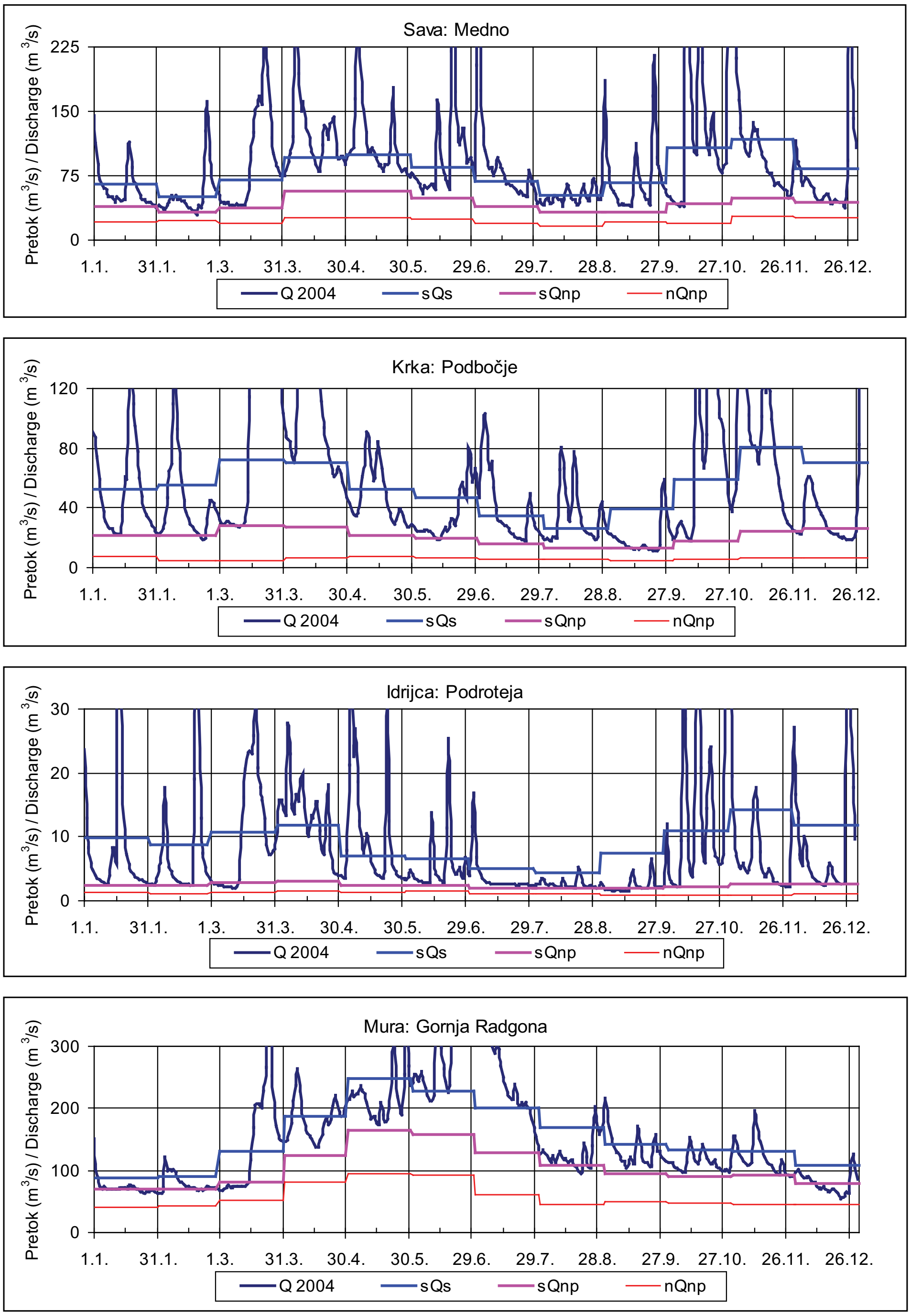
Hidrološko najbolj suha meseca leta 2004 sta bila avgust in september, vendar najmanjši pretoki niso nikjer dosegli najmanjših malih obdobnih pretokov. Na ugodno hidrološko stanje so vplivale padavine, ki so bile v prvi polovici leta v osrednji in vzhodni Sloveniji za okrog 30 odstotkov večje od dolgoletnega povprečja 1971-2000, v južni Sloveniji za okrog 20 odstotkov, v zahodni Sloveniji pa so bile za okrog 15 odstotkov nižje od dolgoletnega povprečja. V drugi polovici leta pa so bile padavine z izjemo oktobra ter ponekod avgusta povečini manjše od dolgoletnega povprečja 1971-2000. Letna količina padavin je povečini malenkostno presegla dolgoletno povprečje 1971-2000.

V letu 2004 nismo beležili daljših nizkovodnih obdobij (graf 15). Na Muri je bila vodnatost najmanjša v zimskih mesecih, ko so najmanjši srednji dnevni pretoki padli pod srednje obdobne male pretoke, vendar se najmanjšim obdobnim pretokom niso približali. Na Meži, Mislinji in Tržiški Bistrici je

Hydrologically, the driest months in 2004 were August and September, however, the monthly minima of discharges did not reach the minimum low discharges of the reference period anywhere. Precipitation had a favourable effect on the hydrological situation as, in the first half of the year, the amount was around 30 percent greater than the multi-annual mean of the 1971-2000 period in central and eastern Slovenia, around 20 percent in southern Slovenia and lower than the multi-annual mean by around 15 in western Slovenia. In the second half of the year, the precipitation, with the exception of October and, in some places, August, was for the most part lower than the multi-annual mean of the 1971-2000 period. The annual amount of precipitation for the most part slightly exceeded the multi-annual mean of the 1971-2000 period.

In 2004, extended periods of low-water (Graph 15) were not recorded. On the Mura River, the stages were at their lowest in the winter months, bila vodnatost najmanjša v prvi polovici marca, ko so pretoki padli pod srednje male obdobne vrednosti, drugod po Sloveniji pa v drugi polovici avgusta ali prvi polovici septembra s pretoki v mejah srednjih malih obdobnih vrednosti.

when the minimum mean daily discharges fell below the mean low discharges of the reference period. However, they did not come close to the minimum discharges of the reference period. On the Meža, Mislinja and Tržiška Bistrica Rivers, the stages were the lowest in the first half of March, when the discharges fell below the mean low values of the reference period. Elsewhere around Slovenia the stages were the lowest in the second half of August or first half of September, with discharges within the limits of the mean low discharges.



Graf 15: Srednji dnevni pretoki na izbranih vodomernih postajah za leto 2004 ter obdobne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) obdobni pretok.

Graph 15: The mean daily discharges at selected gauging stations for 2004 and the reference period discharge values: the mean (sQs), mean low (sQnp) and minimum low (nQnp) discharges of the reference period.

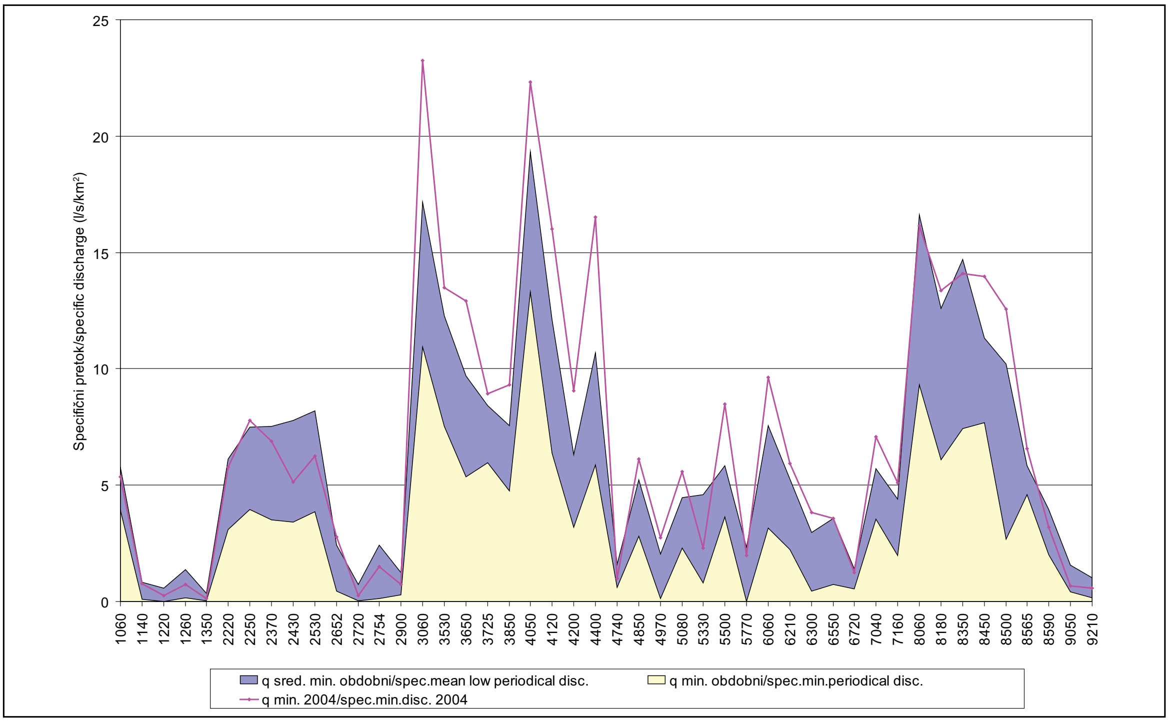
Najmanjši obdobni pretok (nQnp) ni bil nikjer dosežen (preglednica 21). Na večini postaj severovzhodne in vzhodne ter jugozahodne Slovenije je bil najmanjši pretok v letu 2004 manjši od srednjega malega obdobnega pretoka (sQnp), drugod pa povečini večji. Analiza nizkovodnih razmer kaže, da v letu 2004 ni bilo izrazitega pomanjkanja vode, zato tudi hidrološke suše ni bilo občutiti (graf 16).

The minimum reference period discharge (nQnp) was not reached anywhere (Table 21). At the majority of stations in northeastern, eastern and southwestern Slovenia, the minimum discharge in 2004 was lower than the mean low discharge (sQnp), while it was, for the most part, greater elsewhere. The analysis of low-water conditions shows that there was no significant shortage of water in 2004, which is why the hydrological drought was not felt (Graph 16).

Preglednica 21: Najmanjši izmerjeni pretoki v letu 2004 v primerjavi z obdobnima srednjim malim pretokom (sQnp) in najmanjšim pretokom (nQnp) iz obdobja delovanja postaje.

Table 21: The lowest measured discharges in 2004 in comparison with the mean low reference period discharge (sQnp) and the minimum discharge (nQnp) from the period of the operation of the station.

Šifra	Vodomerna postaja Gauging Station	2004		Obdobne vrednosti Periodic discharges	
		Qnp (m^3/s)	Datum/date Qnp	sQnp (m^3/s)	nQnp (m^3/s)
1060	MURA – GORNJA RADGONA	54,6	22.12.	59,0	40,0
1140	ŠČAVNICA - PRISTAVA	0,205	23.09.	0,227	0,030
1220	LEDAVA - POLANA	0,055	27.09.	0,122	0,002
1260	LEDAVA - ČENTIBA	0,635	10.09.	1,18	0,145
1350	VELIKA KRKA - HODOŠ	0,014	08.08.	0,036	0,003
2220	MEŽA - ČRNA	0,546	08.03.	0,580	0,294
2250	MEŽA – OTIŠKI VRH	4,28	21.09.	4,12	2,17
2370	MISLINJA - DOVŽE	0,499	13.03.	0,546	0,255
2430	BISTRICA - MUTA	0,753	14.09.	1,14	0,500
2530	RADOLJNA - RUTA	0,463	19.08.	0,608	0,285
2652	DRAVINJA – VIDEM	2,11	20.08.	1,84	0,35
2720	ROGATNICA - PODLEHNIK	0,014	12.09.	0,042	0,001
2754	POLSKAVA - TRŽEC	0,283	12.09.	0,457	0,024
2900	PESNICA – ZAMUŠANI	0,354	21.08.	0,587	0,141
3060	SAVA DOLINKA – JESENICE	5,99	25.02.	4,42	2,82
3530	SAVA – MEDNO	29,7	18.08.	27,0	16,6
3650	SAVA – LITIJA	62,2	19.08.	46,7	25,9
3725	SAVA – HRASTNIK	46,3	19.08.	43,5	30,8
3850	SAVA – ČATEŽ	94,7	14.09.	77,0	48,3
4050	TRŽIŠKA BISTRICA - PRESKA	2,70	14.03.	2,34	1,61
4120	KOKRA – KOKRA	1,80	23.12.	1,36	0,716
4200	SORA – SUHA	5,12	19.08.	3,58	1,80
4400	KAMNIŠKA BISTRICA - KAMNIK	3,22	06.10.	2,08	1,14
4740	SOTLA – RAKOVEC	0,551	10.09.	0,892	0,337
4850	KOLPA – RADENCI	7,29	13.08.	6,23	3,36
4970	LAHINJA – GRADAC	0,61	26.08.	0,453	0,030
5080	LJUBLJANICA - MOSTE	9,84	23.09.	7,86	4,04
5330	BOROVNIŠČICA - BOROVNICA	0,080	21.09.	0,160	0,028
5500	GRADAŠČICA – DVOR	0,667	12.09.	0,460	0,285
5770	CERKNIŠČICA - CERKNICA	0,094	28.08.	0,110	0,000
6060	SAVINJA – NAZARJE	4,40	23.09.	3,45	1,44
6210	SAVINJA – VELIKO ŠIRJE	10,9	20.08.	9,70	4,10
6300	PAKA – ŠOŠTANJ	0,50	10.09.	0,39	0,059
6550	BOLSKA – DOLENJA VAS	0,605	13.09.	0,603	0,127
6720	VOGLAJNA – CELJE	0,254	15.09.	0,285	0,110
7040	KRKA – DVOR	3,78	17.09.	3,04	1,89
7160	KRKA – PODBOČJE	11,4	20.09.	9,83	4,40
8060	SOČA – LOG ČEZSOŠKI	5,24	03.02.	5,39	3,02
8180	SOČA – SOLKAN	21,0	12.01.	19,8	9,60
8350	IDRIJCA - PODROTEJA	1,59	07.09.	1,66	0,84
8450	IDRIJCA – HOTEŠK	6,19	09.09.	5,01	3,40
8500	BAČA – BAČA PRI MODREJU	1,79	07.08.	1,45	0,379
8565	VIPAVA – DOLENJE	2,08	30.08.	1,85	1,45
8590	VIPAVA – DORNBERK	1,49	16.07.	1,85	0,94
9050	REKA – CERKVENIKOV MLIN	0,255	08.09.	0,590	0,160
9210	RIŽANA - KUBED	0,118	20.09.	0,210	0,030



Graf 16: Minimalni specifični odtoki v letu 2004 in srednji minimalni in najmanjši specifični obdobni odtoki.

Graph 16: The minimum specific discharges in 2004 and the mean minimum and lowest specific discharges of the reference period.

Bohinjsko jezero pod snegom (foto: Marko Burger).

Bohinj lake under the snow (photo: Marko Burger).

B. PODZEMNE VODE

GLADINA PODZEMNIH VODA V ALUVIALNIH VODONOSNIKIH

Urša Gale

V osrednjih delih vodonosnikov Apaškega, Prekmurskega in Dravskega polja je v letu 2004 zaradi izrazitih hidroloških suš v letu 2002 in 2003 še vedno prevladovalo sušno vodno stanje. Pod dolgoletnim povprečjem so bile tudi gladine v pretežnih delih vodonosnikov Krško Brežiške kotline in Mirensko Vrtojbenskega polja. Zaloge podzemnih vod v vodonosnikih Ljubljanske in Celjske kotline so se v letu 2004 gibale nad dolgoletnim povprečjem. V delih Kranjskega in Ljubljanskega polja ter v Vipavski dolini so bile zaloge podzemne vode v letu 2004 nadpovprečne.

Podzemne vode predstavljajo pomemben člen hidrološkega kroga, v katerem se sestavni deli vodne bilance med seboj prepletajo. Stanje zalog podzemne vode predstavlja razmerje med dotoki in iztoki iz vodonosnikov. Viri napajanja podzemne vode so vezani na pronicanje padavin s površine vodonosnikov, na pronicanje padavin iz neposrednega padavinskega zaledja na obrobju ravnin in na pronicanje vode iz rek ali jezer. Podzemna voda se drenira oz. izceja v vodotoke, izgublja pa se tudi z evapotranspiracijo - izhlapevanjem in porabo rastlin. Evapotranspiracija je posebno pomemben člen vodne bilance v plitvih vodonosnikih severovzhodne Slovenije, kjer se zanjo porabi največji delež padavin. Zaloge podzemne vode se zmanjšujejo tudi z odvzemi za potrebe oskrbe z vodo. Ker je tok podzemne vode v aluvialnih vodonosnikih razmeroma počasen, se le-ti polnijo oziroma praznijo z določenim časovnim zaostankom. Čas zakasnitve odzivnosti gladine podzemne vode na zunanje vplive je odvisen tako od lastnosti vodonosnika kot tudi od lastnosti, vezanih na vir napajanja oziroma praznjenja. Za razumevanje vodnega stanja v aluvialnih vodonosnikih je tako potrebno upoštevati prostorsko in časovno spremenljivost količine padavin, evapotransipiracije in pretokov rek, ki mejijo na vodonosnike.

Padavine

Padavinske razmere so se po izrazito sušnem letu 2003 v letu 2004 vrnile nazaj v meje običajne spremenljivosti. Padavine so v povprečju ugodno vplivale na stanje zalog podzemne vode v aluvialnih vodonosnikih Ljubljanske in Celjske kotline. Na Ljubljanskem polju je bil zabeležen največji padavinski presežek, saj so v letu 2004 tam izmerili za petino več padavin, kot znaša dolgoletno povprečje. Povprečna letna količina padavin je bila v letu

B. GROUNDWATER

THE GROUNDWATER LEVELS IN THE ALLUVIAL AQUIFERS

Urša Gale

In the central parts of the aquifers of the Apaško, Prekmursko and Dravsko fields, drought conditions still prevailed in 2004 as a consequence of the marked hydrological droughts in 2002 and 2003. The levels were below the multi-annual mean in most parts of the aquifers of the Krško-Brežice Basin and in the Miren-Vrtojba field. The groundwater reserves in 2004in the aquifers of the basins of Ljubljana and Celje ranged above the multi-annual mean. In parts of the Kranj and Ljubljana fields and in the Vipava Valley, the groundwater reserves in 2004 were above-average.

Groundwater represents an important component of the hydrological cycle, in which the component parts of the water balance intertwine. The state of the groundwater reserves represents a ratio between the inflows into and outflows from the aquifers. The sources of groundwater recharge are linked to the infiltration of precipitation from the surface of the aquifers, to the infiltration of precipitation from the immediate precipitation catchment on the outskirts of plains and to the infiltration of water from rivers and lakes. Groundwater drains or percolates into watercourses and is also lost through evapotranspiration – evaporation and plant consumption. Evapotranspiration is an especially important component of the water balance in the shallow aquifers of northeastern Slovenia, for which the major part of precipitation is used. The groundwater reserves are also reduced by water abstraction to provide a water supply. Because the flow of groundwater in alluvial aquifers is relatively slow, the aquifers are recharged or emptied with a certain temporal delay. The delay time in the responsiveness of the groundwater level to the external effects depends on the characteristics of the aquifers as well as on the characteristics of the source of the recharging or emptying. In order to understand the water situation in alluvial aquifers, it is necessary to take into consideration the spatial and temporal variation in the quantity of precipitation, evapotranspiration and the discharges of rivers bordering on the aquifers.

Precipitation

Precipitation conditions following the distinctly drought-characterised year of 2003, returned in 2004 to within the limits of ordinary variation. The precipitation affected the state of the groundwater in the alluvial aquifers of the Ljubljana and Celje Ba-

2004 značilna za območja vodonosnikov Dravskega polja in Krško Brežiške kotline, manj padavin od dolgoletnega povprečje pa je bilo v letu 2004 v Vipavsko Soški dolini in Pomurju. Na Obali in Krasu je bil letni padavinski primanjkljaj največji in je znašal šestino povprečnih vrednosti. Najbolj deževen mesec je bil oktober, ko so ponekod zabeležili dvakratni presežek padavin, sledil pa je razmeroma suh november, ko dolgoletno mesečno padavinsko povprečje ni bilo doseženo. Povprečna debelina snežne odeje v visokogorju je bila v letu 2004 rahlo presežena. Ledenih in mrzlih dni ob morju ni bilo, v Ljubljanski kotlini pa je bilo 53 dni s snežno odejo.

Evapotranspiracija

Evapotranspiracija je zaradi nadpovprečnih temperatur in povečanega sončnega obsevanja v letu 2004 rahlo negativno vplivala na stanje zalog podzemne vode. Kljub negativnemu predznaku izgube niso bile velike, saj presežek povprečnih temperatur zraka ni presegel 1 ºC, presežek obsevanja, ki je bil zabeležen le v osrednji in zahodni Sloveniji, pa prav tako ni bil pomembno velik. Nekoliko nadpovprečen delež izgub vode zaradi evapotranspiracije je bil v letu 2004 tako zabeležen le na območjih vodonosnikov Ljubljanske in Celjske kotline ter Vipavsko Soške doline.

Pretoki rek

Količina vode, ki odteka iz rek v podzemno vodo, je odvisna od lastnosti vodonosnika, od dimenzij rečne struge, od prepustnosti rečnega dna in od razlike med gladinami površinske in podzemne vode. Večja vodnatost rek, ki so v hidravlični povezavi z vodonosnikom, ugodno vpliva na stanje zalog podzemne vode in obratno.

Vodnatost rek je bila v letu 2004 nadpovprečna v spomladanskem času in v mesecu oktobru, pretoki pa so bili nižji od običajnih v februarju, avgustu in septembru. V letu 2004 so bili povprečni pretoki Save za približno šestino nad povprečjem, kar je ugodno vplivalo na zaloge podzemne vode v vplivnih območjih vodonosnikov Ljubljanske in Krško Brežiške kotline. Zaradi padavinskega primanjkljaja v jugozahodni in severovzhodni Sloveniji so bili pretoki nižji od povprečnih v vodotokih, ki imajo napajalno zaledje v slovenskem Primorju in v Prekmurju.

Prostorska spremenljivost zalog podzemne vode v letu 2004

Značilne letne gladine, nizke (Hnk), srednje (Hs) in visoke (Hvk; graf 17, preglednica 22) so grobi pokazatelji vodnih zalog oziroma statistično povprečnega režima na letni ravni. Ti statistični kazalci omogočajo grobo oceno spremenljivosti v prostoru, ne morejo pa zajeti časovne spremenljivosti med letom. Primerjava srednjih letnih gladin glede na dolgoletno obdobje kaže na izrazito prostorsko podnebno raznolikost Slovenije, ki je bila značilna v letu 2004. Srednje letne vrednosti gladin (Hs) so bile pod dolgoletnim povprečjem na območjih, ki so utrpela izgube zaradi primanjkljaja padavin in presežka eva-

sins favourably on average. The largest precipitation surplus was recorded on the Ljubljana field, where a fifth more precipitation was measured in 2004 than in the multi-annual period. The average annual amount of precipitation in 2004 was characteristic for the areas of the aquifers of the Drava field and the Krško-Brežice Basin, while there was less precipitation than the multi-annual mean in 2004 in the Vipava-Soča Valley and in Pomurje. The annual precipitation deficit was the greatest on the coast and in the karst and it amounted to a sixth of the average values. The rainiest month was October when a double surplus of precipitation was recorded in some places. November was relatively dry and the multi-annual precipitation monthly mean was not reached. The average thickness of the snow cover in the high mountains in 2004 was slightly exceeded. There were no icy and cold days along the coast, while the Ljubljana Basin experienced 53 days of snow cover.

Evapotranspiration

Because of the above-average temperatures and increased insolation in 2004, evapotranspiration affected the state of groundwater reserves slightly negatively. Despite the negative tendencies, the losses were not great as the average air temperatures did not exceed 1 ºC above the average, and the insolation (only recorded in central and western Slovenia) was also not significantly above average. Therefore, a slightly above-average share of the loss of water due to evapotranspiration in 2004 was only recorded in the area of the aquifers of the Ljubljana and Celje Basins and the Vipava-Soča Valley.

River discharges

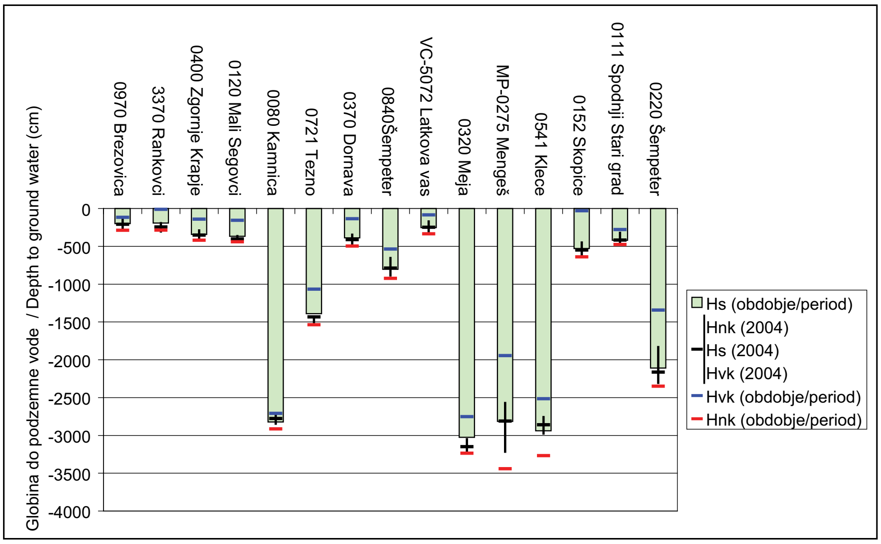
The quantity of water that infiltrates from rivers into the groundwater depends on the characteristics of the aquifer, on the dimensions of the river channel, the permeability of the river bed and on the difference between the levels of the surface water and groundwater. A higher stage of rivers that are hydraulically connected to the aquifer favourably affects the state of groundwater reserves.

The water level in the rivers in 2004 was above-average in springtime and in October, while was lower than normal for the months of February, August and September. In 2004, the average discharges of the Sava River were approximately a sixth above the average, which beneficially affected the groundwater reserves in the affected aquifers of the Ljubljana and Krško-Brežice basins. Because of the precipitation deficit in southwestern and northeastern Slovenia, discharges were lower than average in the watercourses with their recharge catchment in the Slovenian Primorje (Littoral) region and in Prekmurje.

The Spatial Variation of the Groundwater Reserves in 2004

The characteristic annual levels, low (Hnk), mean (Hs) and high (Hvk; Graph 17, Table 22) are rough indicator of the water reserves as well as an inpotranspiracije. Nizke letne konice (Hnk) so bile pod nizkimi konicami iz primerjalnega obdobja tudi zaradi obnavljanja zalog iz predhodnih sušnih obdobij. Maksimalne konice (Hvk) na nobeni od referenčnih postaj niso bile presežene, kar pomeni, da v letu 2004 ni bilo obdobij zelo intenzivnega napajanja vodonosnikov.

dicator of the statistically averaged regime at an annual level. These statistical indicators enable a rough assessment of the spatial variation, but they cannot encompass the temporal variability during the year. A comparison of the mean annual levels with respect to the multi-annual period shows the distinct spatial climatic variation in Slovenia that was characteristic of 2004. The mean annual level values (Hs) were below the multi-annual mean in the areas of the deficit of precipitation and above-average evapotranspiration. The low-water annual peaks (Hnk) were below the low-water peaks of the reference period, also because of the recharge of groundwater deficit from the previous drought periods. The maximum peaks (Hvk) were not exceeded at any of the reference stations, meaning that there were no periods of highly intensive recharging of the aquifers in 2004.



Graf 17: Primerjava značilnih gladin podzemnih vod v letu 2004 z značilnimi gladinami za primerjalno obdobje (Preglednica 22) (Hs – srednja letna/obdobna gladina, Hnk – najnižja letna/obdobna gladina, Hvk – najvišja letna/obdobna gladina).

Graph 17: A comparison of the characteristic groundwater levels in 2004 with the characteristic groundwater levels of the reference period (Table 1) (Hs – mean annual /reference period level, Hnk – minimum annual/reference period level, Hvk – maximum annual / reference period level).

V vodonosnikih severovzhodne Slovenije se je v letu 2004 nadaljevalo sušno obdobje iz preteklih let, ki traja neprekinjeno vse od leta 2000. Sušno stanje je bilo v letu 2004 na tem območju značilno predvsem za osrednja območja vodonosnikov Apaškega, Prekmurskega in Dravskega polja. Nadpovprečno stanje zalog v vodonosniku Vrbanskega platoja je bilo v letu 2004 domnevno tudi posledica povečane vodnatosti Drave. Takšno vodno stanje je v letu 2004 prevladovalo še na iztočnem delu iz vodonosnika Ptujskega polja ter na vtočnem delu vodonosnika Murskega polja, ki se napaja iz zaledja v Slovenskih Goricah.

V aluvialnih vodonosnikih jugovzhodne Slovenije so v letu 2004 prevladovale običajne in nizke gladine podzemne vode. Na pretežnih delih teh vodonosnikov so bile vrednosti Hs pod dolgoletnim povprečjem. Sušno stanje je prevladovalo v osrednjem delu Brežiškega polja ter na Krškem polju v okolici Gorice

In the aquifers of northeastern Slovenia, the drought from the previous periods, which has lasted continuously since 2000 continued in 2004. The drought situation in 2004 in this area was primarily characteristic of the central areas of the aquifers on the Apače, Prekmurje and Drava fields. The above-average situation of the reserves in the aquifer of the Vrbanski Plateau in 2004 was presumably also the result of the increased abundance of water discharges from the Drava River. A similar water condition also prevailed at the outflow from the aquifer of the Ptuj field and in the inflow area of the aquifer of the Mura field, which is recharged from the catchment in Slovenske Gorice.

In the alluvial aquifers of southeastern Slovenia, the regular and low groundwater levels prevailed in 2004. In the major part of these aquifers, the Hs values were below the multi-annual mean. The drought situation prevailed in the central part of the (merilno mesto 0330 Gorica na Krškem polju).

Plitvi vodonosniki Spodnje Savinjske doline so bili v letu 2004 nadpovprečno vodnati, k čemur je prispevala nadpovprečna letna količina padavin in nadpovprečna vodnatost Savinje.

Brežice field and on the Krško field in the surroundings of Gorica (at the 0330 Gorica at the Krško field gauging site).

The shallow aquifers of the Lower Savinja Valley in 2004 exhibited above-average groundwater reserves, to which the above-average annual precipitation and above-average stage of the Savinja River contributed the most.

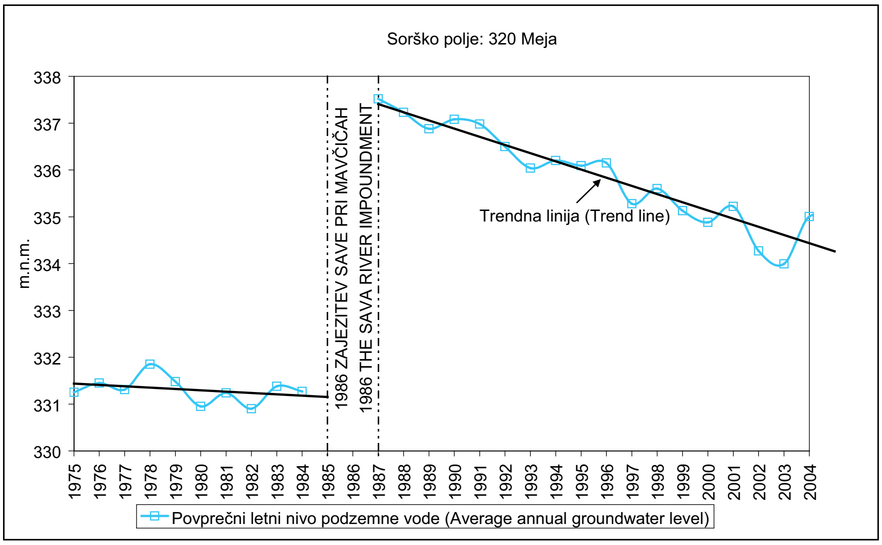
Preglednica 22: Primerjava značilnih gladin podzemnih voda v letu 2004 z značilnimi gladinami primerjalnega obdobja.

Table 22: A comparison of the characteristic groundwater levels in 2004 with the characteristic groundwater levels of the reference period.

Postaja Station	Vodonosnik Aquifer	2004			Obdobje/period					
		Hnk (cm)	Hs (cm)	Hvk (cm)	časovni niz Period	Hnk (cm)	Hnp (cm)	Hs (cm)	Hvp (cm)	Hvk (cm)
0970 Brezovica	PREKMURSKO POLJE	263	208	149	1980-2000	287	251	199	140	116
3370 Rankovci	PREKMURSKO POLJE	302	244	194	1971-2000	286	244	191	102	12
0400 Zgornje Krapje	MURSKO POLJE	404	351	290	1964-2000	420	383	343	283	142
0120 Mali Segovci	APAŠKO POLJE	444	402	365	1991-2000	441	409	366	274	157
0080 Kamnica	VRBANSKI PLATO	2845	2777	2714	1981-2000	2915	2877	2822	2757	2709
0721 Tezno	DRAVSKO POLJE	1527	1434	1460	1971-2000	1537	1479	1391	1268	1066
0370 Dornava	PTUJSKO POLJE	471	412	347	1961-1990	496	445	388	311	135
0840Šempeter	SP. SAVINJSKA DOL.	885	789	654	1982-2000	923	888	804	641	537
VČ-5072 Latkova vas	DOLINA BOLSKE	310	249	172	1975-2000	335	306	253	166	85
0320 Meja	SORŠKO POLJE	3232	3150	3052	1987-2000	3236	3095	3026	2891	2753
MP-0275 Mengeš	D.KAMNIŠKE BISTRICE	3216	2810	2572	1976-2000	3442	3148	2815	2332	1945
0541 Kleče	LJUBLJANSKO POLJE	2975	2859	2758	1974-2000	3269	3080	2939	2735	2516
0152 Skopice	KRŠKO POLJE	614	550	450	1980-2000	640	564	528	316	30
0111 Spodnji Stari grad	BREŽIŠKO POLJE	445	418	322	1971-2000	476	452	419	339	279
0220 Šempeter	VIPAVSKO-SOŠKA D.	2304	2164	1832	1971-2000	2350	2264	2109	1761	1343

Še bolj ugodne kot v vodonosnikih Celjske kotline so bile zaloge podzemne vode v vodonosnikih Ljubljanske kotline, saj je na pretežnih delih Kranjskega, Sorškega in Ljubljanskega polja prevladovalo zelo ugodno vodno stanje, k čemur so prispevale nadpovprečne letne padavine. Stanje zalog podzemne vode je bilo ugodno tudi za vodonosnik doline Kamniške Bistrice, kjer so prevladovale nadpovprečne gladine podzemne vode. Vodonosnik Vodiškega polja dolgoletne povprečne vrednosti gladine Hs ni dosegel. Visoko vodno stanje je bilo na pretežnem delu Sorškega polja odraz umetnega vpliva zajezitve Save pri Mavčičah. Ob zajezitvi leta 1986 je podzemna voda, ki je v hidravlični povezavi z reko, močno narasla. Dvig je mestoma znašal tudi preko 9 metrov. Od tedaj pa vse do danes spremljamo, zaradi zamuljevanja dna vodnega zadrževalnika, upadanje gladine podzemne vode. Kljub trendom zniževanja gladine so zaloge podzemnih vod od zajezitve dalje še vedno nad povprečjem, saj še ni doseženo območje naravne spremenljivosti gladine pred zajezitvijo (graf 18).

Even more favourable than in the aquifers of the Celje Basin were the groundwater reserves of the Ljubljana Basin. Very favourable water conditions prevailed here in most parts of the Kranj, Sora and Ljubljana fields due to the above-average annual precipitation. The state of the groundwater reserves was also favourable for the aquifer of the valley of the Kamniška Bistrica River, where above-average groundwater levels also prevailed. In the aquifer of the Vodice field the Hs reference period mean groundwater level was not reached. The high-water situation over most of the Sora field was a result of the artificial effect of the impoundment of the Sava River at Mavčiče. After the impoundment in 1986, the groundwater level, in hydraulic connection with the river, has risen significantly, up to over 9 metres in some places. Since then and up to now, a decrease in the groundwater level has been monitored because of the silting of the aquifer bed. Despite the decreasing trends of the groundwater level, the groundwater reserves have since the impoundment until today still remained above the average groundwater level before the impoundment. (Graph 18).

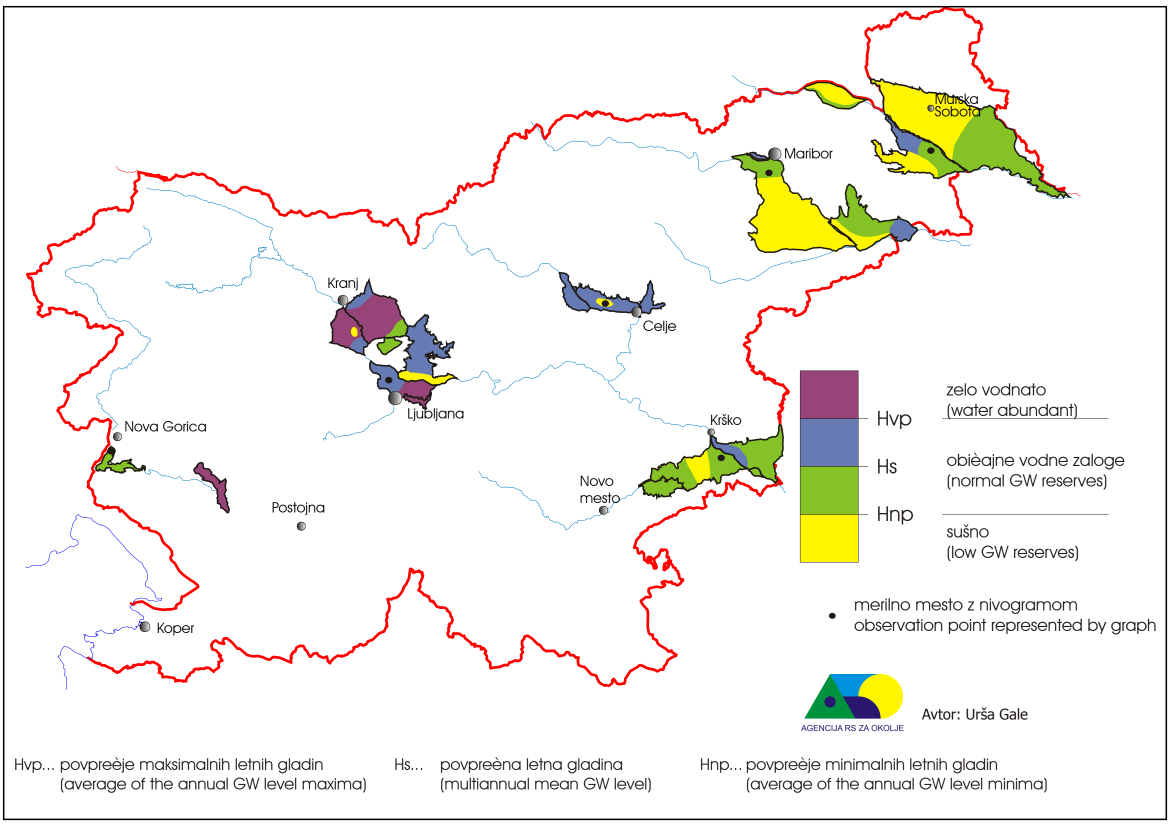


Graf 18: Vpliv zajezitve Save pri Mavčičah na nihanje srednjih letnih gladin podzemne vode na merilnem mestu Meja na osrednjem delu Sorškega polja.

Graph 18: The effect of the impoundment of the Sava River at Mavčiče on the fluctuation of the mean annual groundwater levels at the Meja gauging station in the central part of the Sorško field.

Vodonosnik Vipavske doline, ki se napaja pretežno iz Trnovskega gozda in Nanosa je bil v letu 2004 nadpovprečno vodnat. Vodonosnik Vrtojbensko Mirenskega polja, na katerega vpliva tudi vodnatost rek Vipave in Soče, pa v letu 2004 ni dosegel dolgoletnega povprečja.

The Vipava Valley aquifer, predominantly recharged from the Trnovski gozd forest and Mount Nanos, exhibited an above-average groundwater level in 2004. The aquifer of the Vrtojba-Miren field, also influenced by the water stage in the Vipava and Soča Rivers, did not reach the multi-annual mean in 2004.



Karta 8: Srednje letne gladine leta 2004 v največjih slovenskih aluvialnih vodonosnikih.

Map 8: The mean annual groundwater levels in 2004 in the major Slovenian alluvial aquifers.

Časovna spremenljivost zalog podzemne vode v letu 2004

V prvih dveh mesecih leta 2004 se je v aluvialnih vodonosnikih ob Muri nadaljevalo sušno stanje iz leta 2003. Podobno stanje je prevladovalo tudi v vodonosnikih ob Dravi in v Krško Brežiški kotlini. Štirje vodnjaki na Prekmurskem in Dravskem polju so bili v prvih mesecih leta suhi. Pod običajnimi vrednostmi zalog so bili praktično vsi večji aluvialni vodonosniki v vzhodni Sloveniji, zato je vsakršen odvzem vode v tem času pomenil črpanje statičnih zalog podzemne vode. Prostorsko spremenljivi primanjkljaji padavin v tem letnem času niso povzročili obsežnejše hidrološke suše v vodonosnikih, saj v tem obdobju leta še ni velikih izgub vode zaradi evapotranspiracije. Marca in aprila so se gladine podzemne vode v severovzhodni Sloveniji zaradi nadpovprečnih mesečnih padavin in povečane vodnatosti Mure in Drave nekoliko izboljšali, vendar smo kljub temu na osrednjih delih Apaškega, Prekmurskega in Dravskega polja še vedno lahko spremljali hidrološko sušo. Izboljšanje stanja zalog je bilo v marcu in aprilu zabeleženo tudi v vodonosnikih Krško Brežiške kotline, kjer so se gladine podzemne vode gibale v območju običajnih in nadpovprečnih vrednosti. V vodonosnikih Celjske in Ljubljanske kotline so se vodne zaloge iz nadpovprečno vodnatega januarja in februarja v marcu in aprilu zaradi obilnih padavin in povečane vodnatosti Save in Savinje še nekoliko izboljšale in v nekaterih območjih dosegle zelo ugodno vodno stanje. Tudi vodonosnik Vipavske doline je bil vse do junija zelo vodnat, k čemur so največ prispevali veliki pretoki oz. visoke gladine Vipave.

V času pozne pomladi in poletja se je zaradi višjih temperatur in večje porabe vode za rast rastlin povečal delež evapotranspiracije. Količine mesečnih padavin so tedaj prostorsko in časovno močno nihale. Tako je v Ljubljanski kotlini v povprečju padlo nekoliko manj padavin kot običajno, v Pomurju pa so junija izmerili močan padavinski presežek, ki mu je sledil izrazito suh julij. Na območju vodonosnikov Vipavsko Soške doline je bilo dolgoletno padavinsko povprečje preseženo le v maju, sledili pa so mu štirje meseci s padavinskim primanjkljajem. Med majem in avgustom so se kljub razmeroma neugodnim vremenskim razmeram, z izjemo v juniju, zaloge podzemnih voda nekoliko obnovile na območjih vodonosnikov, ki se napajajo iz Mure in Drave. Reki imata povirje v Alpah in imata zato značilni snežni pretočni režim z viškom v poletnih mesecih. To je ugodno vplivalo na stanje zalog podzemne vode v vplivnih območjih vodonosnikov Prekmurskega polja in Vrbanskega platoja. V maju so bile zaloge podzemnih voda v vodonosnikih Spodnje Savinjske doline zaradi majhne količine padavin in povečane evapotranspiracije pod dolgoletnim povprečjem, sledila sta dva meseca ugodnih vodnih razmer, k čemur je domnevno pripomogla predvsem povečana vodnatost Savinje. V avgustu, ko je gladina Savinje upadla in ko mesečne količine padavin niso dosegle povprečnih vrednosti, je večina aluvialnih vodonosnikov Celjske kotline utrpela hidrološko sušo. Zaradi stalnega primanjkljaja poletnih padavin in velike evapotranspiracije, so se vodne za-

The Temporal Variation of the Groundwater Reserves in 2004

The drought conditions from 2003 continued in the first two months of 2004 in the alluvial aquifers along the Mura River. Similar conditions also prevailed in the aquifers along the Drava River and in the Krško-Brežice Basin. Four wells on the Prekmurje and Drava fields were dry in the first months of the year. The groundwater reserves of practically all of the alluvial aquifers in eastern Slovenia were below the usual values, which is why any abstraction of water during this period meant the pumping of static groundwater reserves. The spatially variable precipitation deficits during this season did not cause extensive hydrological drought in the aquifers, as there are no great losses of water through evapotranspiration during this time of year. In March and April, the groundwater levels in northeastern Slovenia improved somewhat owing to the above-average monthly precipitation and the increased stages of the Mura and Drava Rivers. However, hydrological drought could still be observed in the central parts of the Apače, Prekmurje and Drava fields. Improved groundwater reserve conditions were also recorded in March and April in the aquifers of the Krško-Brežice Basin, where the groundwater levels ranged within usual and above-average values. Because of the abundant precipitation and increased stages of the Sava and Savinja Rivers, the water reserves resulting from the water-abundant months of January and February improved somewhat in the aquifers of the Celje and Ljubljana Basins in March and April, reaching highly favourable water conditions in some areas. The aquifer of the Vipava Valley was also abundant up until June. This was caused by high stages of the Vipava River.

In late spring and in the summer, the share of evapotranspiration increased because of increased temperatures and greater consumption of water for the growth of plants. The monthly precipitation fluctuated significantly in terms of space and time. There was on average slightly less precipitation than normal in the Ljubljana Basin, while in Pomurje a significant precipitation surplus was measured in June, followed by a notably dry July. In the area of the aquifers of the Vipava-Soča Valley, the precipitation multi-annual reference period mean was only exceeded in May, which was followed by four months exhibiting a precipitation deficit. Between May and August (though with the exception of June), despite the relatively unfavourable weather conditions, the groundwater reserves increased slightly in the area of the aquifers recharged from the Mura and Drava Rivers. The rivers have their headwaters in the Alps and therefore also have a characteristic nival discharge regime with the peak occurring in the summer months. This favourably affected the state of the groundwater reserves in those areas of the aquifers of the Prekmurje field and the Vrbanski Plateau that are under influence of recharge from these rivers. The groundwater reserves in the aquifers of the Lower Savinja Valley in May were below the multi-annual mean owing to the lower amount of precipiloge v vodonosnikih Krško Brežiške kotline neprestano zniževale, dokler v avgustu ni celotnega območja vodonosnikov jugovzhodne Slovenije zajela hidrološka suša. Podobno situacijo smo lahko opazovali na območju vodonosnikov Vipavsko Soške doline, kjer so bile gladine podzemne vode v avgustu na vseh območjih pod dolgoletnim povprečjem. Trend zniževanja gladin podzemne vode se je v aluvialnih vodonosnikih iz avgusta nadaljeval v mesec september. Hidrološka suša je tedaj prevladovala na Apaškem, Prekmurskem, Ptujskem in Dravskem polju, v vodonosnikih Krško Brežiške kotline, Spodnje Savinjske kotline in Vipavsko Soške doline.

Kljub deževnemu oktobru se zaloge podzemnih voda v pretežnih delih vodonosnikov Apaškega, Prekmurskega, Murskega in Dravskega polja tedaj še vedno niso povzpele nad povprečno raven. Osrednji deli Apaškega, Prekmurskega in Dravskega polja so ostali sušni vse do konca leta. Bolj ugodne so bile vodne zaloge v vodonosnikih Spodnje Savinjske doline, Krško Brežiške kotline in Vipavsko Soške doline, saj so se gladine podzemne vode v zadnji četrtini leta zvišale in so se do konca leta gibale v območju običajne spremenljivosti.

Kljub temu da so za poletne mesece značilne nizke zaloge podzemnih voda, v letu 2004 za vodonosnike Ljubljanske kotline temu ni bilo tako. Nadpovprečno vodnato stanje je poleti prevladovalo praktično v vseh vodonosnikih kotline, k čemur so pripomogli nadpovprečna vodnatost Save in presežek poletnih padavin. Podobno stanje smo v teh vodonosnikih spremljali vse do konca leta 2004.

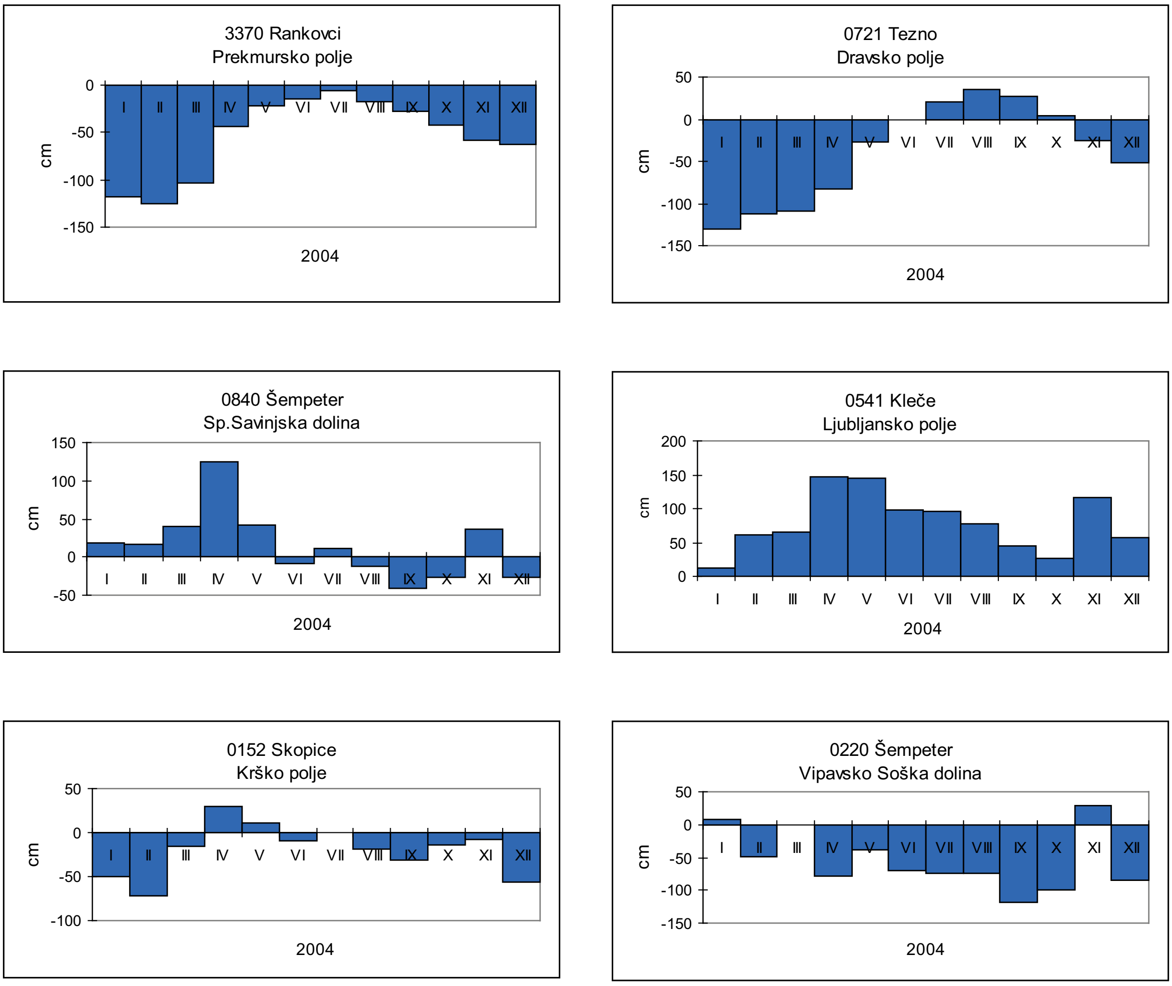
tation and increased evapotranspiration. This was followed by two months of favourable water conditions, presumably caused by the increased water infiltration from the Savinja River. In August, however, when the stage of the Savinja droped and when the monthly precipitation did not reach the average values, the majority of the alluvial aquifers of the Celje Basin suffered hydrological drought. Because of the constant deficit of summer precipitation and the extensive evapotranspiration, the water reserves in the aquifers of the Krško-Brežice Basin decreased continuously until the aquifers over the entire area of southeastern Slovenia were engulfed by hydrological drought in August. A similar situation could be observed in the aquifers of the Vipava-Soča Valley, where the groundwater levels in August were below the multi-annual mean in all areas. The trend of decreasing groundwater levels in the alluvial aquifers in August continued in September and the hydrological drought at the time prevailed in the Apače, Prekmurje, Ptujsko and Drava fields, in the aquifers of the Krško-Brežice Basin, the Lower Savinja Basin and in the Vipava-Soča Valley.

Despite a rainy October, the groundwater reserves in the major part of the aquifers of the Apače, Prekmurje, Mura and Drava fields still did not increased above the average level at this time. The central parts of the Apače, Prekmurje and Drava fields had low groundwater reserves up until the end of the year. The groundwater reserves in the aquifers of the Lower Savinja Valley, Krško-Brežice Basin and the Vipava-Soča Valley were more favourable as the groundwater levels increased in the last quarter and remained within the range of the normal variability up until the end of the year.

The summer months are usually being characterised by a low groundwater reserves, which was not a case in 2004 for the aquifers of the Ljubljana Basin. Above-average groundwater reserves prevailed in the summer in practically all the aquifers of this basin, which resulted from the above-average stage of the Sava River and the high summer precipitation. Similar conditions were being observed in these aquifers up until the end of 2004.

Globok vodnjak v Šentvidu pri Ljubljani, kjer na omočenem delu teče podtalnica iz zgornjega v spodnji horizont. (foto: Peter Frantar).

Deep well in Ljubljana – Šentvid. On the wet part of the well the underground water streams from upper to lower groundwater horizon (photo: Peter Frantar).



Graf 19: Odstopanja srednjih mesečnih gladin podzemne vode v letu 2004 glede na srednje mesečne gladine za primerjalno dolgoletno obdobje (priprava podatkov in grafov: V. Savić).

Graph 19: Deviations in the mean monthly groundwater levels in 2004 compared with the mean monthly groundwater levels for the multi-annual reference period (preparation of data and graphs: V. Savić).

Najnižje gladine podzemne vode so bili v nekaterih vodonosnikih zabeležene v prvih mesecih leta kot podaljšek hidrološke suše iz leta 2003, v drugih pa so bili odraz sušnega septembra in novembra ob koncu leta. Maksimalne vrednosti gladin podzemne vode so bile v letu 2004 v vodonosnikih severovzhodne Slovenije zabeležene v juliju in avgustu, v ostalih vodonosnikih pa so bile izmerjene v aprilu in ponekod v novembru kot zapozneli učinek padavinsko vodnatega oktobra.

Po splošnih značilnostih režima podzemnih vod je bilo leto 2004 hidrološko zelo pestro, kar je odraz podnebne raznolikosti leta in stanja zalog iz predhodnih let. Na eni strani smo bili priča nadpovprečnim vodnim zalogam, ki so prevladovale v Celjski, Ljubljanski in Vipavski kotlini, na drugi strani pa smo v vodonosnikih severovzhodne Slovenije ponekod že četrto leto zapored spremljali hidrološko sušo.

The lowest groundwater levels were recorded in some aquifers in the first months of the year, where they were a continuation of the hydrological drought of 2003, while in others they were recorded in the autumn as a result of the dry months of September and November. The maximum groundwater levels in 2004 in the aquifers of northeastern Slovenia were recorded in July and August, while in the other aquifers, these were measured in April and somewhere in November as a delayed effect of the abundant precipitation in October.

According to the general characteristic of the groundwater regime, the year 2004 was hydrologically a very varied one, which is a reflection of the diversity of weather throughout the year and the state of the reserves from previous years. On the one hand, above-average water reserves were observed, prevailing in the Celje, Ljubljana and Vipava Basins and, on the other, there was hydrological drought in the aquifers of northeastern Slovenia, occurring in some places for the fourth consecutive year.

C. IZVIRI

VODOSTAJI, TEMPERATUTRE IN SPECIFIČNE ELEKTRIČNE PREVODNOSTI IZVIROV

Niko Trišić

Mreža hidrološkega monitoringa izvirov se je v letu 2004 dopolnila z novimi merilnimi postajami. Poleg že delujočih na izvirih Divje jezero, Podroteja, Kamniška Bistrica in Metliški Obrh so pričele delovati še merilne postaje na Jezernici (postaja Divje jezero), Velikem Obrhu (Vrhnika), Krupi (Dolence I), Težki vodi (Stopiče), Rakitnici (Blate) in Loškem potoku (Travnik). Letne preglede hidroloških razmer objavljamo le za merilni postaji na Jezernici in Velikem Obrhu, ki sta pričeli delovati januarja oz. aprila. Jezernica, najkrajši slovenski vodotok, je površinski odtok Divjega jezera in desni pritok Idijce. Izvir Veliki Obrh pri Ložu, kjer izvira ponikalnica Trbuhovica, je prvi izvir Ljubljanice na slovenskem ozemlju. Izvirno območje Velikega Obrha je zajezeno, vodo izvira Veliki Obrh uporabljajo za oskrbo Loške doline.

Divje jezero, Jezernica in Podroteja. Na izviru Divje jezero je podatkovni niz vodostajev za leto 2004 zaradi težav na merilnikih sklenjen le do avgusta. Srednji mesečni vodostaji Divjega jezera, ki so bili v poletnih mesecih sušnega leta 2003 ekstremno nizki, so se v jesenskih mesecih 2003 zvišali, od januarja do avgusta 2004 pa so bili celo najvišji v opazovanem obdobju od leta 1999.

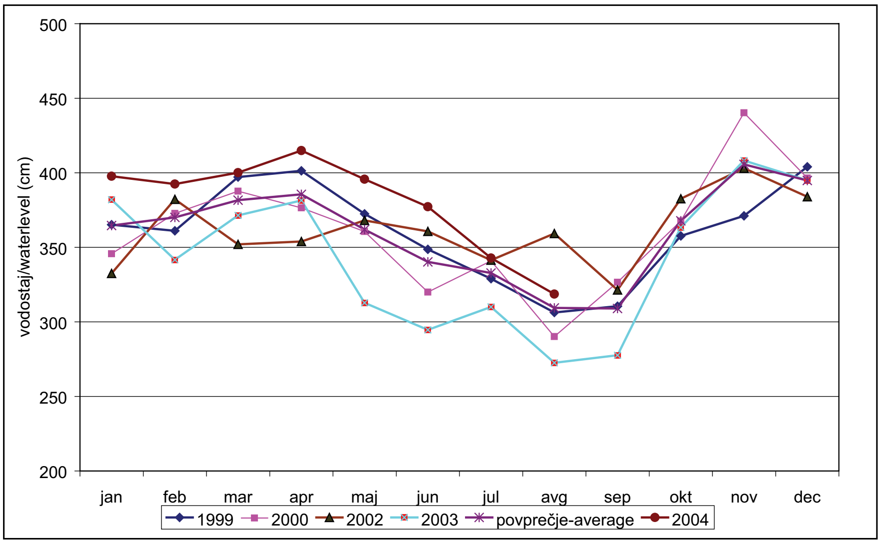
C. SPRINGS

THE WATER LEVELS, TEMPERATURES AND SPECIFIC ELECTRICAL CONDUCTIVITY OF SPRINGS

Niko Trišić

The hydrological spring monitoring network was supplemented in 2004 with new observation stations. In addition to those already in operation on the springs of Lake Divje, Podroteja, Kamniška Bistrica and Metliški Obrh, the observation stations on Jezernica (Lake Divje station), Veliki Obrh (Vrhnika), Krupa (Dolence I), Težka voda (Stopiče), Rakitnica (Blate) and Loški potok (Travnik) began operations. The annual overviews of the hydrological conditions are only published for the observation stations on Jezernica and Veliki Obrh, which began operating in January and April respectively. Jezernica, the shortest Slovenian watercourse, is an outflow of Lake Divje and the right-hand tributary of the Idrijca River. The spring of Veliki Obrh at Lož, where the Trbuhovica losing stream springs, is the first spring of the Ljubljanica River in the Slovenian territory. The springs of Veliki Obrh are impounded and the water from small reservoir is used for the water supply of the Lož Valley.

Lake Divje, Jezernica and Podroteja. On the spring of Lake Divje, the data set for water levels for 2004 is complete only up to August because of failures on gauges. The mean monthly water levels of Lake Divje, which were extremely low in the summer months of the drought year of 2003, increased in the autumn of 2003 and were at their highest from January to August of 2004, the highest in the observed period since 1999.



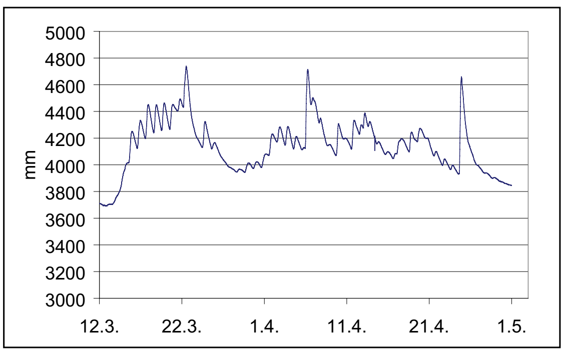
Graf 20: Srednji mesečni vodostaji na Divjem jezeru v obdobju 1999 – 2004.

Graph 20: The mean monthly water levels on Lake Divje in the 1999-2004 period.

Preglednica 23: Srednji mesečni vodostaji na Divjem jezeru (cm).

Table 23: The mean monthly water levels on Lake Divje (cm)

	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letni Annual
1999	365	361	397	401	373	349	329	306	310	358	371	404	360
2000	346	373	388	376	361	320	341	290	327	368	440	396	396
2002	332	382	352	354	368	361	341	359	321	383	403	384	363
2003	382	342	371	381	313	295	310	273	278	363	408	395	343
2004	398	392	400	415	396	377	343	318					
povp	365	370	382	386	362	340	333	309	309	368	406	395	365



Graf 21: Vodostaji Divjega jezera (v mm;15 minutne vrednosti).

Graph 21: The stages of Lake Divje (in mm; 15-minute values).

Prvi letni višek vodostajev in iztokov iz Divjega jezera nastopi leta 2004 že sredi januarja. Nivogram z dnevnimi nihanji vodostajev Divjega jezera (graf 21) in Podroteje v letu 2004 kaže na napajanje izvirov iz snežnih zalog v zaledju še vse do konca aprila. Najmanjši vodostaji na izvirih v Podroteji in na iztoku Jezernice so nastopili šele v sredini septembra, drugi letni višek pa po več zaporednih visokovodnih valovih konec oktobra.

The first annual peak of the water stages and outflows from Lake Divje in 2004 occurred as early as the middle of January. The daily oscillation records of the water stages of Lake Divje (Graph 21) and Podroteja in 2004 show that the springs were being recharged from the snow reserves in the catchment area up until the end of April. The lowest stages of the springs in Podroteja and at the mouth of the Jezernica River occurred only in the middle of September, while the second peak occurred after several consecutive high-water waves at the end of October.

Značilen časovni razpored vrednosti kažeta tudi temperatura in specifična električna prevodnost, ki sta nizki v zimskih mesecih in v času topljenja snega, v poletnem času, ko so zadrževalni časi vode v podzemlju daljši, pa višji. Vrednosti so značilne za območje Visokega dinarskega krasa in se gibljejo v razponu med 8,3 in 9,3 °C ter med 264 in 362 μS/cm. Podatki so za izvir Podroteja, ki podaja realne vrednosti obeh veličin brez vplivov bližine površja, saj so merilne sonde v zajetju izvira.

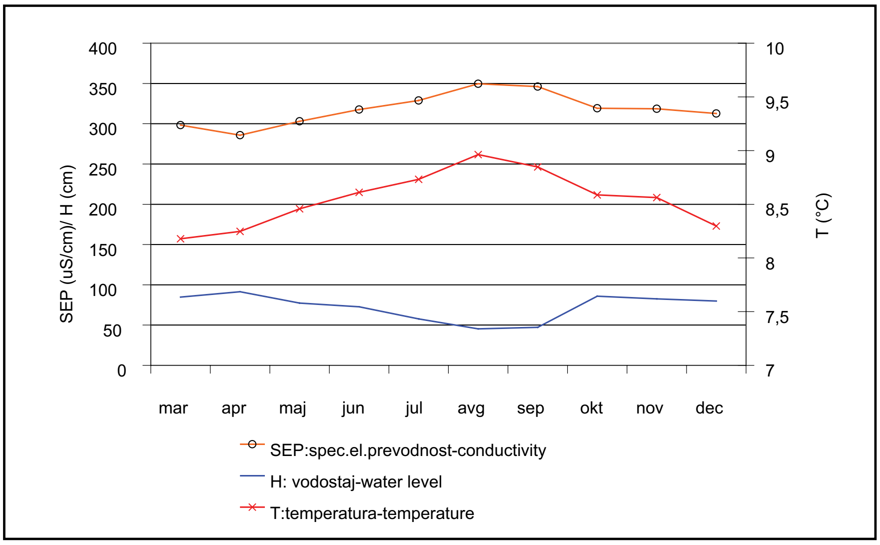
The characteristic temporal distribution of the values is also evident in the temperature and specific electrical conductivity, which are low in the winter months as the snow melts, and higher in the summertime when the water residence time in the underground is longer. The values are characteristic for the area of the High Dinaric Karst and ranges between 8.3 and 9.3 °C and between 264 and 362 μS/cm. The data are given for the Podroteja spring, which indicates the real values of both quantities without the effects of proximity to the surface as the measuring probes are located in the capped spring.

Izvajanje meritev na Jezernici
(foto: Jure Jerovšek).

Measuring procedure on Jezernica River
(photo: Jure Jerovšek).

Največji pretok Jezernice v letu 2004 je na podlagi pretočne krivulje ocenjen na blizu 80 m^3/s. Površinskega iztoka iz Divjega jezera pri vodostajih Jezernice pod 60 cm ni, takrat ves iztok podzemno odteka proti izvirom v Podroteji.

The maximum discharge of the Jezernica River in 2004 is assessed on the basis of the rating curve at close to 80 m3/s. There is no surface outflow from Lake Divje at stages of the Jezernica River falling below 60 cm, as the water flows solely underground towards the springs in Podroteja at that time.



Graf 22: Srednja mesečna specifična električna prevodnost, vodostaj in temperatura vode v izviru Podroteja v letu 2004.

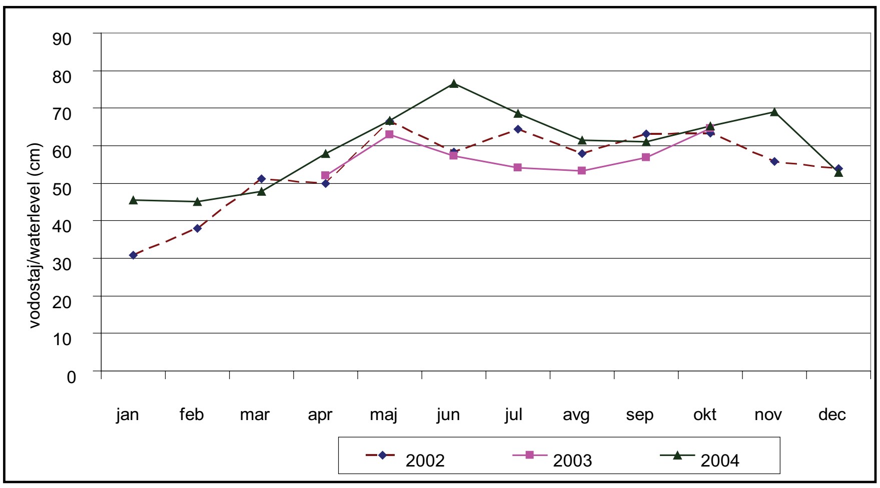
Graph 22: The mean monthly specific electrical conductivity, water stage and water temperature in the spring of Podroteja in 2004.

Kamniška Bistrica.

Reprezentativna merilna postaja na območju Alpskega krasa, na kateri se zvezno spremlja vodostaj, temperaturo in specifično električno prevodnost, je na izviru Kamniške Bistrice. Iz nizov podatkov, ki smo jih kljub občasnim prekinitvam v delovanju podatkovnega zapisovalnika uspeli zbrati, lahko razberemo posebnosti njenega vodnega režima glede na druga kraška območja v Sloveniji.

The Kamniška Bistrica River

The representative gauging station in the area of the Alpine Karst, where the water stage, temperature and specific electrical conductivity are continuously monitored, is located on the spring of the Kamniška Bistrica River. From the data sets that we managed to compile (in spite of the occasional interruptions to the operation of the data logger), we could discern the peculiarities of its water regime in comparison with the other Karst areas in Slovenia.

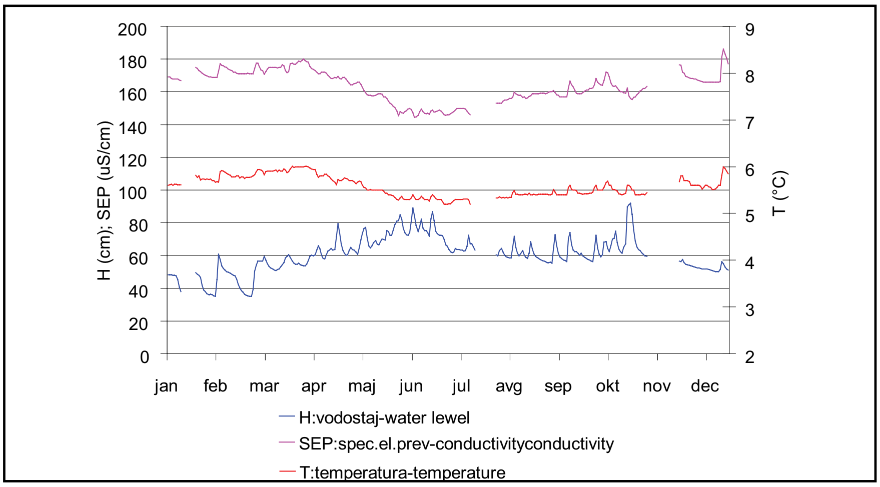


Graf 23: Srednji mesečni vodostaji izvira Kamniške Bistrice v letih 2002 – 2004.

Graph 23: The mean monthly stages of the spring of the Kamniška Bistrica River in the 2002-2004 period.

Najnižji vodostaji na izviru Kamniške Bistrice nastopajo v zimskih mesecih, ko se v zaledju izvira, v visokogorju Kamniško–Savinjskih Alp, padavine zadržujejo v obliki snega. Zaradi počasnega odtoka in daljšega zadrževalnega časa v vodonosniku je temperatura vode in njena specifična električna prevodnost pozimi višja kot v poletnih mesecih, ko hitrejši iztok snežnice vpliva na zniževanje teh vrednosti. Nihanja oz. razponi vrednosti so relativno majhni, vendar značilni. Temperatura izvira je bila v ozkem razponu od 5,2 °C junija in julija do največ 6,1 °C v marcu in aprilu. Povprečna letna temperatura izvira je bila 5,6 °C. Tudi razpon specifične električne prevodnosti vode je bil majhen, med 136 in 187 µS/cm, povprečna letna vrednost je bila 163 µS/cm.

The lowest water stages in the spring of the Kamniška Bistrica River occur in the winter months when the precipitation in the spring's catchment area, in the high-mountains of the Kamnik-Savinja Alps, remains in the form of snow. Because of the slow runoff and longer residence in the aquifer, the water temperature and its specific electrical conductivity are higher in winter than in the summer months when the faster runoff of snow melt causes a reduction in these values. The fluctuation or range of the values is relatively small, but characteristic nevertheless. The spring temperature exhibited a narrow range from 5.2 °C in June and July up to a maximum of 6.1 °C in March and April. The average annual temperature of the spring was 5.6 °C. Even the range of the water's specific electrical conductivity was small, ranging between 136 and 187 µS/cm, with the average annual value being 163 µS/cm.



Graf 24: Srednji mesečni vodostaj, specifična električna prevodnost in temperatura vode v izviru Kamniške Bistrice v letu 2004.

Graph 24: The mean monthly water stage, specific electrical conductivity and temperature of the water in the spring of the Kamniška Bistrica River in 2004.

Metliški Obrh

Na območju Bele krajine je v programu hidrološkega monitoringa merilna postaja Metlika na izviru Metliškega Obrha, ki je najpomembnejši vodni vir za oskrbo mesta. Zaledje izvira je na jugovzhodnem pobočju Gorjancev. Izvir je stalen, v poletnih mesecih pa se pretok močno zmanjša in pojavljajo se težave pri zagotavljanju zadostnih količin za vodooskrbo.

Vodostaji so bili na tem izviru v razponu od 20 do 77 cm. Značilni sta bili dve visoki vrednosti, prva meseca marca in druga oktobra. Dne 4. septembra 2004 zabeleženi najnižji vodostaj (11 cm) značilno odstopa od ostalih najnižjih vrednosti v avgustu in septembru in je domnevno posledica umetnega vpliva. Pretok je ob tem vodostaju znašal okoli 0,05 m^3/s. Temperatura in specifična električna prevodnost vode izvira sta v primerjavi z območji Alpskega in Visokega dinarskega krasa precej višji. Srednja temperatura vode (Ts) je višja za 2 °C, specifične električne prevodnosti pa za več kot 100 µS/cm glede na povprečne vrednosti v Visokem dinarskem krasu. Glede na Alpski kras pa so, zaradi razlik v nadmorski višini hidrografskega zaledja, te razlike še večje.

Metliški Obrh

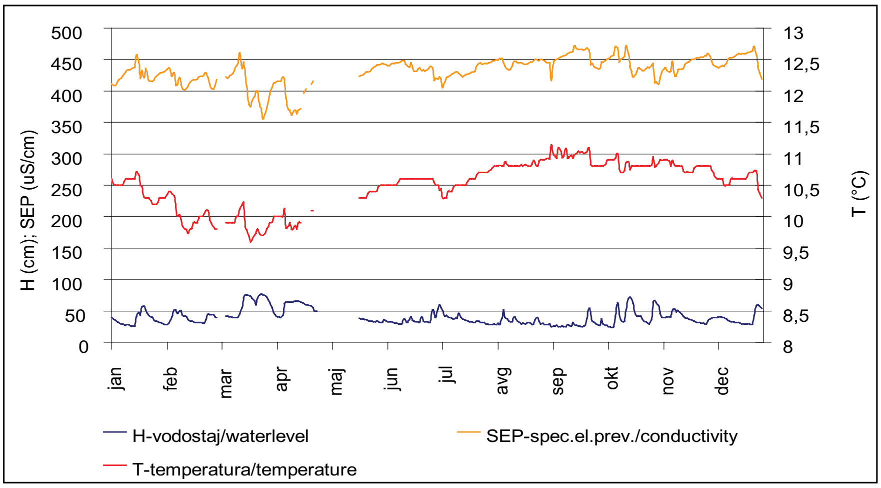
The Metlika gauging station, which is a part of the programme of hydrological monitoring of the Bela krajina region, is located on the Metliški Obrh spring, the most important water source for the town's water supply. The spring catchment area lies on the southeastern slope of the Gorjanci Mountains and the spring is a permanent one. The spring discharge is greatly reduced in the summer months and problems appear in ensuring sufficient quantities for the water supply.

The water stages on this spring range from 20 to 77 cm. Two high values were characteristic, the first occurring in March and the second in October. On 4 September 2004, the lowest stage recorded (11 cm) deviated significantly from the other lowest values in August and September and is presumably the result of artificial effects. The discharge at this water stage amounted to around 0.05 m^3/s. The temperature and specific electrical conductivity of the spring water were much higher in comparison with those in the areas of the Alpine and High Dinaric Karst. The mean water temperature (Ts) is 2 °C higher and the specific electrical conductivity is more than 100 µS/cm higher than the average value in the High Dinaric Karst. With respect to the Alpine Karst, these differences are even greater because of the differences in the elevation above the sea level of the hydrographic catchment.

Preglednica 24: Srednji mesečni vodostaj, specifična električna prevodnost in temperatura vode za Metliški Obrh v letu 2004.

Table 24: The mean monthly stage, specific electrical conductivity and temperature of the water for the Metliški Obrh Spring in 2004.

	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letni Annual
h cm	36	39	60	56	35	34	38	33	29	40	42	37	40
SEP	426	417	406	393	433	439	429	445	454	445	438	450	433
T	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



Graf 25: Srednji dnevni vodostaji, specifične električne prevodnosti in temperature vode Metliškega Obrha v letu 2004.

Graph 25: The mean daily stages, specific electrical conductivities and temperatures of the water of the Metliški Obrh Spring in 2004.

Veliki Obrh

V letu 2004 so bile meritve ponovno vzpostavljene v profilu Velikega Obrha pri Vrhniki na Loškem polju, ki je bil že vključen v hidrološko mersko mrežo v letih od 1961 do 1970 ter od 1981 do 1985. Izvir je zaradi svoje izdatnosti pomemben za preskrbo prebivalstva in hkrati za oceno stanja v telesu podzemne vode Ljubljanice. Območje izvira je zajezeno, zato je merski profil približno kilometer dolvodno v vasi Vrhnika. Največje amplitude so bile na tem merskem profilu zabeležene v jesenskih mesecih in konec decembra. V nivogramu urnih vrednosti pa so opazni sunki v nihanju vodostajev, ki so posledica manipulacij na jezovnih zapornicah. Največji pretok v letu 2004 je bil zabeležen konec decembra (17,4 m^3/s), kar je manj od srednjega obdobnega velikega pretoka. Mali pretok (0,1 m^3/s) v letu 2004 pa je enak srednjim obdobnim malim pretokom.

Veliki Obrh

In 2004, measurements were established again in the cross-section of the Veliki Obrh Spring at Vrhnika na Loškem polju, which had been included in the hydrological gauging network in the 1961-1970 and 1981-1985 periods. Because of its abundance of water, the spring is important for the water supply of the population, as well as for the assessment of the state of the groundwater body of the Ljubljanica River. The area of the spring is capped, which is why the water-gauging cross-section is approximately one kilometre downstream in the village of Vrhnika. The greatest amplitudes in this water gauging cross-section were recorded in the autumn months and at the end of December. Spikes in the water stage fluctuation are noticeable from the records of hourly values, resulting from the manipulation of sluicegates. The largest discharge in 2004 was recorded at the end of December (17.4 m^3/s), which is less than the mean large discharge of the reference period. The lowest discharge (0.1 m^3/s) in 2004 is the same as the mean low discharges of the reference period.

Preglednica 25: Srednji mesečni in letni pretok na vodomerni postaji Vrhnika na Velikem Obrhu (obdobje in leto 2004).

Table 25: The mean monthly and annual discharge at the Vrhnika na Velikem Obrhu gauging station (for the reference period and the year 2004).

	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letni Annual
Qs 61-70/81-85	1.66	1.64	2.69	3.42	1.82	1.95	1.26	0.95	1.57	2.07	2.69	2.43	2.01
Qs -2004				1,70	1.80	1.10	1.00	0.30	0.20	3.00	3.10	2.80	1.70

D. MORJE

D. THE SEA

PLIMOVANJE MORJA

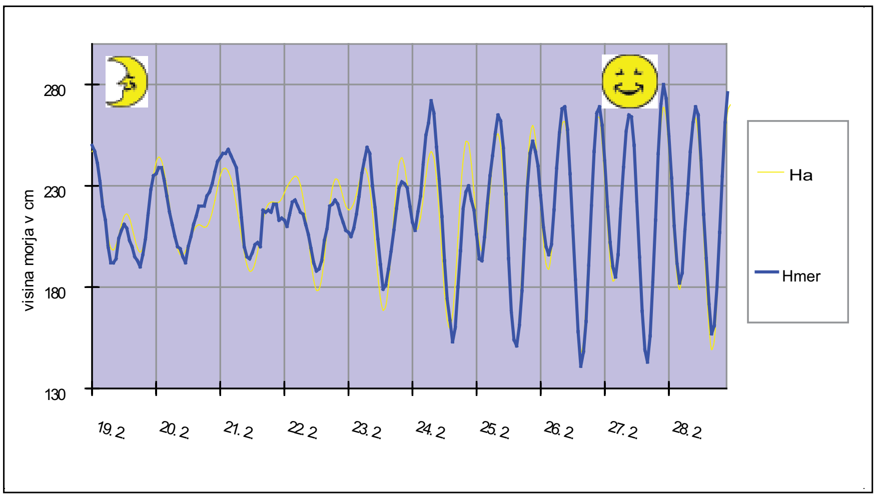
Mojca Robič

Plimovanje, ki je poleg valovanja najizrazitejši pojav spreminjanja gladine morja, je posledica astronomskih in meteoroloških dejavnikov ter lastnega nihanja Jadranskega morja. V Jadranskem morju se navadno dnevno zamenjata dve plimi in dve oseki. Na plimovanje v največji meri vpliva gravitacijska privlačnost med Luno, Soncem in Zemljo, kar imenujemo astronomska plima. To je zaradi znanega cikličnega gibanja nebesnih teles možno napovedati vnaprej. V času mlaja in ščipa, ko sta Sonce in Luna v konjunkciji oz. opoziciji, se vplivi plimotvornih sil seštevajo in amplitude plimovanja so velike. Ob prvem in zadnjem krajcu, ko sta Sonce in Luna v kvadraturi, so amplitude manjše.

SEA LEVELS

Mojca Robič

In addition to the wave action, the tidal action is the most prominent phenomenon of the changing of the sea level. It results from astronomical and meteorological factors (atmospheric forcing), as well as from the Adriatic Sea self-induced oscillation (seiche). Two high and two low tides usually alternate daily in the Adriatic Sea. The tidal action is primarily influenced by the gravitational attraction between the Moon, the Sun and the Earth, and this part is called an astronomical tide. It can be forecast in advance because of the known cyclical movement of the celestial bodies. During new moon and full moon, when the Sun and the Moon are in conjunction or in opposition, the effects of the tide-forming forces are cumulated and the tidal action amplitudes are at their greatest. During the waxing and waning moon when the Sun and the Moon are in quadrature, the amplitudes are smaller.



Astronomska višina morja ob prvem krajcu in ob polni luni (ščipu) kaže občutno razliko v amplitudi plimovanja.

Tidal amplitude at first or last quarters and at full or new moon are significantly different.

Razliko med izračunano astronomsko in dejansko izmerjeno višino morja imenujemo residualna višina. Njena vrednost je odvisna največkrat od meteoroloških dejavnikov, včasih pa tudi od lastnega nihanja morja. Od meteoroloških dejavnikov sta najbolj vplivna veter in zračni pritisk. Z zniževanjem zračnega pritiska se gladina morja zviša. Južni ali jugovzhodni veter nariva vodne mase na obalo severnega Jadrana in prav tako povzroči zvišanje gladine.

The difference between the calculated astronomical sea levels and those actually measured is known as the residual sea level. Its value most frequently depends on atmospheric forcing and sometimes on the seiche. The most influential parameters of atmospheric forcing are the air pressure and the wind. With a decrease in air pressure, the sea level rises. Also, southern and southeastern winds push the water masses towards the shore of the north

Obratno burja znižuje gladino, saj piha s kopnega proti odprtemu morju. Lastno nihanje morja se pojavi v zaprtih in delno zaprtih morjih. V Jadranu ima ob južnem vetru periodo okoli 21 ur, ob jugozahodniku pa le nekaj ur.

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 njih izračunamo povprečje (SVVV v tabeli D.2.). Izračunamo tudi srednjo visoko vodo, ki je povprečje obeh visokih voda v dnevu, oz. vseh v mesecu ali letu (SVV v tabeli D.2.), ter določimo najvišjo gladino morja v mesecu ali letu (NVVV v tabeli D.2. in D.4.).

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

Morje je bilo v letu 2004 zelo visoko. Srednja letna višina (SLV) morja je bila 220.8 cm, to je največja srednja letna višina vode v obdobju merjenja v Kopru (graf 26).

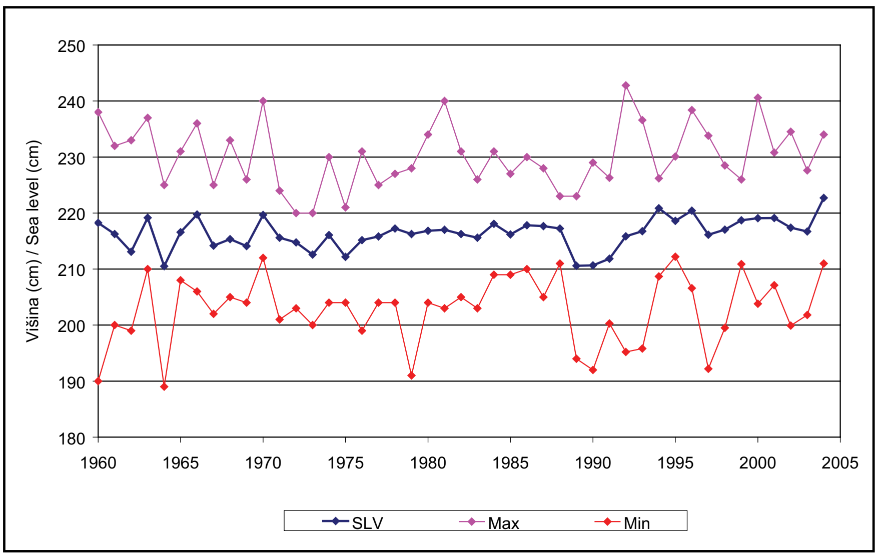
Adriatic Sea, thus also causing a rise in the sea level. Conversely, the bora wind decreases the sea level as it blows from the land towards the high seas. Seiche appears in enclosed and partially enclosed seas. In the Adriatic, with the south wind blowing, it has a period of around 21 hours, and a period of only a few hours with the southwestern wind blowing.

When monitoring the sea levels, both the hourly (values from on the hours) and extreme values (usually, there are two instances of high- and low-water in a day) are analysed. From the hourly data, the mean daily value (SDV in Table D.3.) can be calculated, and, subsequently, the mean monthly value (SMV in Table D.3.) and finally, the mean annual value (SLV in Table D.3.).

While monitoring the high-water conditions, it is determined which of the high water marks was the highest (VVV) and, from this, the average (SVVV in Table D.2.) is calculated. The mean high water is also calculated as an average of both high waters within a day or the average of all the high waters within a month or year (SVV in Table D.2.). We also determine the highest sea level occurring in a month or a year (NVVV in Tables D.2. and D.4.).

Low waters are similarly handled, where the lowest of both extremes (NNV) is determined and, from this data, the average (SNNV in Table D.2.) is calculated. The mean low water (SNV in Table D.2.) is the average of all the low waters in a day, month or year. The lowest sea level within a month or year is designated NNNV and is found in Tables D.2. and D.4.

The sea was very high in 2004. The mean annual sea level (SLV) was 220.8 cm, which is the highest mean annual sea level recorded in Koper in the period of measurement (Figure 26).



Graf 26: Srednje letne višine morja (SLV) ter najvišja in najnižja srednja mesečna višina vode (SMV) v dolgoletnem obdobju. Srednja letna višina morja leta 2004 je bila najvišja v obdobju, tudi najvišja in najnižja mesečna vrednost sta bili nadpovprečni.

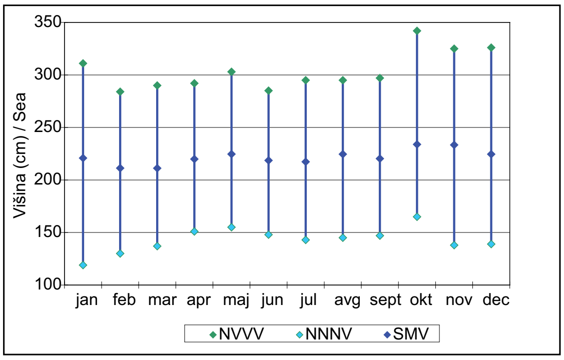
Graph 26: Mean annual sea level (SLV), the highest and lowest mean monthly sea levels (SMV) in long term period. The mean sea level in 2004 was the highest in the period, the highest and lowest mean monthly values were also above the everage.

Po višini je izstopala tudi srednja nizka voda (SNV), ki je bila s 188 cm za en cm višja od obdobnega (1961-2000) maksimuma. Srednja visoka voda (SVV), najvišja (NVVV) in najnižja (NNNV) gladina morja v letu so bile nadpovprečne.

Najvišja srednja mesečna višina morja in najvišja letna višina morja sta bili zabeleženi oktobra. Jesenski meseci so za letne ekstreme običajni.

According to the water level, the mean low water (SNV) was 188 cm, one centimetre higher than the multi-annual reference period (1961-2000) maximum value. The mean high water (SVV) and the maximum (NVVV) and minimum (NNNV) sea levels in the year were also above-average.

The highest mean monthly sea level and the highest annual sea level were recorded in October. The autumn months were normal in terms of the annual extremes.

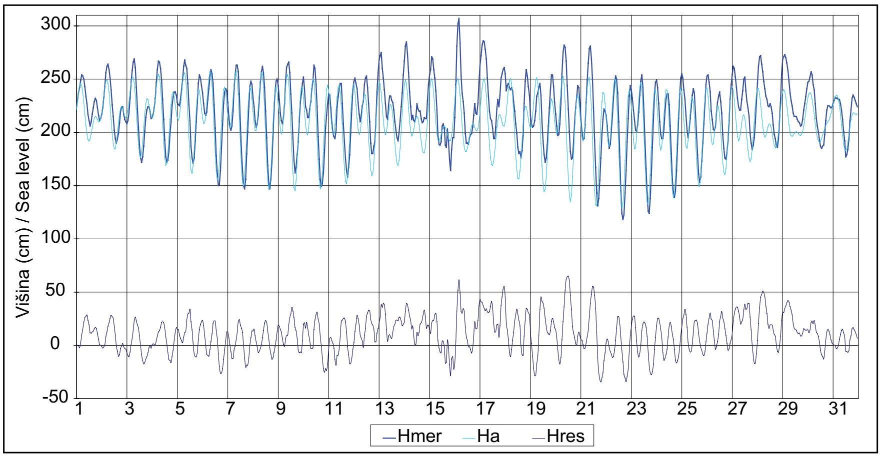


Graf 27: Srednje mesečne višine morja (SMV) z najnižjimi (NNNV) in najvišjimi (NVVV) mesečnimi višinami za leto 2004.

Graph 27: Mean monthly sea level (SMV), the lowest (NNNV) and highest (NVVV) sea levels in 2004.

Januar je navadno mesec, ko je morje prej nizko kot visoko. Tudi januarja 2004 je bila zabeležena najnižja oseka v letu. 119 cm je bilo izmerjenih 22. januarja popoldan. To je nekaj nižje od srednje obdobne vrednosti. Vendar je bilo morje večino meseca visoko in je precej odstopalo od napovedanih vrednosti. To je posledica prevlade nizkega zračnega tlaka, ki je skupaj z južnim vetrom zviševal morsko gladino. Srednja višina morja je bila zato visoka, 221 cm, kar je 8 cm višje od srednje vrednosti za januar v obdobju 1961-2000, najvišje obdobne vrednosti pa ne dosega. Najvišja gladina morja, 310 cm, je bila visoka, blizu najvišje obdobne vrednosti, in dovolj visoka, da je povzročila kratkotrajno poplavitev nižje ležečih delov obale. V enem tednu sta se tako zvrstili najnižja oseka v letu in najvišja gladina v mesecu. Razlika med njima je velika, 192 cm, največja v letu 2004 in hkrati izenačena največja amplituda v obdobju 1960 -1990.

January is usually when the sea level is low rather than high. The lowest low tide of the year was recorded in January of 2004. 119 cm was measured in the afternoon of 22 January. This is somewhat lower than the mean reference period value. However, the sea was also high for the major part of the month and the levels deviated significantly from the values forecast. This results from the prevalence of low air pressure together with the southern wind, which raised the sea level. The mean sea level was therefore high, at 221 cm, which is as much as 8 cm higher than the mean value for January in the 1961-2000 period, however still being below the maximum reference period value. The maximum sea level, 310 cm, was also high. It was close to the maximum reference period value and high enough to cause short-term flooding of lower-lying parts of the coast. It was thus that the lowest annual low tide and the highest sea level of the month followed each other within the period of one week. The difference between the two was high – 192 cm. It was the largest in 2004 and at also equalled the maximum amplitude in the 1960-1990 period.



Graf 28: Morje je bilo v januarju večinoma precej visoko, višje od pričakovanega, a tudi zelo nizko (119 cm, 22. januarja), najnižje v letu 2004.
Legenda: Vv = hitrost vetra
dP = razlika zračnega pritiska do srednje vrednosti 1016 mb
Hmer = izmerjena višina morja
Ha = astronomska višina morja

Graph 28: Sea level in January was high in general, but also very low (119 cm, 22nd of January), the lowest in 2004.
Legend: Vv = wind velocity
dP = deviation of air pressure from the mean value 1016 mb
Hmer = measured sea level
Ha = astronomical sea level

Ob koncu januarja sea je nad Primorjem ustalilo območje visokega zračnega pritiska in se tam obdržalo še dobršen del **februarja**. Tako je bila gladina morja v prvih dveh tretjinah meseca podobna napovedanim vrednostim ali nekoliko nižja (slika 5). Po 19. februarju je prevladoval nizek zračni pritisk in močan veter, ki je predvsem v zadnjih dneh meseca zviševal gladino morja. Najvišja gladina 284 cm je bila izmerjena 27. februarja. Vse značilne vrednosti so bile podobne srednjim obdobnim (1961-2000) za februar.

Podobne vremenske razmere so se nadaljevale tudi v začetku **marca**. Sledilo je obdobje povišanega zračnega pritiska in ustaljenega vremena, ko je bila gladina morja podobna napovedani ali malo nižja. Mesečne vrednosti značilnih gladin morja so podobne srednjim obdobnim (1961-2000) ali malenkost višje.

Aprila je bilo morje visoko, vendar ne ekstremno. Gladine so bile ves mesec višje od napovedanih. Vse karakteristične vrednosti so v primerjavi z obdobjem nekje na sredini med srednjo in najvišjo vrednostjo.

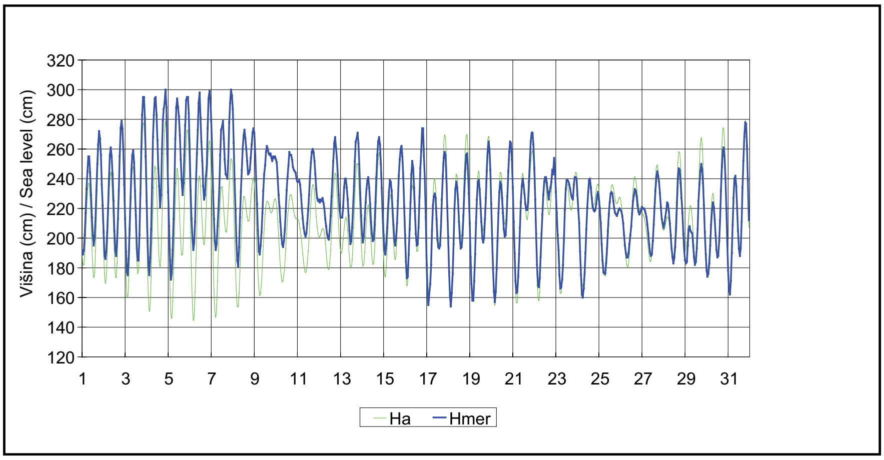
V prvi polovici **maja** so se vremenske razmere iz aprila nadaljevale in stopnjevale. Zračni pritisk je kar nekaj dni vztrajal zelo nizko, pod 1000 mb, hkrati pa je pihal veter iz južnega kvadranta, kar je močno zviševalo gladino morja. Vremenski pogoji in visoka astronomska plima so povzročili, da je morje v prvi polovici meseca kar sedemkrat preseglo mejo, ko se začne razlivati po nižje ležečih delih obale. Najvišja gladina morja, 303 cm, je bila zabeležena 4. maja v večernih urah. Srednja mesečna vrednost je bila visoka, le 5cm nižja od najvišje obdobne. Posebej visoka je bila v primerjavi z obdobjem najnižja nizka voda (155 cm), ki je bila za centimeter višja od maksimuma, izmerjenega v obdobju 1961-2000. Srednja visoka in najvišja visoka voda sta bili nad srednjo obdobno vrednostjo, obdobnih maksimumov pa nista dosegli.

At the end of January, an area of high air pressure stabilised above the Primorska region (the Slovenian Littoral) and stayed there for the major part of **February**. The sea level in the first two thirds of the month was therefore either similar to the forecast values or slightly lower (Figure 5). After 19 February, low air pressure prevailed again, as did the strong winds, which raised the sea level primarily in the last days of the month. The highest sea level, 284 cm, was measured on 27 February. All the characteristic values were similar to those of the mean reference period (1961-2000) for the month of February.

Similar weather conditions continued at the beginning of **March**. This was followed by a period of high air pressure and stable weather when the sea level was either similar to that forecast or slightly lower. The monthly values for the characteristic sea levels are similar to the mean reference period (1961-2000) values or slightly higher.

In April, the sea was high, though not extremely so. The sea levels were higher than forecast for the entire month. All the characteristic values are somewhere in between the mean and maximum in comparison with the reference period.

In the first half of **May**, the weather conditions from April continued and intensified. The air pressure remained rather low for a few days, below 1000 mb, and the wind blew simultaneously from the southern quadrant, which raised the sea level significantly. The weather conditions and the high astronomical tide caused the sea in the first half of the month on seven occasions to exceed the limit height at which it overflows the low-lying parts of the coast. The highest sea level, 303 cm, was recorded in the evening hours of 4 May. The mean monthly value was high and only 5 cm lower than the maximum reference period value. The minimum low water, at 155 cm, was especially high in comparison with that of the reference period and was a centimetre higher than the maximum from the 1961-2000 period. The mean high and maximum high water were above the mean reference period value, but failed to reach the all time highs.



Graf 29: Morje je bilo v prvi polovici maja precej povišano.
Legenda: Hmer = izmerjena višina morja
Ha = astronomska višina morja

Graph 29: Sea level was high in the first half of May.
Legend: Hmer = measured sea level
Ha = astronomical sea level

Tudi **junija** je bilo morje nekoliko višje od povprečja. Srednja mesečna vrednost je bila 219 cm, kar je 3 cm višje od srednje obdobne vrednosti za junij. Najnižja gladina vode v mesecu je bila podobna srednjim obdobnim vrednostim, ostale značilne vrednosti pa so bile nekoliko višje od srednjih, niso pa se približale maksimalnim obdobnim vrednostim.

V **juliju** in **avgustu** je bilo morje nekoliko višje od napovedanega. Nobena od vrednosti ni bila izjemna, vse pa nekoliko nad obdobnim povprečjem.

V začetku **septembra** je bilo morje nekoliko nižje od napovedanega, v drugem delu meseca pa je bila gladina morja precej višja. Srednja mesečna vrednost 220.3 cm je bila tako nekoliko nad obdobnim povprečjem. Najvišje je bilo morje 27. septembra zvečer, 279 cm.

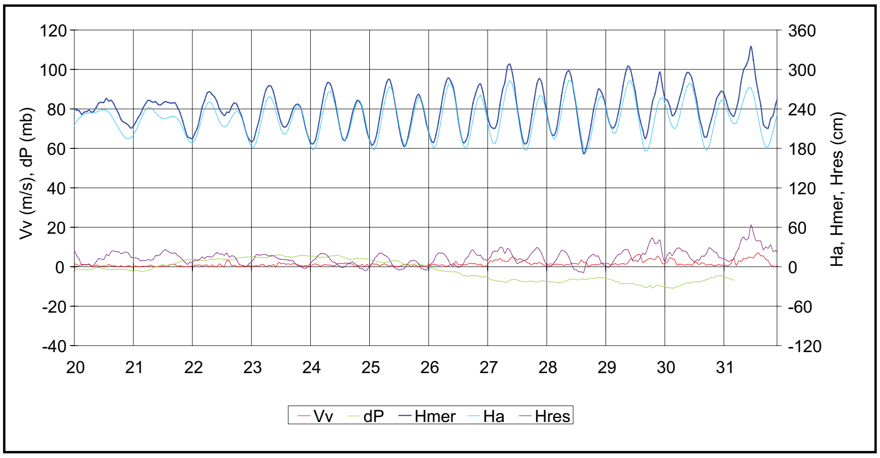
Oktober se je pričel umirjeno, s povprečno visoko gladino morja. V drugi polovici meseca pa je bila gladina morja močno povišana. Že 15. oktobra je residualna višina (razlika med napovedano in dejansko izmerjeno gladino morja) dosegla 40 cm. Do konca meseca se je razlika še stopnjevala in 31. oktobra dosegla 63 cm. Od 26. oktobra do konca meseca je ob nizkem zračnem pritisku pihal tudi močan veter južne smeri in ob visokih astronomskih višinah je bila gladina morja zelo visoka. Nekajkrat je tudi za nekaj ur poplavila nižje predele obale. Najvišja gladina morja je bila 342 cm, kar je 19 cm višje od srednje obdobne vrednosti, a nižje od obdobnega maksimuma (370 cm). Tudi vse ostale značilne vrednosti so bile nadpovprečne. Srednja mesečna vrednost 233.9 cm je bila najvišja v letu 2004.

Even in June, the sea was slightly higher than average. The mean monthly value was 219 cm, which is 3 cm higher than the mean reference period value for the month of June. The minimum sea level in the month was similar to the mean reference period values, while other characteristic values were slightly higher than the mean, but not approximating the maximum reference period values.

In July and August, the sea was slightly higher than was forecast. None of the values were exceptional and all were slightly above the reference period mean.

In the beginning of September, the sea was slightly lower than forecast, then significantly higher in the second part of the month. The mean monthly value of 220.3 cm was therefore slightly above the reference period mean. At 279 cm the sea was at its highest in the evening of 27 September.

October began rather placidly with an average high sea level, but in the second half of the month, the sea level was significantly elevated. As early as on 15 October, the residual level (the difference between the forecast and the sea levels actually measured) had reached 40 cm and, by the end of the month, the difference had increased, reaching 63 cm on 31 October. From 26 October until the end of the month, the low air pressure was accompanied by strong winds from the south and, in conjunction with the high astronomical levels, the sea level was very high. A few times, it even inundated the low-lying parts of the coast for a few hours. The maximum sea level was 342 cm, which is 19 cm higher than the mean reference period value, but lower than the reference period maximum (370 cm). All of the other characteristic values were also above-average. The mean monthly value of 233.9 cm was the highest in 2004.

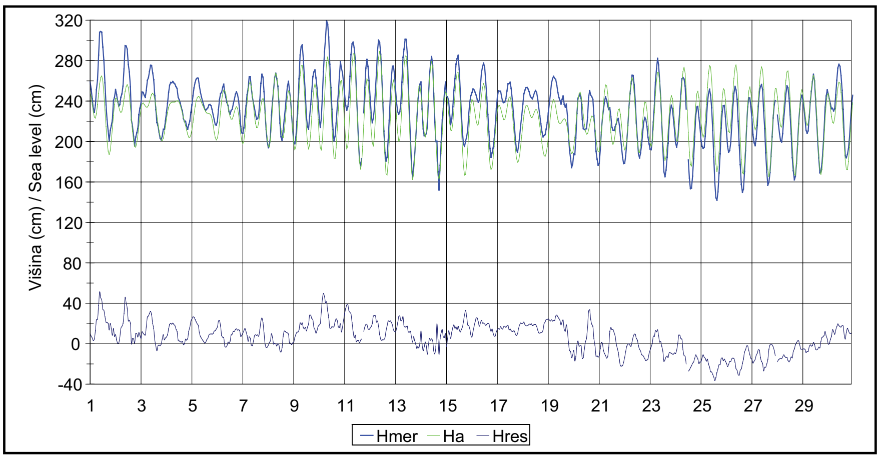


Graf 30: Najvišja gladina morja v oktobru je bila izmerjena 31. oktobra, ko so sovpadali visoka astronomska plima, nizek pritisk in južni veter.
Legenda: Vv = hitrost vetra
dP = razlika zračnega pritiska do srednje vrednosti 1016 mb
Hmer = izmerjena višina morja
Ha = astronomska višina morja

Graph 30: The highest sea level in Octobre was measured on 31st of October, and was caused by high astronomic tide, low air pressure and southern wind.
Legend: Vv = wind velocity
dP = deviation of air pressure from the mean value 1016 mb
Hmer = measured sea level
Ha = astronomical sea level

November se je nadaljeval tako, kot se je oktober končal, s povišanim morjem. V prvih dneh je bilo morje zelo visoko, dvakrat je bilo višje od 300 cm. Najvišjo višino 325 cm je morje doseglo 10. novembra zjutraj. V drugi polovici meseca je bilo morje nižje. Srednja mesečna višina je bila 233.4 cm.

November continued as October ended, with elevated sea levels. In the first days, the sea was very high, exceeding the 300 cm mark twice. The sea reached its highest level, 325 cm in the morning on 10 November. The sea was lower in the second part of the month. The mean monthly sea level was 233.4 cm.

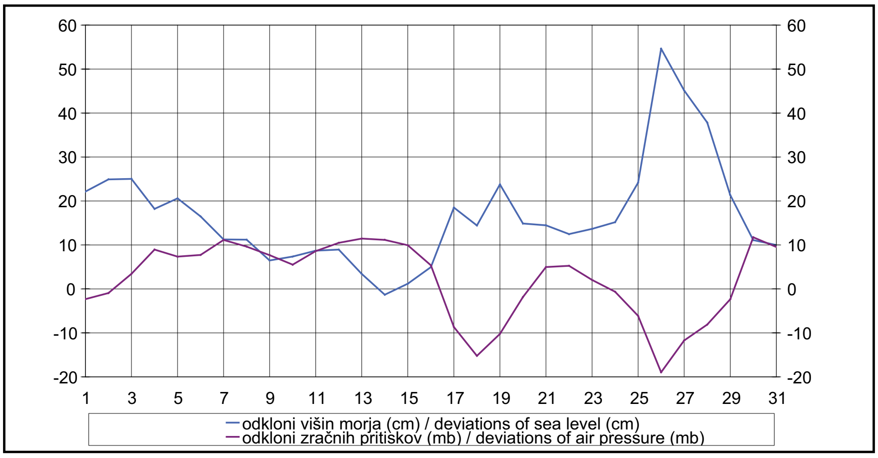


Graf 31:
Legenda: Hmer = izmerjena višina morja
Ha = astronomska višina morja
Hres = residualna višina je razlika med napovedano in izmerjeno višino morja

Graph 31:
Legend: Hmer = measured sea level
Ha = astronomical sea level
Hres = residual sea level is the difference between the measured and forcasted sea level.

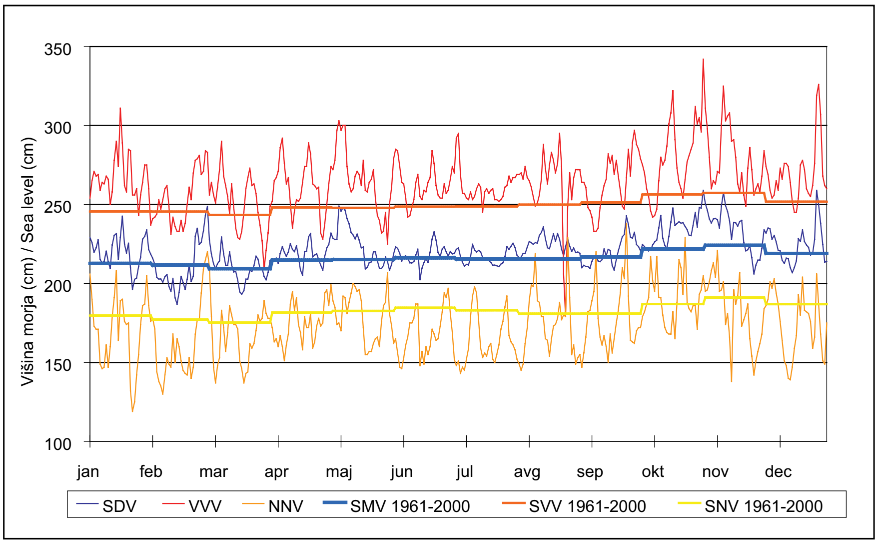
Tudi srednja mesečna višina morja v **decembru** je bila nadpovprečno visoka. Morje je bilo povišano predvsem v zadnjih dneh leta. Najvišja je bila gladina morja 27. decembra zjutraj, dosegla je 326 cm. Poplavila je nižje dele obale, med drugim Semedelsko cesto v Kopru in Tartinijev trg v Piranu. Vse značilne vrednosti so bile višje od obdobnega povprečja za december.

The mean monthly sea level in **December** was also above average. The sea was especially elevated in the last days of the year, reaching its highest value of 326 cm in the morning of 27 December. It flooded the lower-lying parts of the coast, including the Semedelska cesta Road in Koper and the Tartinijev trg Square in Piran. All the characteristic values were higher than the reference period mean for the month of December.



Graf 32: Odkloni zračnega pritiska in višine morja od povprečja v decembru.

Graph 32: Deviations of air pressure and sea level in December.



Graf 33: Povprečne dnevne višine morja, povprečne dnevne plime in oseke v letu 2004 s pripadajočimi mesečnimi vrednostmi obdobja 1961-2000.

Graph 33: Mean daily sea levels, mean high tides and low tides in 2004 and the accompanying monthly values from the 1961-2000 period.

E. VODNA BILANCA

E. WATER BALANCE

VODNA BILANCA POREČIJ

Peter Frantar

Vodnobilančni izračuni temeljijo na analizi enot glavnih povodij z uporabo geoinformacijske tehnologije. V povprečju je bilo leto 2004 precej bolj namočeno od let 2002 in 2003. Primerjava potencialne in bilančne evapotranspiracije, ki je razlika med padavinami in odtokom, pa nakazuje tudi na polnjenje zalog podzemnih voda, ki so se zmanjšale v prejšnjih sušnih letih.

Preglednica 26: Člени vodne bilance leta 2004 po hidrogeografskih enotah Slovenije (v mm).

(mm)	Pomurje	Podravje	Posavje	Posočje	Primorje
padavine / precipitation	904	1308	1774	2449	1571
evapotranspiracija / evapotranspiration	840	765	791	880	1033
neto odtok / net runoff	64	543	983	1569	538
odtočni količnik / runoff coeficient	0.07	0.41	0.55	0.64	0.34

Pomurje obsega 1390 km^2 in ima povprečno najmanj padavin v Sloveniji. Tudi leta 2004 je bilo tako. V Pomurju je padlo v povprečju 904 mm padavin (v obdobju 1961-90: 903 mm) oz. 39,9 m^3/s. Količina izhlapele vode je bila po izračunu potencialne evapotranspiracije skoraj 20 % manjša od »bilančne« evapotranspiracije, ki je bila 840 mm oz. 37,1 m^3/s. Najmanj padavin je bilo leta 2004 na skrajnem severu Pomurja, v porečju Velike Krke - 800 mm, največ pa v Slovenskih goricah in sicer okoli 1000 mm. Na Goričkem je padlo okoli 950 mm padavin, po murskem nižavju pa 850 do 900 mm. Količina tekoče vode v tej pokrajini je močno odvisna od dotoka iz Avstrije. Pri vtoku v Slovenijo smo upoštevali Muro, del porečja Kučnice in Ledave izven Slovenije. Pri odtoku iz države pa smo upoštevali Muro, Veliko Krko, Ledavo ter odtok s preostalega območja, ki ga ne zajamemo z vodomernimi postajami. Vsi dotoki v Pomurje so leta 2004 doprinesli 157,5 m^3/s, iz Pomurja pa je odteklo skupaj 160,34 m^3/s. Leta 2004 je slovensko Pomurje k pretoku Mure prispevalo v povprečju 2,3 m^3/s. Odteklo je torej le 7 % oz. 64 mm padavin (preglednica 26).

Leta 2004 je bilo v **Podravju** (3265 km²) v povprečju 1308 mm padavin (v obdobju 1961-90: 1222 mm) kar je 135,6 m^3/s. Najmanj padavin v Podravju je bilo leta 2004 na vzhodnem delu, v osrednjem delu Slovenskih goric (okoli 950 mm), največ pa na Pohorju, ponekod preko 1850 mm. V povirju Meže je bilo tega leta približno 1800 mm padavin. Količino dotoka iz Avstrije smo določili s pretoki na

THE WATER BALANCES OF RIVER BASINS

Peter Frantar

Water balance calculations are based on analysis of the individual units of the main catchment areas using geoinformation technology. On average, the 2004 year was much wetter than years 2002 and 2003. A comparison of the potential and water balance evapotranspirations, which is the difference between precipitation and runoff, also points to the recharging of groundwater reserves that had been diminishing in the previous years of drought.

Table 26: Components of the water balance in 2004 according to the hydrogeographical units of Slovenia (in mm).

Pomurje (the river basin of the Mura River) encompasses 1,390 km^2 and has the least precipitation in Slovenia on average. This was also the situation in 2004. There was, on average, 904 mm of precipitation in Pomurje (in the 1961-1990 reference period: 903 mm) or 39.9 m^3/s. The quantity of water evaporated, according to the calculation of potential evapotranspiration, was almost 20 percent lower than the “water balance” evapotranspiration, which amounted to 840 mm or 37.1 m^3/s. The lowest precipitation of 2004 fell in the northernmost part of Pomurje, in the river basin of the Velika Krka River – 800 mm – and the most fell in the Slovenske gorice region, where there was approximately 1000 mm of precipitation. In Goričko, there was around 950 mm of precipitation and from 850 to 900 mm in the lowlands along the Mura River. The quantity of running water in this region is highly dependent on the inflow from Austria. Inflow of the Mura River into Slovenia, as well as inflows from a part of the river basin of the Kučnica and Ledava Rivers lying outside Slovenia were taken into consideration. At the outflow from the country, the Mura, Velika Krka and Ledava Rivers and the runoff from the remaining part of the area not covered by hydrometric stations was also taken into consideration. All the inflows into Pomurje in 2004 contributed 157.5 m^3/s, while a total of 160.34 m^3/s flowed out of Pomurje. The Slovenian Pomurje contributed 2.3 m^3/s on average to the discharge of the Mura River in 2004. Thus, only 7% or 64 mm of the precipitation flowed out (Table 26).

Dravi v Dravogradu, na Bistrici v Muti ter na povirju Pesnice. Skupni odtok vsega Podravja je Drava pri Ormožu. V Podravje je leta 2004 v povprečju priteklo dobrih 260 m³/s vode, odteklo pa 316 m³/s. Neto prispevek Podravja k odtoku Drave je bil torej skoraj 56,2 m³/s. Bilančna evapotranspiracija Podravja je 765 mm oz. 79,4 m³/s vode.

Posavje zajema več kot polovico (11750 km²) Slovenije. Leta 2004 je bilo na območju slovenskega Posavja v povprečju 1774 mm (v obdobju 1961-90: 1575 mm) padavin oz. za 661,4 m³/s. V porečju je znan velik razpon v količini padavin – od okoli 1000 mm v Posotelju, do nad 3500 mm v ožjem območju zahodno od Bohinja. Vzhodni del je imel do 1500 mm padavin, osrednji do 2000 mm, preko 2000 mm padavin pa je bilo še na območju Goteniške gore in Snežnika ter Kamniških Alp in Karavank. Pritoki v slovensko Posavje iz hrvaškega dela porečja Ljubljanice, Kolpe, Krke in Sotle so prispevali 43,9 m³/s, skupen iztok iz Slovenije pa je bil 410 m³/s. Neto odtok iz slovenskega Posavja je bil 366,2 m³/s (še enkrat več kot sušnega leta 2002). Po bilančni enačbi izračunana evapotranspiracija je bila 791 mm oz. 295,3 m³/s.

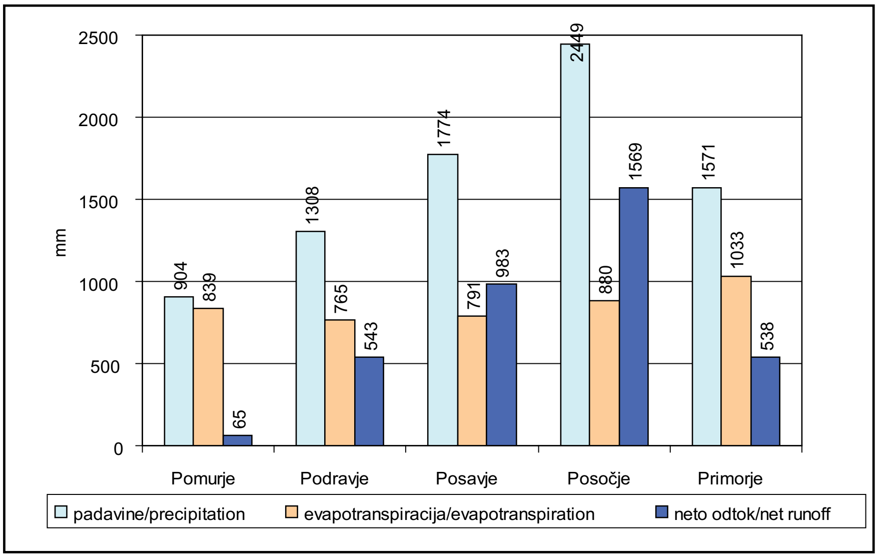
Posočje meri 2320 km² in je po specifičnih odtokih najbolj vodnato porečje. Tudi leta 2004 je tu padlo največ padavin v Sloveniji, 2450 mm oz. 180 m³/s, kar je nekaj nad dolgoletnim povprečjem obdobja 1961-90 z 2383 mm. Preko 3500 mm padavin je v letu 2004 padlo na območju najvišjih predelov Julijcev. Visoki dinarski rob je imel okrog 2500 mm padavin, najmanjša količina padavin pa je bila v Vipavski dolini – okoli 1500 mm. Večina vode v Posočju se steka s slovenskega ozemlja, iz Italije, kamor segajo povirja Učje, Nadiže in deloma Idrije, pa je pritekalo leta 2004 v Slovenijo povprečno 5,65 m³/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, po katerih je odteklo okrog 121 m³/s. Bilančna evapotranspiracija je bila leta 2004 v Posočju 880 mm oz. 64,8 m³/s, neto odtok pa dobrih 115 m³/s.

Povodje preostalih Jadranskih rek zajema 1530 km²; največji vodotok je Reka. Tu je leta 2004 padlo 1571 mm padavin (v obdobju 1961-90: 1601 mm), kar je 76,2 m³/s. Najmanj padavin je bilo v dolini spodnje Dragonje, okoli 900 mm, največ pa na območju Snežnika, nad 2500 mm. Na Krasu je bilo padavin okoli 1500 mm. Dotoki v Slovenijo so tu v povirju Rižane in Reke ter v zaledju Dragonje. Skupaj je priteklo v Slovenijo manj kot 0,83 m³/s vode. Iztokov je več: poleg večine Krasa (s podzemnim odtokom) ter obale, v Italijo odteka tudi Osapska reka, na Hrvaško pa teče voda povirja Mirne. Skupni odtok je bil leta 2004 26,8 m³/s, neto odtok pa je 26 m³/s. Leta 2004 je bila bilančna evapotranspiracija 1033 mm oz. 50,2 m³/s.

There was 1,308 mm of precipitation in **Podravje** (**the river basin of the Drava River**, covering 3,265 km²) on average in 2004 (1,222 mm in the 1961-1990 reference period), which equals 135.6 m³/s. The least precipitation in Podravje in 2004 fell in the eastern area, in the central part of Slovenske gorice (around 950 mm), and the most fell on Pohorje, where exceeded 1,850 mm in some places. In the headwaters of the Meža River, there was approximately 1,800 mm of precipitation in that year. The quantity of inflow from Austria was determined using the discharges of the Drava River at Dravograd, of the Bistrica River at Muta and in the headwaters of the Pesnica River. The Drava River at Ormož is the common outflow of the entire Podravje river basin. In Podravje in 2004, there was, on average, 260 m³/s of water flowing in and 316 m³/s of water flowing out. The net contribution of Podravje to the discharge of the Drava River was therefore almost 56.2 m³/s. The water balance evapotranspiration of Podravje is 765 mm or 79.4 m³/s of water.

Posavje (the river basin of the Sava River) encompasses more than half (11,750 km²) of Slovenia. In 2004, the territory of the Slovenian Posavje had, on average, 1,774 mm (1,575 mm in the 1961-90 reference period) of precipitation or 661.4 m³/s. The river basin is known for the great variation in the amount of precipitation – from around 1,000 mm in Posotelje (the river basin of the Sotla River) to more than 3500 mm in the local area west of Bohinj. The eastern part received up to 1,500 mm of precipitation, the central part up to 2,000 mm, and more than 2000 mm of precipitation fell in the area of Mount Goteniška gora and Mount Snežnik, the Kamniške Alps and the Karavanke Mountains. The inflows into the Slovenian Posavje from the Croatian part of the river basins of the Ljubljanica, Kolpa, Krka and Sotla Rivers were 43.9 m³/s, while the total outflow from Slovenia was 410 m³/s. The net outflow from the Slovenian Posavje was 366.2 m³/s (which is twice as much as in the drought year of 2002). The evapotranspiration calculated according to the water balance equation was 791 mm or 295.3 m³/s.

Posočje (**the river basin of the Soča River**) measures 2,320 km² and is the most water abundant river basin in terms of specific discharges. Also in 2004, the river basin had the most precipitation in Slovenia, namely 2,450 mm or 180 m³/s, which is somewhat more than in the multi-annual reference period of 1961-1990 (with 2,383 mm). There was more than 3,500 mm of precipitation in 2004 in the highest parts of the Julian Alps, with the High Dinaric Plateaus Ridge receiving around 2,500 mm. The smallest quantity was recorded in the Vipava Valley with around 1,500 mm. Most of the water in Posočje, the river basin of the Soča River, comes from the Slovenian territory, while 5.65 m³/s on average flowed into Slovenia in 2004 from Italy, where the headwaters of the Učja, Nadiža and partly the Idrija Rivers are located. The water runs off from the Slovenian Posočje to the greatest extent in rivers Soča, Vipava and Nadiža, while some of it also runs off in rivers Idrija, Reka (of the Goriška Brda region) and Koren. Runoff alltogether accounted for around 121 m³/s. The water balance evapotranspiration in 2004 in Posočje was 880 mm or 64.8 m³/s, while the net runoff was well over 115 m³/s.



Graf 34: Člени vodne bilance leta 2004 po hidrogeografskih enotah Slovenije v mm.

Figure 34: Water balance components in 2004 according to the hydrogeographical units of Slovenia, in mm.

Primerjava z obdobno vodno bilanco

Vse člene vodne bilance leta 2004 smo za Črnomorsko in Jadransko povodje primerjali z referenčno obdobno vodno bilanco 1961-90 (Kolbezen et al., 1998).

V slovenskem delu Črnomorskega povodja je leta 2004 padlo več padavin kot je obdobno povprečje. Med leti 1961-90 je bila povprečna količina padavin 1445 mm, leta 2004 pa jih je padlo 1609 mm, kar je dobra desetina več. Tudi evapotranspiracija je bila leta 2004 večja kot v povprečju obdobja 1961-90. Leta 2004 je bilančna evpotranspiracija znašala kar 792 mm vode, v obdobju 1961-90 pa 644 mm. V obdobju 1961-90 smo iz Slovenije v črnomorsko povodje prispevali skoraj 420 m^3/s vode oz. 800 mm/leto, v letu 2004 je bila ta količina 425 m^3/s oz. 818 mm. V primerjavi z dolgoletnim obdobjem je bilo leto 2004 bolj namočeno od povprečja.

Tudi v slovenskem delu **Jadranskega povodja** je v letu 2004 padlo več padavin kot v dolgoletnem obdobju. V tem letu je bila količina padavin 2100 mm, obdobno povprečje pa je 2070 mm. Evapotranspiracija je bila po letnih vodnobilančnih izračunih 944 mm. V letu 2004 je bil povprečni odtok v Jadran 141 m^3/s (1160 mm), medtem ko je dolgoletni povprečni odtok preko 170 m^3/s (1410 mm). Odtok v letu 2004 je bil od povprečja manjši zlasti zaradi večjega izhlapevanja.

The water catchment area of the rest of the Adriatic Sea rivers encompasses 1,530 km², its largest watercourse being the Reka River (of the Ilirska Bistrica region). This area had 1,571 mm of precipitation in 2004 (1,601 mm in the 1961-1990 reference period), which amounts to 76.2 m^3/s. The lowest precipitation amount was in the valley of the lower Dragonja River, around 900 mm, and the highest in the area of Mount Snežnik with more than 2,500 mm. There was around 1,500 mm of precipitation in the Karst. The inflows into Slovenia in this region are in the headwaters of the Rižana and Reka Rivers and in the catchment area of the Dragonja River. The total inflow into Slovenia was less than 0.83 m^3/s of water. There are several outflows: in addition to the majority of the Karst (with underground runoff) and the coast, there is the Osapska River also flowing into Italy, while the water from the headwaters of the Mirna River flows out into Croatia. The total runoff in 2004 was 26.8 m^3/s and the net runoff was 26 m^3/s. The water balance evapotranspiration in 2004 was 1033 mm or 50.2 m^3/s.

Comparison with the Reference Period Water Balance

All the components of the 2004 water balance for the Black Sea and Adriatic Sea basins were compared with the water balance of the 1961-1990 reference period (Kolbezen et al., 1998).

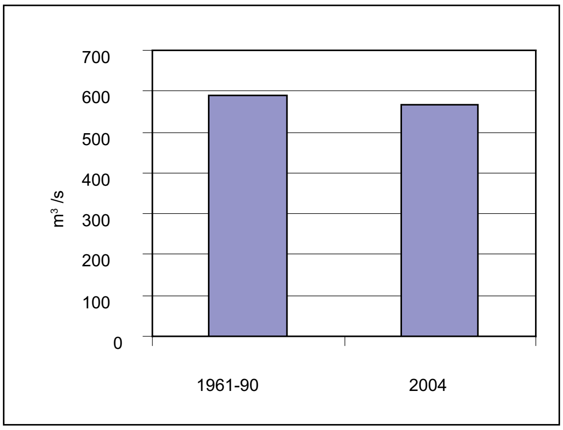
Preglednica 27: Primerjava členov vodne bilance 2004 z dolgoletnim obdobjem 1961-90 (v mm).

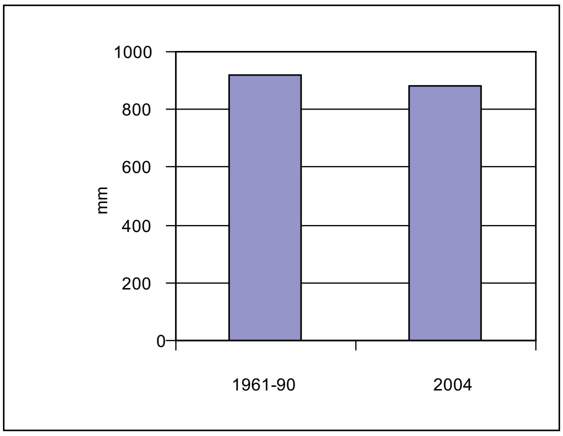
Table 27: Comparison of the components of the water balance for 2004 with the multi-annual reference period of 1961-1990 (in mm).

(mm)	Podonavje 1961-90	Jadran 2004	Slovenija 1961-90	2004	1961-90	2004
padavine / precipitation	1445	1609	2073	2104	1565	1703
evapotranspiracija / evapotranspiration	644	792	664	944	648	821
neto odtok / net runoff	801	818	1410	1160	917	883
odtočni količnik	0.55	0.51	0.68	0.55	0.59	0.52

Leto 2004 je bilo v **Sloveniji** v primerjavi z referenčnim obdobjem v okviru povprečja. Skupno smo imeli za slabo desetino več padavin, za četrtino višjo evapotranspiracijo in posledično nekaj manjši odtok od povprečja.

In the Slovenian part of the Black Sea Basin, there was more precipitation in 2004 than the mean of the reference period. Between 1961 and 1990, the average precipitation amount was 1,445 mm, while the amount in 2004 was 1,609 mm, which is somewhat over a tenth more. The evapotranspiration in 2004 was also greater than the mean of the 1961-1990 reference period. In 2004, the water balance evapotranspiration amounted to as much as 792 mm of water, compared with 644 mm in the 1961-1990 reference period. In the 1961-1990 reference period, Slovenia contributed almost 420 m^3/s of water or 800 mm/year into the Black Sea Basin, while this quantity was 425 m^3/s or 818 mm in 2004. In comparison with the multi-annual reference period, the year 2004 was more water abundant than the average.



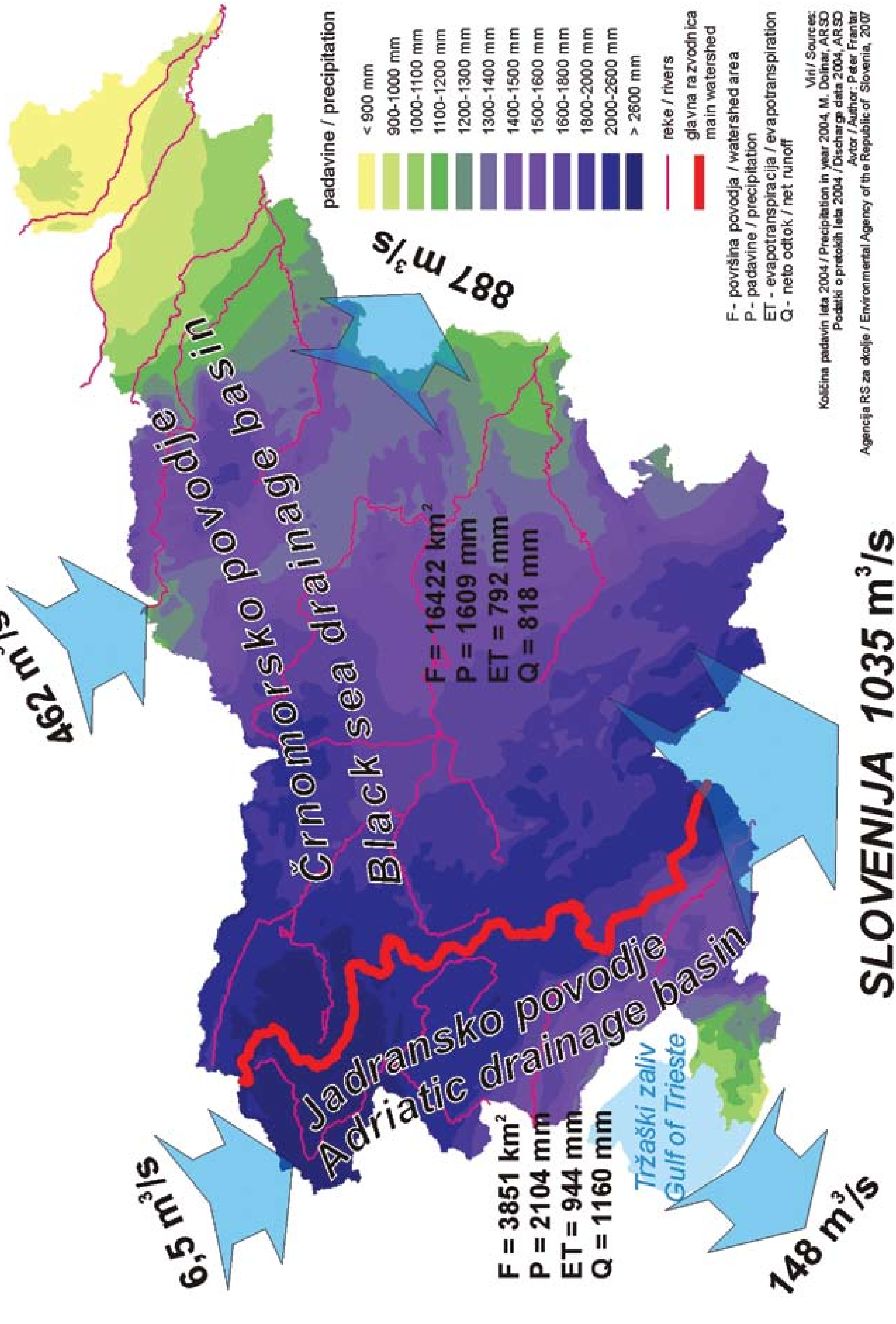


Graf 35: Odtok v referenčnem obdobju 1961-90 ter letu 2004 v m^3/s in v mm.

Figure 35: Runoff in the 1961-1990 reference period and in 2004 in m^3/s and in mm.

Even in the Slovenian part of the **Adriatic Sea Basin,** there was more precipitation in 2004 than in the multi-annual reference period. In that year, there was 2,100 mm of precipitation, while the reference period mean is 2,070 mm. Evapotranspiration amounted to 944 mm according to the annual water balance calculations. In 2004, the average runoff into the Adriatic Sea was 141 m^3/s (1,160 mm), while the multi-annual reference period average runoff exceeded 170 m^3/s (1,410 mm). The runoff in 2004 was lower than the average, because of greater evaporation especially.

Hydrologically, the year 2004 in **Slovenia** was close to the average of the multi-annual reference period. There was about a tenth higher amount of precipitation, evapotranspiration was higher by a quarter and consequently the runoff was slightly lower than average.



Karta 9: Karta vodnobilančnih členov v Sloveniji leta 2004.

Figure 9: Map of the water balance components in Slovenia in 2004.